
1990
2023

Welcome to Germany's

Informative Inventory Report 2025

(IIR 2025)

This report covers the preparation, maintenance, and improvement of the German air pollutant emission inventory.

Emission estimates are provided for the **timeseries from 1990 to 2023**, with exceptions for **fine particulate matter** with aerodynamic diameters of ≤2.5 ($PM_{2.5}$) or ≤10µm (PM_{10}) respectively with data as of **1995**, and black carbon (BC) with data as of **2000**.

For faster navigation please refer to the TABL E OF CONTENTS.

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EXECUTIVE SUMMARY

About this report

The Informative Inventory Report (IIR) is providing complementary information to Germany's air pollution inventories under the Geneva Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE/CLRTAP) as well as the EU's National Emission Ceiling Directive (NECD).

Germany's air pollution inventory includes emission data in consistent time-series ranging from 1990 (1995 for PM_{10}, $PM_{2.5}$ and 2000 for Black Carbon) to the latest reported year for all 26 air pollutants or groups of air pollutants (NO_x, NMVOC, PCDD/PCDF) considered under UNECE reporting.

This report provides a comprehensive analysis of the inventory data, descriptions of the methods applied, data sources, and carried out QA/QC procedures. It follows the outline established by the latest guidelines for estimating and reporting of emission data and all data presented in this report were compiled according to those same guidelines.

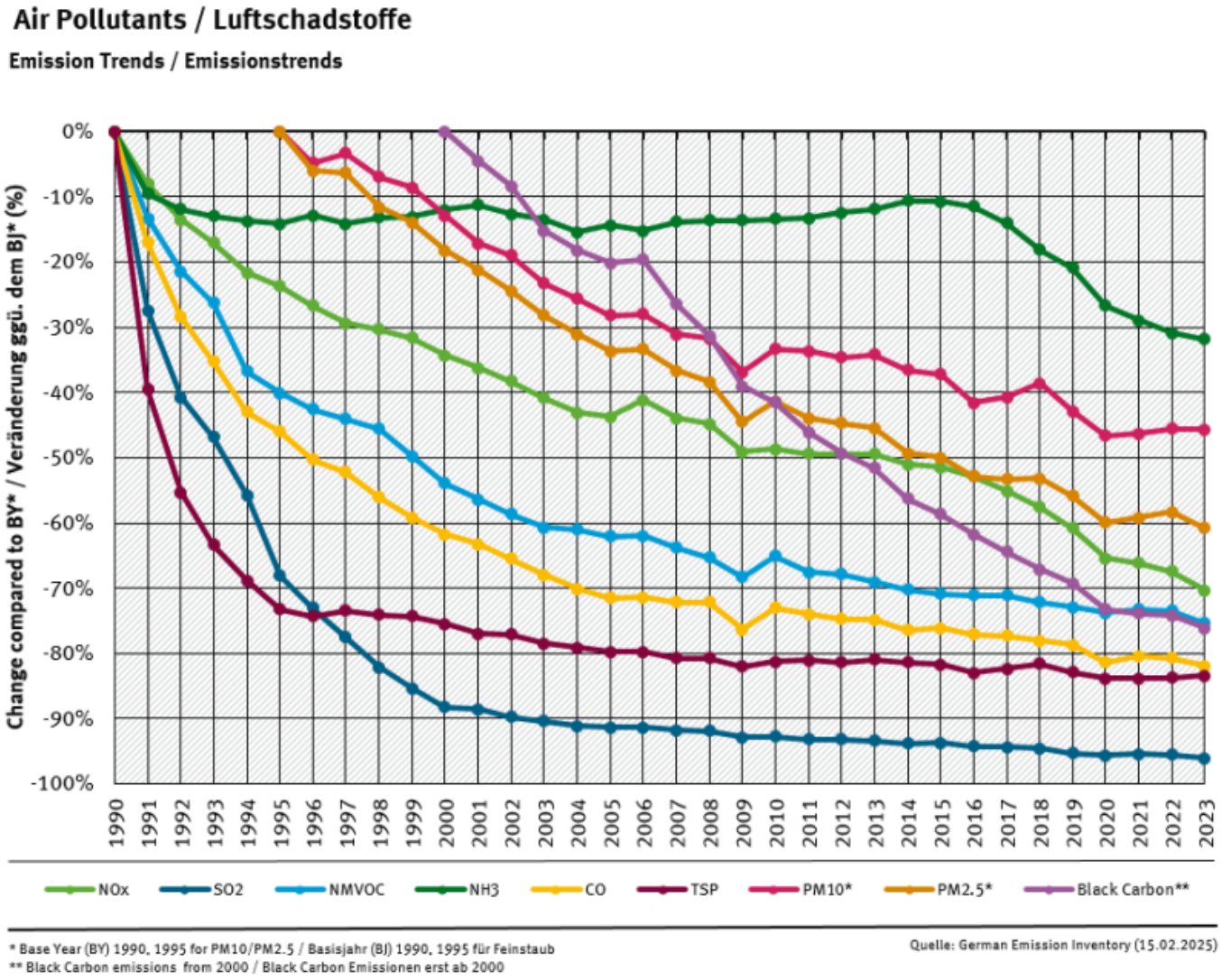
However, this report does *not* provide a comprehensive discussion on air pollution or the measures and politics dealing with it. Such information is included in the published national programs for further emission reductions, e.g. under the NEC directive or the trend and projection reports for green-house gases. Instead, it provides a detailed insight on the process of air pollution and emission inventory preparation. The focus lies on the methods and assumptions used for the German emission reporting and to underpin the “technical” review of the emission data as reported under the CLRTAP convention and its protocol.

Air pollution trends in Germany

Air pollution in Germany declined significantly over the last few decades. As the figure below illustrates, emissions decreased sharply for most pollutants monitored in the time from 1990 onwards.

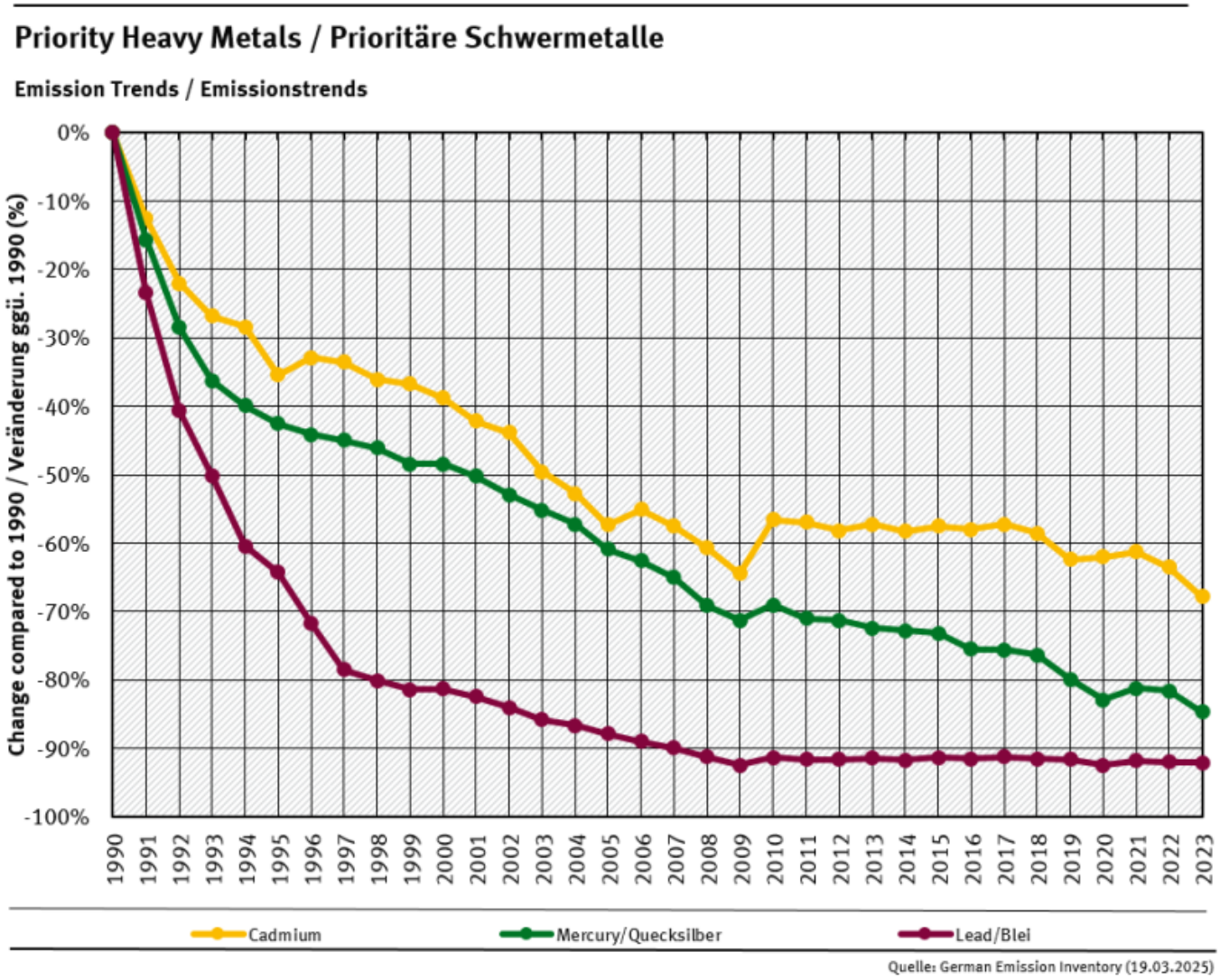
Especially in the 1990s, big improvements have been achieved due to the re-organisation of the former East German economy after the re-unification and the measures applied to German industry. One basic reason is the fuel switch in the former eastern part of Germany, i.e. the replacement of lignite by gaseous and liquid fuels.

A decrease of emissions is seen for all pollutants, though progress varies: Sulphur dioxide and TSP (total suspended particles), for example, saw a rapid decline in the early 1990s while the decrease of other pollutant's emissions developed more or less linear. Values for particulate matter are measured and calculated since 1995 and reveal a slow though steady improvement.



Nevertheless, the above figure also illustrates that for certain pollutants (namely ammonia, sulphur dioxide, and total suspended particles) only moderate progress can be observed since 2000. This particularly holds true for the development of ammonia, where recent years saw steady or even increasing emissions.

For heavy metal and POP (Persistent Organic Pollutants) emissions, the picture is far more heterogeneous: While the release of these substances generally declined, some trends appear to be less favourable. Generally, data completeness and inventory compatibility remains an issue for these pollutants. For the three priority heavy metals cadmium, mercury, and lead, however, very significant reductions have been achieved in the 1990s (see figure below).



All trends are analysed and explained in detail in the Chapter 2 - Explanation of Key Trends.

Major improvements compared to last submission

For more details, please refer to chapters 9.1 - Recalculations and 9.2 - Improvements.

Completeness

With respect to all major air pollutants, the German inventory is generally considered complete. In contrast, for heavy metals and persistent organic pollutants there are still quite a few missing bits and pieces.

For more information, refer to chapter 1.8 General Assessment of Completeness.

Completeness of the German inventory can also be assessed by referring to the data submission. All cells marked “NE” (not estimated) within the NFR tables do indicate missing information.

Priorities for further improvement

For an overview on major improvements introduced with the current submission or planned for future submissions please refer to Chapter 9.2 - Improvements.

Most notably, Germany will seek to improve the completeness of the report, in particular regarding heavy metals and

persistent organic pollutants. Moreover, we will continue to provide a comprehensive and up-to-date IIR.

Structure of this report

This report does not provide a comprehensive discussion on air pollution or the measures and politics dealing with it. This type of information is included in the published national programs for further emission reductions, e.g. under the NEC directive or the trend and projection reports for green-house gases. Instead, it provides a detailed insight on the process of air pollution and emission inventory preparation. The focus lies on the methods and assumptions used for the German emission reporting. The report is intended to underpin the “technical” review of the emission data as reported under the CLRTAP convention and its protocol.

Thus, the outline of this report follows the recommendations of the CLRTAP emission reporting guidelines.

CHAPTER 1: Introduction to the German emission reporting & air pollutants emissions inventory

The following pages provide an overview on the fundamental inventory work, its backgrounds and basic tasks.

1.1 National Inventory Background

Why we do what we do: The CLRTAP convention and its protocols, Germany's reduction obligations, …

1.2 Institutional Arrangements

The necessary institutional framework: Inventory preparation, responsibilities of the Single National Entity, …

1.3 Inventory Preparation Process

How we do it: The process of inventory preparation.

1.4 Methods and Data Sources

Where we get our data from: Main data sources, national statistics, models, plant specific data, …

1.5 Key Categories

Main emission sources and interesting trends.

1.6 QA/QC and Verification methods

Assuring a high quality inventory: The German Quality System for Emission Inventories.

1.7 General Uncertainty Evaluation

The quality of numbers: specific and over-all uncertainty assessment.

1.8 General Assessment of Completeness

Mind the gap: necessary efforts to achieve the “complete” inventory.

Chapter 1.1 - National Inventory Background

Air pollution and the Convention on Long-range Transboundary Air Pollution

Starting in the late 18th century, the industrial revolution caused an ever-growing need for energy and resources. As a result, pollution of the atmosphere, going alongside with threats to environment and health, became a highly visible, undeniable problem waiting to be solved.

As one answer to this situation, the Convention on Long-Range Transboundary Air Pollution (also: Convention on Air Pollution, CLRTAP) was opened for signature in November 1979 and came into effect about 3 years later in March 1983.

By now, the Convention - identifying the Executive Secretary of the United Nations Economic Commission for Europe (UNECE) as its secretariat - has 51 parties and addresses some of the major environmental problems of the UNECE region through scientific collaboration and policy negotiation and, during the years, has been extended by eight protocols that identify specific measures to be taken by Parties to reduce their emissions of air pollutants.

Aim of the Convention is that parties shall endeavour to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution. Parties develop policies and strategies to combat the discharge of air pollutants through exchanges of information, consultation, research, and monitoring.

Annually, the Parties meet at sessions of the Executive Body to review ongoing work and plan future activities including a work plan for the coming year. The three main subsidiary bodies - the Working Group on Effects, the Steering Body to EMEP and the Working Group on Strategies and Review - as well as the Convention's Implementation Committee, report to the Executive Body each year.

Currently, the Convention's priority activities include review and possible revision of its most recent protocols, implementation of the Convention and its protocols across the entire UNECE region (with special focus on Eastern Europe, the Caucasus and Central Asia and South-East Europe) and sharing its knowledge and information with other regions of the world.

Germany and the convention protocols

As mentioned above, the Convention on Long-Range Transboundary Air Pollution has, by now, been extended by eight protocols on the reduction of several pollutants such as Sulphur, Nitrogen Oxides or Volatile Organic Compounds. Germany, as a member of the CLRTAP, has signed each additional protocol.

The Geneva Convention…	**opened / put into force**
Geneva Convention on Long-Range Transboundary Air Pollution, CLRTAP	1979 / 1983
…and its Protocols	
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)	1984 / 1988
Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent	1985 / 1987
Sofia Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes	1988 / 1991
Geneva Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes	1991 / 1997
Oslo Protocol on Further Reduction of Sulphur Emissions	1994 / 1999
Aarhus Protocol on Heavy Metals	1998 / 2003
Aarhus Protocol on Persistent Organic Pollutants (POPs)	1998 / 2003
Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone	1999 / 2005

Today, the last three protocols are the most relevant. All three of them have been updated to foster further reductions of air pollution towards the new milestones in 2020 and 2030.

Reduction obligations and reporting

Reporting of emission data to the executive body of the Convention on Long-Range Transboundary Air Pollution (CLRTAP) is required in order to fulfil obligations of the protocols under the convention. Parties are required to submit annual national emissions of SO_2, NO_x, NMVOC, CO and NH_3, particulate matter, various heavy metals and persistent organic pollutants (POPs) using the “Guidelines for Estimating and Reporting Emission Data” under the Convention. This process is underlined by activities to review the submitted information by independent experts.

The report at hand contains information on Germany's inventories for all years from 1990 to the latest reporting year including descriptions of methods, data sources, QA/QC activities carried out and a trend analysis. The inventory accounts for anthropogenic emissions of SO_2, NO_x, NH_3, NMVOC, CO, TSP (Total Suspended Particulate matter), PM_{10} (particles of size <10µm), $PM_{2.5}$ (<2.5µm), BC (Black Carbon), Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn, PAH and dioxins. Emission estimates are mainly based on official German statistics, e.g. energy statistics, agricultural statistics and environmental reports from industry. The emission factors used are both nationally developed factors as well as internationally recommended ones. For details please refer to the sector-specific sections.

Germany uses the EMEP/EEA Air Pollutant Emission Inventory Guidebook for reporting to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and to the Economic Commission for Europe (UNECE). The methodologies used are to some extend also in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines) and, in general, in line with Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories IPCC-NGGIP (IPCC Good Practice Guidance).

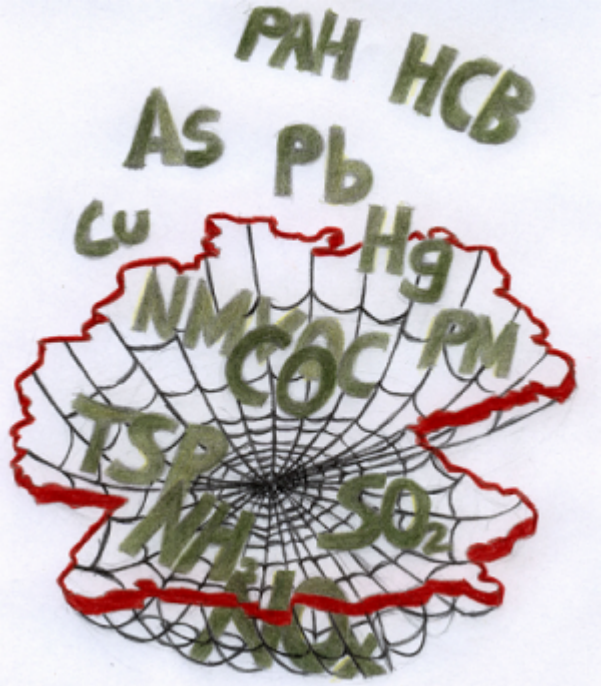
Besides its CLRTAP obligation and as an EU member state, Germany also has to report the full data set and this inventory report under the updated National Emissions Ceilings Directive (EU/2016/2284). Both submissions are fully aligned in format, timing and content. There are no differences when comparing the submissions presented under the LRTAP convention, the EU's NEC directive and the UNFCCC other than the minor and expected incompatibilities in the reporting of emissions from mobile sources (aviation and marine shipping).

National territory emissions

All of Germany’s emissions occur inside the EMEP grid domain. This excludes international aviation and maritime navigation as shown in methodical issues and laid out by the CLRTAP guidelines. There is only one offshore island (Helgoland) were all emission relevant activities are included in the national statistics used for the emission estimation. Thus, all numbers for national totals given are considered to be “real totals”.

Chapter 1.2 - Institutional Arrangements

Inventory preparation and responsibilities



Article 5.1 of the UNFCCC/Kyoto Protocol mandates the establishment of a National System for preparation of greenhouse-gas emissions inventories. The National System for Germany fulfils the requirements of the revised UNFCCC Reporting Guidelines on National Inventory Arrangements (UNFCCC Decision 24/CP.19), requirements which are binding under the Kyoto Protocol (according to UNFCCC Decision 19/CMP.1) and the European Greenhouse gas Monitoring Mechanism Regulation (525/2013). The German emission inventory as submitted to the Geneva LRTAP Convention is prepared in the very same institutional framework, by the same actors and processes.

The National System provides for the preparation of inventories conforming to the principles of transparency, consistency, comparability, completeness and accuracy. Such conformance is achieved through extensive use of the methodological regulations from the CLRTAP Guidelines and the EMEP/EEA air pollution guidebook, through ongoing quality management and through continuous inventory improvement.

The National System in Germany has been essentially institutionalized at three levels, at the ministerial level, at the level of the German Environmental Agency and the level outside the federal government. At the ministerial level, the system is leaded by the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU) through an agreement of the Secretaries of the ministries involved as policy paper “National System for Emissions Reporting” established from 05.06.2007, extended in December 2014. With the incorporation of the Federal Ministry of the Interior, Building and Community (BMI), the Federal Ministry of Defence (BMVg); the Federal Ministry of Finance (BMF), the Federal Ministry of Economic Affairs and Energy (BMWi), the Federal Ministry of Transport and Digital Infrastructure (BMVI) and the Federal Ministry for Food and Agriculture (BMEL) all the key institutions are included that are in a position to make high-quality specialised contributions to the preparation of the emission inventories.

The policy paper defines the relevant responsibilities of the various departments. In addition, it was resolved that the German Environment Agency (UBA) should serve as the Single National Entity (National Co-ordinating Agency) for Germany. The tasks of the Single National Entity include the planning, preparation, and storage of the inventories and the description of those in the inventory reports as well as the quality control and quality assurance in all relevant process steps. In addition, various other institutions and organizations outside the federal government are integrated into the National System via agreements with the Single National Entity.

Instruments of the Single National Entity

The German Environment Agency has developed a range of instruments for supporting the Single National Entity in carrying

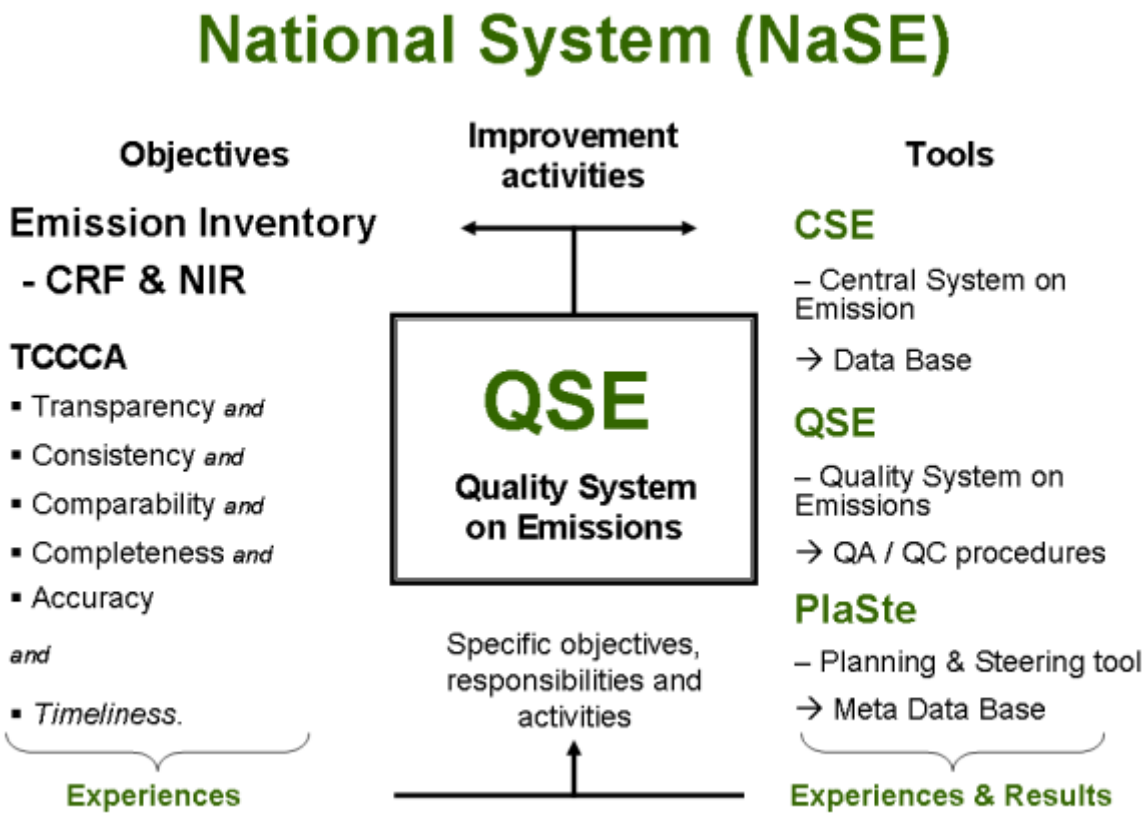
out its tasks.

The German Environment Agency's Central System on Emissions (CSE) database is the national, central database for emissions calculation and reporting. It is used for central storage of all information required for emissions calculation (methods, activity rates, emission factors). The CSE is the main instrument for documentation and quality assurance at the data level. It also tracks data provider responsibilities.

Within the German Environment Agency, the Quality System for Emissions Inventories (QSE) provides the necessary framework for good inventory practice and for routine quality assurance. Established in 2005 via in-house directive 11/2005, within the German Environment Agency it comprises the processes necessary for continually improving the quality of emissions inventories. The framework it provides includes defined responsibilities and quality objectives relative to methods selection, data collection, calculation of emissions and relevant uncertainties and recording of completed quality checks and their results (confirmation that objectives were reached, or, where objectives were not reached, listing of the measures planned for future improvement). The quality control procedures have been developed with the help of external experts, taking special account of the German Environment Agency's work structures, general guidelines for quality assurance and the CLRTAP Reporting Guidelines. Establishment of minimum requirements pertaining to data documentation, QC/QA and archiving ensures that additional authorities, institutions and inventory experts are included in the quality management process.

A searchable Access database – the Planning and Control Instrument (Planungs- und Steuerungsinstrument – PlaSte) – serves as the key instrument for monitoring success within the QSE framework. This database is the repository for all tabular documents emerging from the national QC/QA process (QC/QA plan, checklists, lists of responsibilities, etc.).

The manner in which these instruments interact in implementation of quality measures within the framework of inventory preparation is laid out by the figure below.



Documentation and archiving

As a general requirement, all data and information used for inventory calculation must be documented (i.e. recorded) and archived, for each report year. The purpose of such documentation (i.e. recording) is to make it possible to completely reconstruct all emissions calculations after the fact.

Consequently, data providers have the obligation to keep records of the following information relative to data they supply to the German Environment Agency, for purposes of inventory calculations:

- Publication/source of activity data and emission factors, with detailed referencing of the relevant table numbers and names, and of the relevant pages in the original sources;
- Survey contents (definitions of the surveyed characteristics, delimitations used, survey units used) and survey methods;
- The legal foundations and ordinances on which surveys are based;
- Chronological and spatial comparability with previous-year data, and any changes with regard to definitions, scopes of validity, cut-off points, sources of activity rates or data collection methods;
- Any revision of previously published data;
- The accuracy or quantitative error of activity data, methods used to estimate errors and the names of experts who have carried out error estimation.
- Secrecy and data protection: suitable notification with regard to any individual data items that are considered secret.

Such materials should be provided to the German Environment Agency on an annual basis, together with pertinent data, and they are centrally archived by the German Environment Agency both electronically and on paper.

Chapter 1.3 - Inventory Preparation Process



In Germany, emissions reporting is coordinated by a Single National Entity in the German Environment Agency (UBA). Since the mid-1990s, when reporting obligations for preparation of emissions inventories of air pollutants and greenhouse gases increased sharply, efforts to harmonise emissions calculation and reporting have been intensified. At the same time, requirements from reporting obligations relative to the UNECE Geneva Convention on Long-range Transboundary Air Pollution and its protocols, to the EU NEC Directive and to EU plant specific reporting obligations, must be considered.

The National System performed according to the requirements of the Kyoto Protocol provides for the preparation of inventories conforming to the principles of transparency, consistency, comparability, completeness and accuracy. Such conformance is achieved through extensive use of the methodological regulations provided by international institutions (UNECE, UNFCCC, IPCC, IPPC). The institutional arrangements are – like for greenhouse gases – as used for the reporting procedures established under the UNECE Convention and its protocols as well as the European reporting obligations.

The instruments and stakeholder acting in inventory preparation have already been laid out in the previous section Institutional Arrangements. For even more details on the German national system as well as for the methods and processes applied for the preparation of the emission inventory please refer to Germany's National Inventory Document (NID) 2024 as submitted under the UNFCCC. The process of inventory preparation depicted there is exactly the same as the one used for air pollution emissions. Where differences occur, namely in the use of emission factors, the NFR-specific chapters of this report will provide further explanation.

In practice, as many experts are involved in the inventory compilation process, an efficient organisation is required. The major advantage of this concept is the provision of additional expertise for quality control and verifications. The co-operation with the technical experts responsible for legislation and Best Available Technology (BAT) ensures a detailed technical knowledge for the inventory compilation process. The knowledge of abatement technologies and limit values is essential for the evaluation of emission factors. Since the German Environment Agency (UBA) operates several analytical laboratories and monitoring stations, it is possible to draw on the specialist expertise in order to get a better understanding of measurements and uncertainties.

Furthermore, the UBA provides expert advice and support for negotiations of National Emission Ceilings, POPs and heavy metal protocols. The information exchange and co-operation with the competent sections of the UBA facilitates the identification of key sources and possible gaps within the current emissions reporting.

Chapter 1.4 - Methods and Data Sources

This chapter elaborates some methodical issues concerning the inventory preparation process. In addition, it lists the main data sources used for emission calculation. It does not address the calculation methodologies on the detailed level, i.e. information on tiers and emission factors, these are discussed in the source-specific chapters. As a general rule, Germany uses many country-specific process information and emission factors where available.

Main data sources

The German air pollution emission inventory is based on a large number of sources and publications. Most of the time these are specific for certain source categories.

Energy

over-all and stationary combustion

For the **energy sector**, the most important data sources for determination of activity rates are the “Energiebilanzen der Bundesrepublik Deutschland” (Energy Balances of the Federal Republic of Germany, hereinafter referred to as: Energy Balance), which are published by the Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen, AGEB). An energy balance provides an overview of the links within Germany's energy sector, and it supports breakdowns in accordance with fuels and source categories. An energy balance receives data from a wide range of other sources. As a result, publication of energy balances is subject to some delay.

Along with the Energy Balance, the Working Group on Emissions Balances (AGEB) also publishes “Evaluation Tables for the Energy Balance” (Auswertungstabellen zur Energiebilanz (hereinafter referred to as: evaluation tables). In the area of fuels, these tables only list those fuels with the highest activity levels and aggregate lower activity levels to form sum values (such as other solid fuels). Breakdowns according to specific source categories are limited largely to source categories that consume final energy (such as manufacturing sector or transport). Some source categories are not listed (such as production of district heat). The evaluation tables are published relatively promptly (in the summer of the relevant subsequent year). The tables can be used to determine aggregated activities at the source category levels for the most commonly used fuels. Further disaggregation can be achieved via formation of relevant differences using other statistics.

mobile combustion

Basically, as already mentioned above, annual data on domestic fuel deliveries is available from (i) the National Energy Balances (as compiled by the Working-Group on National Energy Balances, AGEB) with the specific information on mineral-oil and its products coming from (ii) the Official Oil Data of the Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle - BAFA).

However, to further distribute and allocate the aggregated fuel deliveries onto the different mobile sources, a variety of models has been developed that are now used for computing the extensive basic data from generally accessible statistics, special surveys, and measurements.

For road transport (1.A.3.b), railways (1.A.3.c), and inland navigation (1.A.3.d ii) specific activity data and country-specific implied emission factors at least for regulated pollutants are calculated within TREMOD (“Transport Emission Estimation Model”; IFEU). Here, for 1.A.3.b, highly detailled data on annual mileage together with information on fleet composition and new-registration numbers are applied to to allocate the statistically recorded fuel sales to different vehicle types and classes as well as the individual Euro standards. A precise description of the data sources for emission factors used within TREMOD for road transport is provided by the "Handbook of Emission Factors for Road Transport" (version 4.2, 2022). For estimating emissions from civil aviation (1.A.3.a), specific fuel consumption data for domestic and international flights further distinguished into landing/take-off (L/TO) and cruise phase as well as corresponding implied emission factors are derived from TREMOD Aviaton (TREMOD AV), a standalone module of TREMOD using flight data from the German Statistical Office (Statistisches Bundesamt, DESTATIS). Another model (E.M.M.A. - Emission Modelling for Maritime Activities) is used for national and international maritime navigation, fishing (1.A.4.c iii) and military navigation (1.A.5.b iii) using ship-specific movement data (AIS) for estimating specific fuel consumptions and implied emission factors for domestic trips. Finally, for emissions from offroad vehicles and machinery as used in 1.A.2.g vii, 1.A.4.a ii, b ii and c ii, specific consumption data and

IEF are computed within TREMOD Mobile Machinery (TREMOD MM), yet another standalone module of the aforementioned TREMOD.

fugitive emissions from fuels

Data for calculating **fugitive emissions** principially originates from the Association Fuels & Energie (en2x) and the Federal association of the natural gas, oil and geothermal energy industries (BVEG).

Industrial Processes

Most industrial processes are covered by either the German Statistical Office (DESTATIS) or branch association publications. These reports are generally available in due time and do have low uncertainty ranges.

Data on product use is drawn from the same sources.

Collaboration between the UBA and DESTATIS have been set on solid ground by agreements of their respective “parent” authorities, the former Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU, currently BMUV) and the Federal Ministry of the Interior, Building and Community (BMI) respectively.

Agriculture

For agriculture, emissions calculations are carried out by the Thünen Institutes (TI). For calculation of agricultural emissions in Germany, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Food and Agriculture (BMEL) initated a suitable joint project, in the framework of which the former Federal Agricultural Research Institute (FAL) developed a modular model for relevant spread-sheet calculation (GASeous Emissions, GAS-EM). The BMU and BMEL now have a framework ministerial agreement in place for management of relevant data and information exchange and for operation of a joint database at the UBA and the vTI.

Waste

Finally, reports on waste and waste water again originate from publications by the German Statistical Office (DESTATIS).



More detailed information on data sources is found in the NFR-specific chapters of this report and in the German National Inventory Document (NID, see References).

Chapter 1.5 - Key Categories

The table below shows the key category analysis for the current reporting year. Dominant source categories vary largely for different pollutants. The key category analysis was carried out in accordance with the EMEP/UNECE guidebook for the base year (1990/1995/2000) and the actual year. Due to missing information on uncertainties, a tier 1 key category analysis was selected. Thus, the table gives “L” for category-pollutant combinations being key categories because of the high level of emissions. “T” indicates key categories resulting from trend analysis.

	Pollutant																								
Category Code	**NO_x**	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/F**	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAH1-4**	**HCB**	**PCBs**
1.A.1.a	**L/T**	-/-	**L/T**	-/-	**L/T**	**L/T**	**L/T**	-/-	**L/-**	-/-	**L/T**	**L/T**	**L/T**	**L/T**	**L/T**	**L/T**	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	**L/-**	**L/T**
1.A.1.b	-/-	-/-	**L/-**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	**L/-**	-/-	**L/-**	-/-	-/-	**L/-**	**L/T**	-/-	-/-	-/-	IE	IE	IE	-/-	-/-	-/-
1.A.1.c	**L/T**	-/-	**L/T**	-/-	**-/T**	**-/T**	**L/T**	-/-	-/-	-/-	**L/T**	**L/T**	**L/T**	**L/T**	**L/T**	**L/T**	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
1.A.2.a	**-/T**	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	IE	IE	-/-	NE	NE	NE	NE	NE	NE	-/-	-/-	NE	NE	NE	-/-	NA	NA
1.A.2.b	-/-	-/-	-/-	-/-	IE	IE	IE	IE	-/-	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1.A.2.c	IE: Energy-related emissions from power plants and boiler systems are reported in NFR 1.A.2.g vii whereas process related emissions aire reported in NFR 2.B.																									
1.A.2.d	IE: Emissions from power plants and boiler systems are reported in NFR 1.A.2.g viii whereas all process-related emissions as well as emissions from black liquor incineration are reported in NFR 2.H.1.																									
1.A.2.e	-/-	-/-	-/-	-/-	IE	IE	IE	IE	-/-	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA
1.A.2.f	-/-	-/-	-/-	-/-	IE	IE	IE	IE	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.A.2.g.vii	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	**L/-**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE
1.A.2.g.viii	**L/T**	-/-	**L/T**	-/-	**L/-**	-/-	**L/T**	-/-	-/-	-/-	**L/-**	**L/T**	**L/T**	**L/T**	**-/T**	**L/T**	-/-	**L/T**	**L/T**	**-/T**	IE	IE	IE	**-/T**	-/-	-/-
1.A.3.a.ii.(i)	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	NA	NA
1.A.3.a.i.(i)	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	NA	NA
1.A.3.b.i	**L/T**	**L/T**	-/-	-/-	**L/T**	**L/T**	-/-	**L/T**	**L/T**	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-
1.A.3.b.ii	**L/-**	-/-	-/-	-/-	**L/T**	**L/T**	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-
1.A.3.b.iii	**L/T**	-/-	-/-	-/-	**L/T**	**L/T**	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-
1.A.3.b.iv	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-
1.A.3.b.v	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.A.3.b.vi	NA	NA	NA	NA	**L/-**	**L/-**	**L/-**	**L/-**	-	**L/-**	-/-	NA	**L/-**	**L/-**	**L/T**	-/-	**L/-**	**L/T**	NA	-/-	-/-	NE	-/-	-/-	NA	NA
1.A.3.b.vii	NA	NA	NA	NA	**L/-**	**L/-**	**L/-**	NE	-/-	-/-	-/-	NA	-/-	-/-	-/-	-/-	NE	-/-	NA	NA	NA	NA	NA	NA	NA	NA
1.A.3.c	-/-	-/-	-/-	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	**L/-**	**L/-**	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
1.A.3.di(ii)	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1.A.3.d.ii	**L/-**	-/-	-/-	-/-	**L/T**	**-/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
1.A.3.e.i	-/-	-/-	-/-	NA	-/-	-/-	-/-	NE	-/-	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.A.3.e.ii	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/F**	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAH1-4**	**HCB**	**PCBs**
1.A.4.a.i	-/-	**L/T**	-/-	-/-	**L/T**	**L/T**	**L/T**	L-/-	**L/T**	**L/-**	-/-	-/-	**L/-**	-/-	-/-	-/-	NE	**L/T**	**L/-**	**L/-**	**L/-**	**L/-**	**L/-**	**L/-**	-/-	-/-
1.A.4.a.ii	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE
1.A.4.b.i	**L/-**	**L/T**	**L/T**	-/-	**L/T**	**L/T**	**L/T**	**L/-**	**L/T**	-/-	-/-	**L/-**	-/-	-/-	-/-	-/-	NE	**L/T**	**L/-**	**L/T**	**L/T**	**L/T**	**L/T**	**L/T**	**L/-**	**L/-**
1.A.4.b.ii	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	**L/-**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE
1.A.4.c.i	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
1.A.4.c.ii	**L/-**	-/-	-/-	-/-	**L/T**	**L/T**	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE
1.A.4.c.iii	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
1.A.5.a	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE	-/-	NE	NE	NE	NE	NE	NE	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE
1.A.5.b	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
1.B.1.a	NA	-/-	NA	NA	-/-	**-/T**	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.1.b	-/-	-/-	-/-	-/-	-/-	-/-	**L/T**	-/-	-/-	NA	NA	-/-	NA	NA	NA	NA	NA	NA	-/-	**L/T**	**-/T**	**-/T**	**-/T**	**-/T**	NA	NA
1.B.1.c	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.a.i	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.a.iv	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.a.v	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.b	-/-	-/-	-/-	NA	NA	NA	NA	NA	-/-	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.c	-/-	-/-	-/-	NA	-/-	-/-	-/-	-/-	-/-	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.d	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.1	-/-	-/-	-/-	-/-	**-/T**	**-/T**	-/-	NE	-/-	-/-	-/-	**L/-**	NE	NE	NE	NE	NE	NE	-/-	-/-	IE	IE	IE	-/-	-/-	-/-
2.A.2	-/-	-/-	-/-	IE	-/-	-/-	-/-	NE	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.3	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	NA	-/-	-/-	-/-	-/-	**L/T**	-/-	NA	NA	NA	NA	NA	NA	NA	NA
2.A.5.a	NA	NA	NA	NA	**L/-**	**L/T**	**L/-**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.5.b	NA	NA	NA	NA	-/-	**L/-**	**L/-**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.5.c	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
2.A.6	-/-	-/-	-/-	-/-	-/-	**-/T**	**L/-**	NA	IE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/F**	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAH1-4**	**HCB**	**PCBs**
2.B.1	-/-	NA	NA	-/-	NA	NA	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

2.B.2	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B.3	-/-	NA	NA	NA	NA	NA	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B.5	NA	NA	NA	NA	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B.6	-/-	NA	-/-	NA	NA	NA	-/-	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B.7	NA	NA	NA	-/-	NE	NE	-/-	NE	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B.10.a	NA	-/-	**L/-**	-/-	-/-	-/-	-/-	-/-	-/-	NA	NA	-/-	NA	NA	NA	NA	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA
2.B.10.b	NA	-/-	NA	NA	IE	IE	IE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.C.1	-/-	-/-	**L/-**	-/-	**L/T**	**L/T**	-/-	NE	**L/-**	**L/T**	**L/T**	**L/T**	NE	**L/T**	NE	-/-	NE	NE	**L/T**	NE	NE	NE	NE	**L/T**	**L/-**	**L/T**
2.C.2	NE	NE	NE	NA	-/-	-/-	-/-	NE	NE	NE	NE	NE	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.C.3	-/-	NE	-/-	NA	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	-/-	**-/T**	-/-	-/-	-/-	-/-	**L/T**	-
2.C.4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.5	NA	NA	-/-	NA	-/-	-/-	-/-	NE	NA	-/-	-/-	-/-	-/-	NA	-/-	NA	NE	-/-	-/-	NA	NA	NA	NA	NA	NA	**L/T**
2.C.6	NA	NA	-/-	NA	-/-	-/-	-/-	NE	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NE	**L/-**	-/-	NA	NA	NA	NA	NA	NA	**L/T**
2.C.7.a	NA	NA	-/-	NA	-/-	-/-	-/-	NE	NA	-/-	**L/T**	-/-	**L/-**	NA	-/-	NE	NE	-/-	-/-	NA	NA	NA	NA	NA	**L/-**	-
2.C.7.b	NE	NE	-/-	NE	NR	NR	-/-	NR	NE	NE	NE	NE	NE	NE	NE	-/-	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.C.7.c	NA	NA	NE	NA	-/-	-/-	**L/T**	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.C.7.d	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
2.D.3.a	NA	**L/-**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3.b	-/-	-/-	-/-	NA	-/-	-/-	-/-	NE	IE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE	NA	NA
2.D.3.c	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE	NA	NA
2.D.3.d	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3.e	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3.f	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3.g	NA	**L/-**	NA	NA	NA	NA	NA	NA	NA	NA	-/-	NA	NA	-/-	NA	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3.h	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3.i	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.G	-/-	**L/-**	-/-	-/-	**L/-**	**L/-**	-/-	-/-	-/-	-/-	**L/-**	NA	NA	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NA
	NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/F**	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAH1-4**	**HCB**	**PCBs**
2.H.1	-/-	-/-	-/-	NE	-/-	-/-	-/-	NE	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.H.2	NA	-/-	NA	NA	-/-	-/-	-/-	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.H.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.I	NA	-/-	NA	NA	-/-	-/-	-/-	NE	IE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.J	NO: There is no POP-production occuring in Germany.																									
2.K	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE
2.L	NA	NA	NA	NA	**L/-**	**L/T**	**L/T**	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.1.a	-/-	**L/-**	NA	**L/-**	**L/-**	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.1.b	-/-	**L/T**	NA	**L/T**	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.2	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.3	-/-	-/-	NA	**L/T**	-/-	-/-	**L/-**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.4.a	IE	IE	NA	IE	IE	IE	IE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.4.d	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.4.e	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.4.f	IE	IE	NA	IE	IE	IE	IE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.4.g.i	-/-	-/-	NA	-/-	-/-	-/-	**L/-**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.4.g.ii	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.4.g.iii	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.4.g.iv	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.4.h	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.1	**L/T**	NA	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.a	**L/-**	IE	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.b	-/-	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.c	-/-	NA	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.3	-/-	IE	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/F**	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAH1-4**	**HCB**	**PCBs**
3.D.a.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.c	NA	NA	NA	NA	**L/-**	**L/-**	**L/-**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.d	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.e	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.f	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**-/-**	NA	
3.F	NO: Field burning of agricultural residues is not occuring in Germany.																									
3.I	-/-	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.A	NA	-/-	NA	NA	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B.1	NA	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B.2	NA	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.C.1.a	NO																									
5.C.1.b.i	NO																									
5.C.1.b.ii	NO																									

5.C.1.b.iii	NO																								
5.C.1.b.iv	NO																								
5.C.1.b.v	-/-	-/-	-/-	NA	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	NE	NE	NE	NE	NE	NE	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-
5.C.1.b.vi	NO																								
5.C.2	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE
5.D.1	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.D.2	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.D.3	NO																								
5.E	NE	NE	NE	NE	**L/-**	**L/-**	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE	NE	**L/-**	NE	NE	NE	NE	NE	NE	NE
6.A	NA	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Qualitative criteria to identify Key Categories

According to guidebook section 2.4.3 parties to the convention have to assess qualitative criteria to identify key categories. The German inventory has been carefully checked and it was found that no additional categories need to be marked as key categories.

Key Categories and Inventory Improvements

The results of the KCA, as presented above, are carefully checked each year and are an integral part of both the inventory planning and the QA/QC activities. Key categories receive greater attention when quality control measures are taken and their methods are regularly checked for appropriateness. Where needed, key categories are more likely to have research funded that aims at moving them to a higher tier method.

Chapter 1.6 - QA/QC and Verification Methods



The Quality System for Emission Inventories and it´s contribution to UNECE/CLRTAP reporting

The German Quality System for Emission Inventories (QSE) originally was designed to serve the purposes of emission reporting under the UN Framework Convention on Climate Change (UNFCCC).

It takes account of provisions of the **2006 IPCC (Intergovernmental Panel on Climate Change) Guidelines, Volume 1, Chapter 6: General Guidance and Reporting (GGR)** [1)], of national circumstances in Germany and of the internal structures and procedures of the German Environment Agency (UBA), the reporting institution.

Thus it can be assumed that by adopting the IPCC Guidelines, the UNECE/CLRTAP seriously facilitated the task of developing a QC/QA system for the reporting of air pollutants. It is likely that all QSE procedures are flexible enough to be able to routinely incorporate these demands in the future as well.

The QSE is designed to cover all participants of the National System on Emissions (NaSE) which are mostly identical to those responsible for the reporting of air pollutants.

Within the German Federal Environment Agency (UBA), the appliance of the QSE and its procedures has been made mandatory for UNFCCC reporting by an internal directive (UBA-Hausanordnung 11/2005). The adoption of the QSE´s approach will be useful for CLRTAP reporting too but its implications have to be considered carefully (mostly due to human resources), which is why the appliance of QSE procedures is partly outstanding. Currently few parts are used for reporting under CLRTAP, (see below, “Current State”).

The requirements pertaining to a system for quality control and quality assurance (QC/QA system) and to measures for quality control and quality assurance are defined primarily by Chapter 6 of the 2006 IPCC GL, Volume 1: GGR [2)].

From those provisions, the German Environment Agency derived **“General requirements pertaining to quality control and quality assurance in connection with greenhouse-gas-emissions reporting”**. It is assumed that these requirements completely apply for CLRTAP reporting, too. Therefore, they are briefly given in the following to depict the necessary though partly outstanding trail of action for the development of a consistent QC/QA system under UNECE/CLRTAP.

Main demands

The 2006 IPCC Guidelines require that QC/QA systems be introduced with the aim of enhancing transparency, consistency, comparability, completeness, accuracy and timeliness and, especially, that such inventories fulfill requirements pertaining to “good inventory practice”.

A QC/QA system comprises the following:

- an agency responsible for coordinating QC/QA activities,
- development and implementation of a QC/QA plan,
- general QC procedures,

- source-category-specific QC procedures,
- QA procedures,
- verification activities,
- reporting procedures,
- documentation and archiving procedures

Agency responsible for coordinating QC/QA activities

A Single National Entity (national coordinating agency) is responsible for the QC/QA system.

The German Single National Entity is established in the German Environment Agency (Umweltbundesamt - UBA). In executing its function, it is good practice to establish the position of a coordinator for the Quality System to be developed. A QC/QA coordinator has responsibility for ensuring that a relevant QC/QA system is developed and implemented. Such implementation should be suitably institutionalised – for example by means of an in-house directive or association agreements.

QC/QA plan

The purpose of a QC/QA plan is to ensure that QC/QA measures are properly organised and executed. It includes a description of all required QC/QA measures and a schedule for implementation of such measures. It also defines the primary emphasis of such measures.

Good practice calls for establishing a QC/QA plan and then reviewing and updating it each year after the latest inventory has been prepared. On the basis of the results of annual inventory review, the results of QC/QA measures and other informations of which it is aware, the Single National Entity aims to prepare an improvement plan for the entire inventory. On this basis, in turn, it will then derive proposals for a binding inventory plan for the next year to be reported.

General quality control

Pursuant to the definition used by the 2006 IPCC GL (Volume 1: Chapter 6.1)[3)], quality control (QC) comprises a system of routine specialised measures for measuring and checking the quality of inventories in preparation.

Requirements pertaining to general (formerly so called Tier-1) QC procedures can be derived from the requirements mentioned in Chapter 6.6, especially Table 6.1 which includes a complete list of general QC measures.

Required quality controls and their results should be recorded and not all quality controls have to be carried out on an annual basis. It should be ensured that all source categories undergo detailed quality control at least periodically.

Source-category-specific quality control

In addition to undergoing general procedures, particularly relevant source categories (such as key sources), available resources presupposed, should undergo category specific (formerly so called Tier2) quality control with regard to determination of activity data, emissions and uncertainties (cf. Chapter 6.7; GGR).

The chapters of the 2006 IPCC GL that pertain to the various individual source categories (Volumes 2 to 5) include additional information relative to source-category-specific QC measures. Such guidelines should be considered in preparation of a QC/QA plan.

Quality assurance procedures

While the primary aim of quality control is to ensure that methods are correctly applied, the primary purpose of quality assurance is to examine methods and data as such and improve or correct it as necessary.

Pursuant to the relevant IPCC definition (Chapter 6.1; GGR), measures for quality assurance (QA) are based “on a planned system of reviews by persons who are not directly involved in preparing the inventory. Such reviews – which are best carried out by independent third parties – should be applied to completed inventories, after QC procedures have been carried out.

The required instrument for quality assurance is the annual “basic” peer review, though additional audits on “strategic points of the inventory” should also be conducted.

Verification activities

According to the **Chapter 6.10** of Volume 1 - General Guidance and Reporting of the 2006 IPCC Guidelines, “verification activities” refer to emission estimates only.

Verification activities for emission factors and activity data are subsumed under the headword and chapter “quality control”, which is a somewhat confusing approach. Nevertheless, and by leaving this peculiarity aside, verification, next to QC, is undoubtedly one key to ensure confidence and reliability of the estimates, corresponding emission factors and activity data.

Reporting procedures

The Single National Entity is responsible for initiating, coordinating and globally organising reporting. Provision of data and reports by third parties must conform to applicable requirements pertaining to the scope, form and scheduling for such provision.

Documentation and Archiving

As a general requirement, all data and information used for inventory calculation must be documented (i.e. recorded) and archived, for each report year. The purpose of such documentation (i.e. recording) is to make it possible to completely reconstruct all emissions calculations. The general requirements pertaining to documentation and archiving for the entire process of of inventory preparation are described in Chapter 6.10.1 of the 2006 IPCC GL GGR.

Consequently, **data providers** have the obligation to keep records information relative to data they supply to the UBA for purposes of inventory calculations.
Information to be recorded by the institution supplying the pertinent data include:

- the types of quality control,
- the dates on which those measures were carried out,
- the pertinent results,
- and
- the corrections and modifications triggered by quality control measures.

Providers of emissions calculations are obliged to record the calculation methods and the rationale for their appliance. Calculation models, -files and -software, as well as the assumptions and criteria for the appliance of activity data and emission factors and their references have to be archived.

Moreover, quality assurance (QA) and confidentiality issues for data secrecy have to be archived.

Current state

Information regarding the UBA's current organisational measures for implementing the requirements given above is provided in the following.

Structural organisation - Role concept

Within the QSE framework, a concept was developed that defines binding responsibilities inside the German Environment Agency for the implementation of the necessary QC and QA measures.

The purpose of defining roles and responsibilities is to facilitate the effective information exchange and the directive-conformal execution of QC and QA.

The following roles are also used for reporting under CLRTAP but not yet on the same mandatory basis as established for GHG reporting.

Specialised expert at the operational level (FV)

- source (NFR) specific expert
- tasks: compilation and entry (into the CSE) of activity data (AD)

Quality control manager (QKV)

- superior of the FV
- tasks: checking and approving of activity data

Specialized contact person (source-category specific, FAP)

- member of the Single National Entity
- tasks: checking of AD, compiling emission factors; data entry (into CSE) & calculation; preparation of texts; facilitation of specialised and technical support (inventory work and reporting).

IIR co-ordinator (IIRK)

- member of the Single National Entity
- tasks: co-ordination of IIR editing; establishing the framework for preparation of the IIR from the various relevant contributors.

CSE co-ordinator (ZSEK)

- member of the Single National Entity
- tasks: ensuring database integrity; compilation of NFR tables

NaSE co-ordinator (NaSEK)

- member of the Single National Entity
- tasks: co-ordination of reporting activities; final emissions reporting (upload of IIR & NFR tables to CDR).

QSE co-ordinator (QSEK)

- member of the Single National Entity
- tasks: co-ordination of entire QSE and QA/QC activities; provision of QSE checklists.

Current workflow management

The workflow specified by the QSE is also applied for activity data and, additionally, emission factors for NFR 3 - Agriculture.

However, in contrast to UNFCCC GHG reporting, no administrative agreement with the data-providing institution is in place yet.

Moreover, these parts of the adopted design are altered to serve the purposes of UNECE/CLRTAP reporting in the present state. For example, FVs are currently responsible for compiling, entry (into the CSE data base) and, if necessary, the calculating of activity data but, in contrast to GHG reporting under UNFCCC, not for compiling of emission factors.

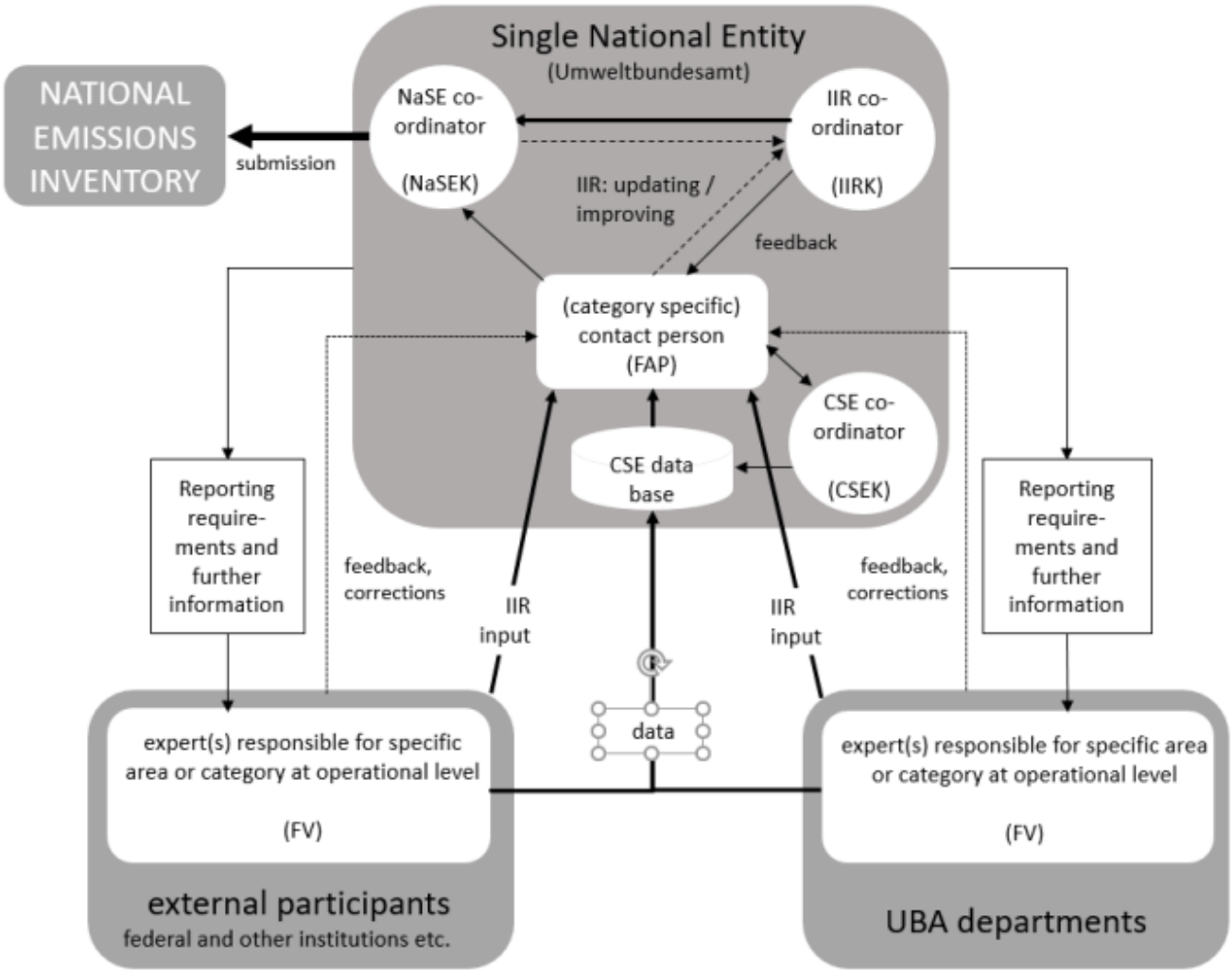


Figure: QSE – Roles, responsibilities and workflow

General and category-specific quality control (QC)

As all activity data (except for the handling of bulk products) are also applied for UNFCCC GHG reporting, the same general and category-specific quality control of the QSE is already in force for activity data within the UNECE/CLRTAP reporting.

The quality of these activity data is supervised by the appliance of QC checks via special QSE checklists mandatory for all partcipants. The QSE checklists cover the set of general QC measures given in Table 6.1 of the 2006 IPCC GL GGR plus additional category-specific measures for key-category-specific quality control.

The QSE checklists are to be filled in annually throughout the whole inventory regardles whether or not a specific NFR category is a key source for emissions and by FV, FAP, and QKV consecutively.

Quality assurance (QA)

Data, methods and estimates are generally derived by staff (FV) who are not member of the Single National Entity (see “Structural organisation - Role concept”). The quality-related activities to be performed by the FV are limited to quality

control (QC).

QA tasks are to be performed by the following roles, starting with the QKV (internal QA). The tasks are given within the already mentioned consecutive and successive QSE checklists for FV, QKV and FAP relying on reviewing and checking of finalized estimates and data. Within these checklists, each role/participant has it's own set of QA checks.

The FAP, as a member of the Single National Entity, is the first role that is not directly involved in activity data preparation (external QA) so a “basic annual peer review” is conducted by the FAP. QA independence is guaranteed henceforward.

The QA checks are carried out annually and for the entire emissions inventory.

More intense peer reviews are undertaken whenever necessary and are performed by national experts and, in most cases, conducted by means of a national workshop.

As mentioned above, as all activity data (except for the handling of bulk products) are also applied for UNFCCC reporting, the same QA procedures are already in force for activity data within the UNECE reporting.

[1)], [2)], [3)] IPCC (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 1, General Guidance and Reporting: Chapter 6 - Quality Assurance/Qualitiy Control and Verification; https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_6_Ch6_QA_QC.pdf

Chapter 1.7 - General Uncertainty Evaluation

Introduction



Uncertainties are a key part of any emission inventory effort. Recording and assessing the inevitable errors made in estimating emissions allows for the inventory team to direct their attention as well as for the public and the scientific community to work with the results presented. Germany employs the statistical approaches as defined in the EMEP/EEA Guidebook to evaluate its inventory's uncertainties. The Guidebook offers two methods for the combination of individual source uncertainties to the level of categories and national totals, namely error propagation (EP, tier 1) and Monte Carlo simulation (MC, tier 2). Although Germany presents all results from both approaches here, the MC values are generally considered to represent the actual confidence interval more precisely.

An important aspect of an uncertainty analysis concerns the ways on how to express the uncertainties associated with individual estimates or the total inventory. It is recommended to use the same quantity to express uncertainty in a LRTAP Convention inventory as required in a greenhouse gas inventory, namely the 95% confidence interval. The confidence interval is specified by the confidence limits defined by the 2.5 percentile and 97.5 percentile of the cumulative distribution function of the estimated quantity, that means that there is a 95% probability that the actual value of the quantity estimated is within the interval defined by the confidence limits. For a normal distribution, the 95% confidence interval lies between ±2 standard deviations around the mean.

The data presented in this chapter are derived from the work of the emissions inventory experts contributing to the German emission inventory, who picked a confidence interval and a probability distribution function for each of the ~2,000 activity data and ~20,000 emission factor time series employed. In practice, every time series receives a metadata record in the database comprised of upper limit, lower limit and distribution function as well as an uncertainty information source reference (e.g. EEA/EMEP GB 2019, other literature or expert judgement). However, while uncertainties are currently considered separately for each individual time series, they remain static for each series across years. On this basis, the combination approaches described above are used to derive uncertainty information at the level of categories and national totals.

Uncertainty overview

Germany currently reports detailed uncertainty information for five pollutants: NO_x, SO_2, NMVOC, NH_3 and $PM_{2.5}$. While

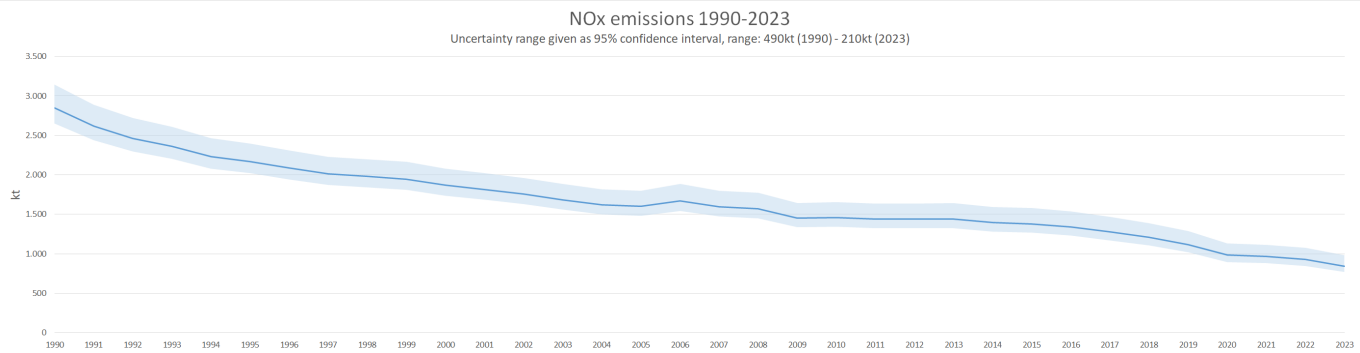
detailed spreadsheet tables are available for download below, the following table offers a quick overview and comparison per pollutants at the level of the national totals:

	Base year [kt]	2023 [kt]	Trend [%]	Method	Base year uncertainty [%]		2023 uncertainty [%]		Trend uncertainty [%]	
NO_x	2,846	845	-70.3	EP	±10.9		±16.1		±8.8	
				MC	-6.8	+10.4	-8.9	+15.9	-8.3	+11.2
SO_2	5,461	217	-96.0	EP	±8.7		±8.2		±1.4	
				MC	-8.0	+9.0	-6.9	+7.2	-1.5	+1.6
NMVOC	3,954	975	-75.3	EP	±17.9		±35.7		±20.7	
				MC	-9.9	+16.4	-16.7	+33.1	-15.5	+25.2
NH_3	834	569	-31.8	EP	±10.3		±10.2		±10.2	
				MC	-9.6	+10.1	-8.9	+9.5	-50.4	+55.8
$PM_{2.5}$	197	77	-60.8	EP	±14.3		±27.2		±15.1	
				MC	-9.1	+10.9	-17.5	+20.8	-13.2	+15.7

Uncertainties per pollutant

The sections below detail pollutant specific uncertainty interpretations and show the values in the context of the pollutant's emissions and trends.

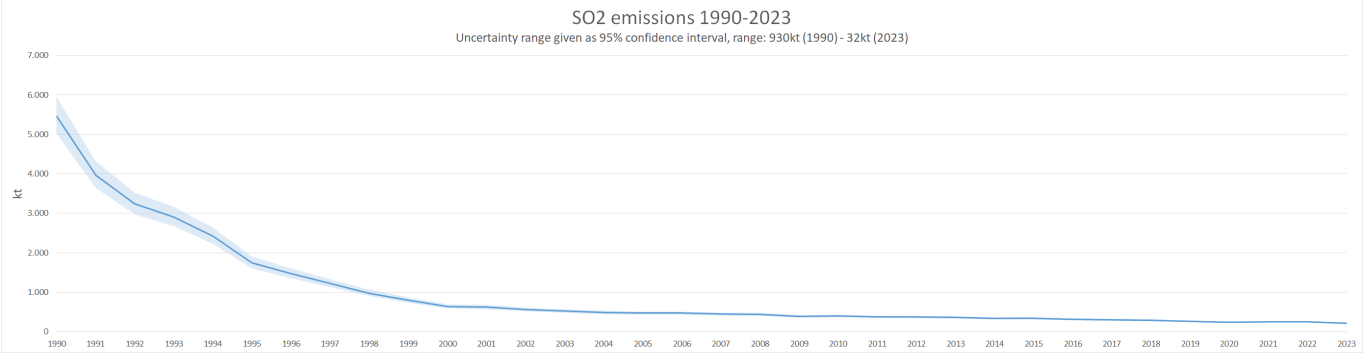
NOx



Compared to other pollutants, NO_x emission uncertainties are moderate. The national total has a 95% confidence interval of about -8.9% to +15.9% in 2023, which amounts to about 210kt of NO_x. Interestingly, with NO_x, the differences between the two approaches in uncertainty combination (EP and MC) are particularly visible. This is because of the highest contributing sector 3.D - Agricultural Soils, where emissions and uncertainties are high (> +200%) and, crucially, do not follow a normal distribution. Therefore, only the MC simulation, which takes the log-normal distribution of these emissions into account, correctly reflects this source, while the EP yields unrealistic high uncertainties at about 15.2% in both directions.

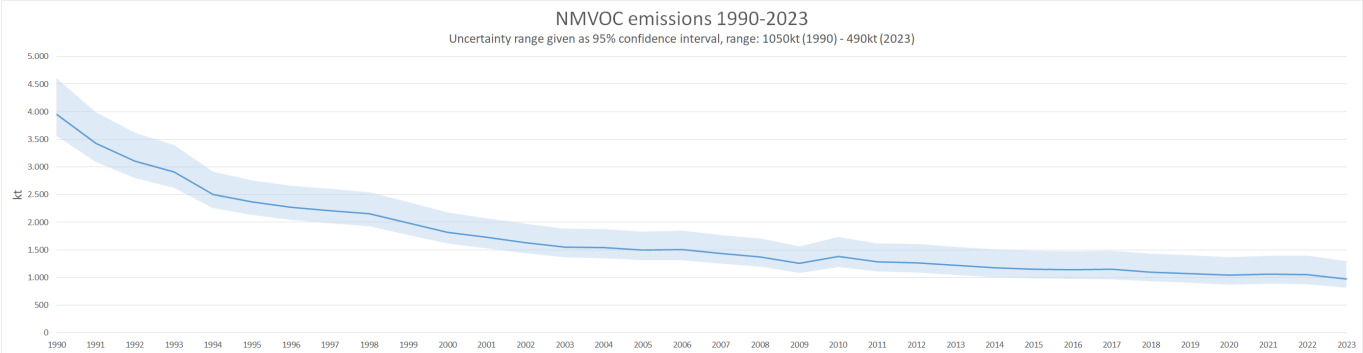
Using the MC simulation, the top three contributors to the overall uncertainty are 3.D.a.1 - Inorganic N-fertilizers, 3.D.a.2.a - Animal manure applied to soils and 3.D.a.2.c - Other organic fertilisers applied to soils. 1.A.3.b i - Road transport: Passenger cars and 1.A.4.b.i - Residential: Stationary are other important sector in regard to NO_x overall uncertainties. Please refer to the spreadsheet file for details.

SO2



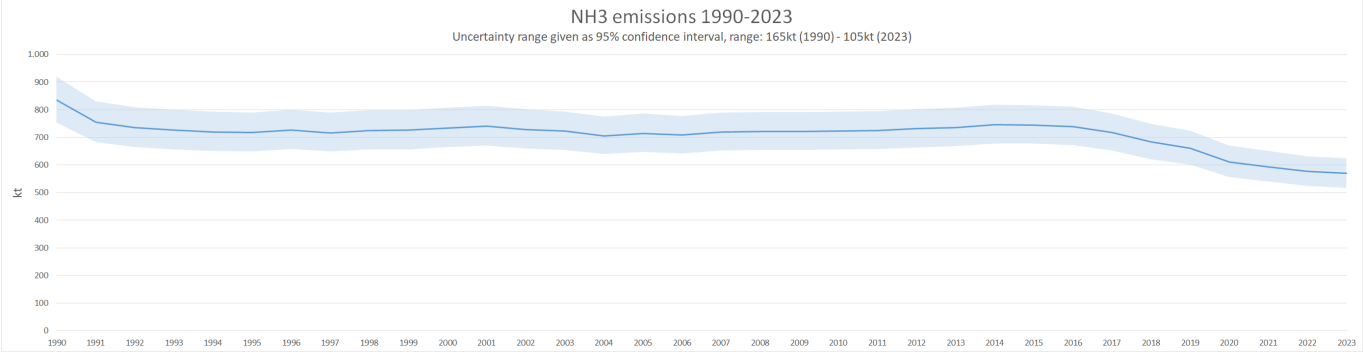
SO_2 emissions are mainly emitted by stationary combustion plants. Since those are heavily regulated and fuel sulphur contents are generally well known, uncertainties in SO_2 emissions are low. The national total has a 95% confidence interval of about -6.9% to +7.2% in 2023, which amounts to about 32kt of SO_2. The top contributing sector to the SO_2 uncertainties is 1.A.1.a - Public Electricity And Heat Production, followed by a rather big margin by 1.A.1.b - Petroleum Refining, 1.A.4.b i - Residential: Stationary Combustion, as well as 2.C.1 - Iron and Steel Production. All data is available in the spreadsheet file.

NMVOC



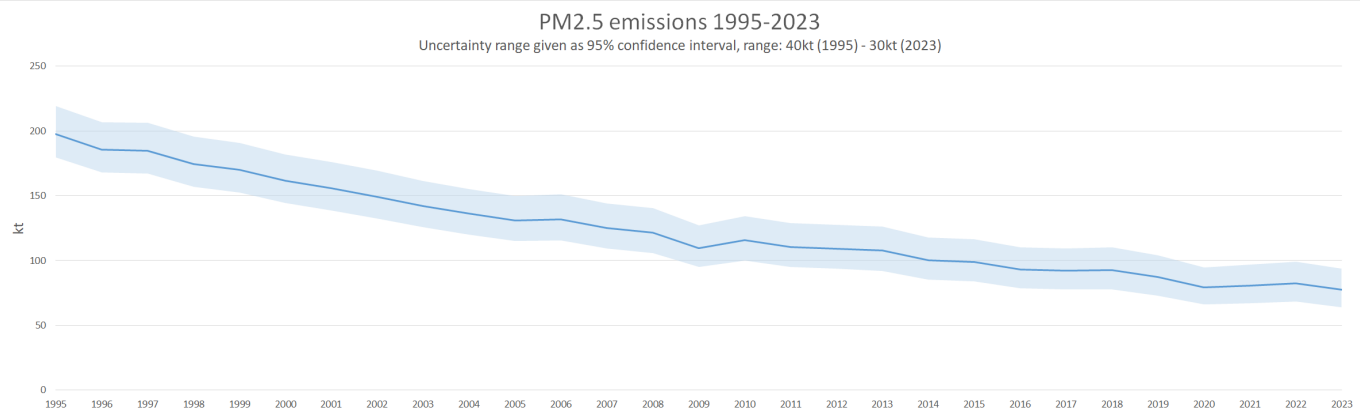
NMVOC emissions and trends are driven by solvent use. While solvent contents of most products are well known, application context and use statistics introduce significant model error bars. Agriculture emissions of NMVOC are, while not very high in value, very uncertain and also contribute to the overall error margins. In sum, NMVOC emissions show moderate to high uncertainty. The national total has a 95% confidence interval of about -16.7% to +33.1% in 2023, which amounts to about 490kt of NMVOC. In order of significance, the top five contributors are 3.B - Manure Management - Dairy cattle, 3.B.1.b Manure management - Non-dairy cattle, 2.D.3.a - Domestic Solvent Use, including Fungicides, 1.A.4.b.i - Residential: Stationary Combustion as well as 2.D.3.d - Coating Application. As with the other pollutants, details are to be found in the spreadsheet file.

NH3



Uncertainty in the NH_3 emission national total is moderate and mainly caused by agriculture sources, in particular 3.D.a.2.a - Animal manure applied to soils. 3.B.3 - Manure management - Swine, 3.B - Manure Management - Dairy cattle and 3.D.a.1 - Inorganic N-fertilizers do also play significant roles. The national total has a 95% confidence interval of about -8.9% to +9.5% in 2023, which amounts to about 105kt of NH_3. You can drive your own analysis with the numbers found in the spreadsheet file attached.

PM2.5



$PM_{2.5}$ emissions are associated with high uncertainties. The national total has a 95% confidence interval of about -17.5% to +20.8% in 2023, which amounts to about 30kt of $PM_{2.5}$. Three sectors contribute the bulk of these errors: 1.A.4.b.i - Residential: Stationary Combustion, 2.L - Other production, consumption, storage, transportation or handling of bulk products and 3.D.3 - Farm-level Agricultural Operations. Germany is also one of the few countries that reports abrasion under 1.A.3.c - Transport: Railways, adding noticeably to both emission values and uncertainties. Please refer to the spreadsheet file for details.

Other pollutants

There is currently no uncertainty assessment for additional air pollutants, heavy metals and POPs. Germany seeks to expand the list of pollutants covered as resources allow.

Chapter 1.8 - General Assessment of Completeness

Introduction

The German inventory is generally complete regarding the main pollutants, TSP, particulate matter and CO. National total emissions of these pollutants are considered to be representative and to reflect the current emissions situation. Nevertheless, there are some cases where no appropriate method or data is available. It is assumed that these cases do not have a noticeable effect on the national totals and are in the range of its uncertainties.

In terms of heavy metals and POPs, the situation is different due to the low data availability. As additional information, there is a specific overview on the completeness of the German POP inventory available.

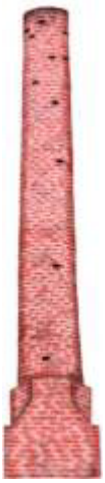
Germany does not report any emission data for years prior 1990. Due to the split into the German Democratic Republic and the Federal Republic of Germany before 1990, there are no consistent data sets covering what is now the re-united country. Germany has no plans to work on emission inventories for the years 1980 to 1989 in the future. However, some summarizing information on the time span 1970 to 1989 is presented below, also comparing these data to the current emission inventory.

Completeness in detail

The completeness of the German inventory as a whole has also been assessed by multiple reviews, both under the CLRTAP and the NECD. These reviews all confirm the good coverage of the German inventory. Where there are small omissions, Germany is working continuously to update and complete its data.

The following sections reflect on a few approaches, by source category, for improving the completeness of the inventory.

Fuel combustion



In principle, all combustion-related activities (1.A) are recorded in full within the National Energy Balance (NEB) of the Federal Republic of Germany. Nonetheless, where it is evident that complete coverage is not achieved for certain sub-sectors (i.e. non-commercial use of wood, waste fuels), the NEB is supplemented with further statistical data, surveys etc. Moreover, there are frequent changes within the NEB, in particular concerning renewable energies. Such changes in fuel and source categories require considerable research work. Insofar, it's not always possible to implement all data in time. However, based on current information, combustion related activity data can be considered complete.

This also applies for the main pollutants, particulate matter and CO. There may be cases, where a further breakdown of activity data and emission factors would be more appropriate to represent any specific technology. In such cases, where the share of a specific technology is very small, the influence of a missing sub-division on the national totals is considered small, too.

In some source categories, separation of combustion-related and non-combustion-related emissions from industry requires

further verification. In general, for such categories, avoidance of double counting is an important part of quality assurance.

In terms of heavy metals and POPs, emissions are not yet complete in some sectors due to a lack of appropriate emission factors. Since they may not properly reflect the situation in Germany and in order to avoid inconsistencies within the German inventory as a whole, it is not always advisable to use default emission factors. In addition, fixed default EFs do not reflect the influence of technological developments onto the trends of certain emissions. Nevertheless, many country-specific emission factors (which are highly uncertain) are available for all combustion plants. All key categories are reported.

Industrial processes

In the area of industrial processes, for the application of higher tier approaches some use is made of production data from association statistics and of manufacturers' information. In the interest of the inventory's completeness and reliability those data sets get specific QA/QC procedures. The inventory is considered complete for the main industrial processes.

Agriculture

In the area of agriculture, while survey data from a past research project on management systems in animal husbandry are available, an effort is being made to carry out periodic, representative data surveys, in the interest of the inventory's continuing completeness and consistency.

Explanation on the use of notation keys

The use of notation keys in the German inventory is carefully checked each year. All notation keys are used as defined in the guidance documents.

The following tables from the CLRTAP Stage 1 Reviews 2022 and 2023 give a good indication on where and how frequently notation keys are used in Germany's air polltutant reporting.

Though NEs are great in number, the actual emission behind each of the notation keys is estimated to be very small. In some cases, it is actually used instead of NA to make absolutely sure to be on the conservative side of the estimate.

Germany is working continuously to decrease the number of notation keys used and has already made good progress in this regard. The comparison shows that the number of NE notations used in the inventory could be reduced for almost all reported pollutants. However, this is mainly due to two facts:

- For *NFR 1.A.2.b*, all NE notations have been replaced by IE.

and

- The entire *NFR 2.J - Production of POPs* is reported as not occuring in Germany now and all NE have been replacd by NO notations.

Component	% Value	% 0	% NO	% NE	% NA	% IE	% C	% NR	% All
NOx	48.0	0.0	6.0	3.0	38.0	5.0	0.0	0.0	100.0
NMVOC	55.0	0.0	6.0	5.0	29.0	5.0	0.0	0.0	100.0
SOx	36.0	0.0	6.0	3.0	51.0	3.0	0.0	0.0	100.0
NH3	42.0	0.0	6.0	4.0	43.0	5.0	0.0	0.0	100.0
PM2.5	51.0	0.0	6.0	4.0	30.0	9.0	0.0	0.0	100.0
PM10	51.0	0.0	6.0	3.0	31.0	9.0	0.0	0.0	100.0
TSP	53.0	0.0	6.0	2.0	30.0	9.0	0.0	0.0	100.0
BC	23.0	0.0	6.0	22.0	45.0	4.0	0.0	0.0	100.0
CO	33.0	0.0	6.0	3.0	52.0	6.0	0.0	0.0	100.0
Pb	27.0	0.0	6.0	6.0	57.0	5.0	0.0	0.0	100.0
Cd	28.0	0.0	6.0	6.0	56.0	5.0	0.0	0.0	100.0
Hg	28.0	0.0	6.0	6.0	56.0	3.0	0.0	0.0	100.0
As	23.0	0.0	6.0	8.0	60.0	3.0	0.0	0.0	100.0
Cr	22.0	0.0	6.0	7.0	61.0	3.0	0.0	0.0	100.0
Cu	23.0	0.0	6.0	8.0	60.0	3.0	0.0	0.0	100.0
Ni	22.0	0.0	6.0	8.0	61.0	3.0	0.0	0.0	100.0
Se	17.0	0.0	6.0	12.4	61.0	3.0	0.0	0.0	100.0
Zn	22.0	0.0	6.0	9.0	60.0	3.0	0.0	0.0	100.0
DIOX	26.0	0.0	6.0	3.0	61.0	3.0	0.0	0.0	100.0
PAH	24.0	0.0	6.0	5.0	62.0	2.0	0.0	0.0	100.0
HCB	11.7	0.0	6.0	11.4	68.9	2.0	0.0	0.0	100.0
PCB	15.0	0.0	6.0	10.0	66.0	2.0	0.0	0.0	100.0

Overview from CLRTAP Stage1 Review 2022

Component	% Value	% 0	% NO	% NE	% NA	% IE	% C	% NR	% All
NOx	48.0	0.0	7.0	2.0	38.0	5.0	0.0	0.0	100.0
NMVOC	55.0	0.0	7.0	4.0	28.0	6.0	0.0	0.0	100.0
SOx	36.0	0.0	7.0	2.0	51.0	3.0	0.0	0.0	100.0
NH3	43.0	0.0	7.0	3.0	43.0	5.0	0.0	0.0	100.0
PM2.5	51.0	0.0	7.0	3.0	30.0	9.0	0.0	0.0	100.0
PM10	51.0	0.0	7.0	2.0	31.0	9.0	0.0	0.0	100.0
TSP	53.0	0.0	7.0	2.0	30.0	9.0	0.0	0.0	100.0
BC	23.0	0.0	7.0	19.0	46.0	6.0	0.0	0.0	100.0
CO	34.0	0.0	7.0	2.0	52.0	6.0	0.0	0.0	100.0
Pb	27.0	0.0	7.0	4.0	57.0	5.0	0.0	0.0	100.0
Cd	28.0	0.0	7.0	4.0	57.0	5.0	0.0	0.0	100.0
Hg	30.0	0.0	7.0	4.0	55.0	4.0	0.0	0.0	100.0
As	23.0	0.0	7.0	6.0	61.0	4.0	0.0	0.0	100.0
Cr	22.0	0.0	7.0	6.0	61.0	4.0	0.0	0.0	100.0
Cu	23.0	0.0	7.0	6.0	61.0	4.0	0.0	0.0	100.0
Ni	22.0	0.0	7.0	6.0	61.0	4.0	0.0	0.0	100.0
Se	17.0	0.0	7.0	13.0	59.0	4.0	0.0	0.0	100.0
Zn	22.0	0.0	7.0	6.0	61.0	4.0	0.0	0.0	100.0
DIOX	26.0	0.0	7.0	2.0	61.0	3.0	0.0	0.0	100.0
PAH	24.0	0.0	7.0	3.0	62.0	3.0	0.0	0.0	100.0
HCB	11.6	0.0	7.0	9.0	69.0	3.0	0.0	0.0	100.0
PCB	15.0	0.0	7.0	9.0	66.0	3.0	0.0	0.0	100.0

Overview from CLRTAP Stage1 Review 2023

As for categories, NE notations are used mainly in **Industrial Processes** and **Waste** (please refer to section 1c of the review report 2022 for details). (The correspondig report for 2023 is not yet publically avilable) Each use is individually justified in the corresponding source category sections of this report as well as in the table below.

NFR categories reported as 'not estimated' ('NE')

NFR category	pollutants effected	explanation / reasoning
1.A.1.b	HCB, PCBs	no country-specific EF at hand; notation key 'NE' provided in EMEP/EEA GB 2023, Chapter 1.A.1 Energy industries 2023
1.A.1.c	HCB (as of 2012), PCBs	no country-specific EF at hand; notation key 'NA' provided in EMEP/EEA GB 2023, Chapter 1.A.1 Energy industries 2023 –> implementation will be checked
1.A.2.a	BC, Pb, Cd, As, Cr, Cu, Ni, Se, Zn, B[b]F, B[k]F, I[1,2,3-c,d]P	no country-specific tier2 EFs at hand; notation key 'NE' provided in EMEP/EEA GB 2023, Chapter 1.A.2 Combustion in manufacturing industries and construction 2023 , Tables 3-7 to 3-12

NFR category	pollutants effected	explanation / reasoning
1.A.2.e	Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, B[a]P, B[b]F, B[k]F, I[1,2,3-c,d]P	only emissions from process-combustion in sugar industry reported here with no country-specific tier2 EF at hand; only tier1 default EF provided EMEP/EEA GB 2023, Chapter 1.A.2 Combustion in manufacturing industries and construction 2023 , Tables 3-2
1.A.2.g vii	HCB, PCBs	no country-specific EF at hand; no default provided in EMEP/EEA GB 2023, Chapter 1.A.4 Non road mobile machinery 2023
1.A.3.a i(i)	PCDD/F	no country-specific EF at hand; no default provided in EMEP/EEA GB 2023, Chapter 1.A.3.a Aviation 2023
1.A.3.a ii(i)	PCDD/F	no country-specific EF at hand; no default provided in EMEP/EEA GB 2023, Chapter 1.A.3.a Aviation 2023
1.A.3.b i-iv	HCB	no country-specific EF at hand; no default provided in EMEP/EEA GB 2023, Chapter 1.A.3.b.i-iv Road transport 2023
1.A.3.b vi	B[k]F	no country-specific EFs at hand; no defaults for BC provided in EMEP/EEA GB 2023, Chapter 1.A.3.b.vi-vii Road tyre and brake wear 2023
1.A.3.b vii	Hg, Se as of 2000: BC	no country-specific EFs at hand; no defaults for BC provided in EMEP/EEA GB 2023, Chapter 1.A.3.b.vi-vii Road tyre and brake wear 2023
1.A.3.e i	as of 2000: BC	no EF provided in EMEP/EEA GB 2023 Table 2-1: Tier 1 emission factors for pipeline transport
1.A.4.a i	Se	several EFs provided in EMEP/EEA GB 2023, Chapter 1.A.4 Small combustion 2023 –> implementation will be checked
1.A.4.a ii	HCB, PCBs	no country-specific EF at hand; no default provided in EMEP/EEA GB 2023, Chapter 1.A.4 Non road mobile machinery 2023
1.A.4.b i	Se	several EFs provided in EMEP/EEA GB 2023, Chapter 1.A.4 Small combustion 2023 –> implementation will be checked
1.A.4.b ii	HCB, PCBs	no country-specific EF at hand; no default provided in EMEP/EEA GB 2023, Chapter 1.A.4 Non road mobile machinery 2023
1.A.4.c i	Se	several EFs provided in EMEP/EEA GB 2023, Chapter 1.A.4 Small combustion 2023 –> implementation will be checked
1.A.4.c ii	HCB, PCBs	no country-specific EF at hand; no default provided in EMEP/EEA GB 2023, Chapter 1.A.4 Non road mobile machinery 2023
1.A.5.a	Pb, Cd, As, Cr, Cu, Ni, Se, Zn, PCBs	several EFs provided in EMEP/EEA GB 2023, Chapter 1.A.4 Small combustion 2023 –> implementation will be checked
2.A.1	As, Cr, Cu, Ni, Se, Zn as of 2000: BC	no appropriate EFs available
2.A.2	Pb, Cd as of 2000: BC	no appropriate EFs available
2.B.3	$PM_{2.5}$	no country-specific EF at hand; no default provided in EMEP/EEA GB 2023, Chapter: 2.B Chemical industry 2023 , Table 3.16 - Tier 2 emission factors for source category 2.B.3 Adipic acid production
2.B.7	as of 1995: $PM_{2.5}$, PM_{10}; as of 2000: BC	use of split factors for PM will be checked for following submissions
2.C.1	As, Cu, Se, Zn, B[a]P, B[b]F, B[k]F, I[1,2,3-c,d]P, BC (as of 2000)	use of default EF will be checked for following submissions
2.C.2	NO_x, NMVOC, SO_x, CO, Pb, Cd, Hg, Cr BC	EMEP/EEA GB 2023, Chapter 2.C.2 Ferroalloys production, table 3.1: no EFs provided in EMEP GB 2023
2.C.3	NMVOC, Cr, Se BC, B[b]F, B[k]F, I[1,2,3-c,d]P	EMEP/EEA GB 2023, Chapter 2.C.3 Aluminium production: no EFs provided in EMEP GB 2023 use of default EFs will be checked for following submissions
2.C.4	NMVOC, TSP, $PM_{2.5}$, PM_{10}, BC	no primary magnesium production in Germany; only F-Gases are reported under 2.C.4, other occurring emissions from secondary magnesium production are reported in the Energy sector under 1.A.2.b.
2.C.5	BC (as of 2000), Se	EMEP/EEA GB 2023, Chapter 2.C.5 Lead production no EFs provided in EMEP GB 2023
2.C.6	BC (as of 2000), Se	EMEP/EEA GB 2023, Chapter 2.C.6 Zinc production
2.C.7.a	Se BC (as of 2000), Ni	EMEP/EEA GB 2023, Chapter 2.C.7.a Copper production no EF provided in EMEP GB 2023 use of default EF will be checked for following submissions
2.C.7.c	BC (as of 2000), SO_x	EMEP/EEA GB 2023, Chapter 2.C.7.c Other metal production for galvanization no EF provided in EMEP GB 2023
2.D.3.b	BC, B[a]P, B[b]F, B[k]F, I[x]P, PAH 1-4, as of 2000: BC	no country-specific EF at hand; GB 2023 to be checked; BC: use of 'NA' will be checked
2.D.3.c	PM2.5,PM10,TSP,as of 2000: BC,B[a]P, B[b]F, B[k]F, I[1,2,3-c,d]P, PAH 1-4	no country-specific EF at hand; notation key 'NE' provided in EMEP/EEA GB 2023, Chapter 2.D.3.c Asphalt roofing 2023 , Table 3-1 to 3-3
2.H.1	NH3, PCBs, as of 2000: BC	use of default EF will be checked for BC, use of 'NA' for PCB will be checked
2.H.2	as of 2000: BC	use of default EF will be checked for following submissions
2.H.3	as of 2000: BC	as for all other pollutants, 'NA' will be reported for BC and for the next annual submission
2.I	as of 2000: BC	no country-specific EF at hand; no information provided in EMEP/EEA GB 2023, Chapter 2.I Wood processing 2023
2.K	PCB	EMEP GB 2019, https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/2-industrial-processes/2-k-consumption-of-pops/2-k-consumption-of-pops/view, Table 3.1: emissions of PCB could not be ruled out but no data on national level is available and the standard EF (based on capita) will lead to unrealistic high emissions.
2.L	BC	BC emissions unlikely to occur from dry bulk goods; no information EMEP/EEA GB 2023, Chapter 2.L Other production, consumption etc of bulk products 2023
5.C.1.b v	BC, As, Cr, Cu, Ni, Se, Zn, B[k]F	BC: 'NE' provided in EMEP/EEA GB 2023, Chapter 5.C.1.b.v Cremation 2023 , use of 'NA' will be checked; HM and B[k]F: use of national EF will be checked
5.C.2	NH_3, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, HCB, PCBs	NH_3 and Heavy Metals: use of 'NA' will be checked; for other pollutants no appropriate EFs available
1.A.3.a i(ii)	PCDD/F	no country-specific EF at hand; no default provided in EMEP/EEA GB 2023, Chapter 1.A.3.a Aviation 2023
1.A.3.a ii(ii)	PCDD/F	no country-specific EF at hand; no default provided in EMEP/EEA GB 2023, Chapter 1.A.3.a Aviation 2023
1.A.5.c	all pollutants	no AD available for multilateral military operations

NFR categories reported as 'included elsewhere ('IE')

NFR category	pollutants effected	included in	explanation / reasoning
1.A.1.a	B[b]F, B[k]F, I[1,2,3-c,d]P	PAHs 1-4 total	only summarized PAH data available
1.A.1.b	B[b]F, B[k]F, I[1,2,3-c,d]P	PAHs 1-4 total	only summarized PAH data available
1.A.1.c	B[b]F, B[k]F, I[1,2,3-c,d]P	PAHs 1-4 total	only summarized PAH data available
1.A.2.b	$PM_{2.5}$, PM_{10}, TSP, as of 2000 BC, Pb,Cd,Hg,As,Cr,Cu,Ni,Se,Zn, PCCDF, PCCDF B[a]P, B[b]F, B[k]F, I[1,2,3-c,d], PAHs 1-4 total, HCB, PCBs	2.C	considered to be process emissions

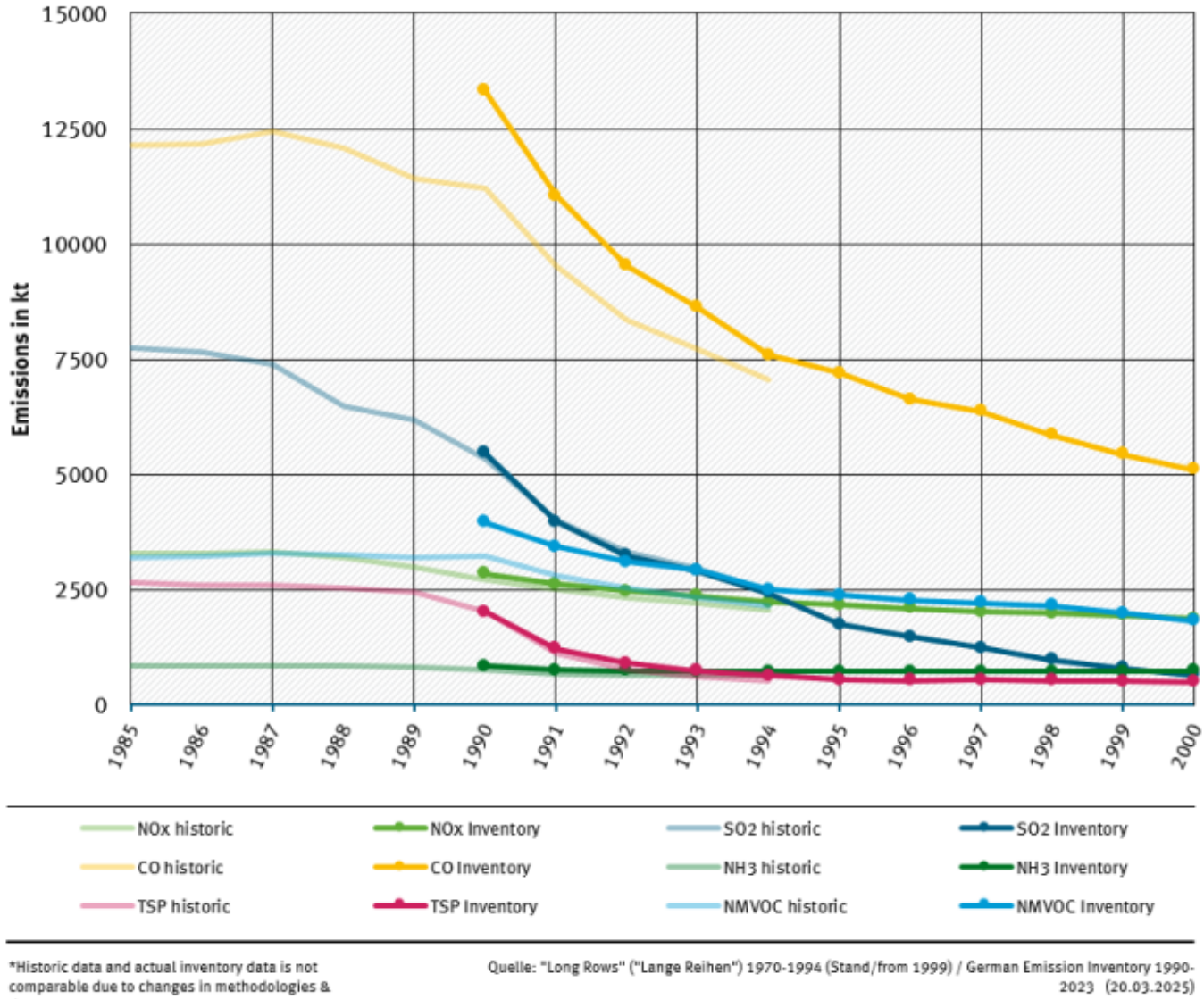
NFR category	pollutants effected	included in	explanation / reasoning
1.A.2.c	all emissions	1.A.2.g viii (energy related emissions), 2.B (process related emissions)	
1.A.2.d	all emissions	1.A.2.g viii (energy related emissions), 2.H.1 (process related emissions)	Process related part include the complete trend of SO_2 emissions instead a fuel based calculation within this category
1.A.2.e	$PM_{2.5}$, PM_{10}, TSP, as of 2000 BC	2.H.2 (process related emissions)	Relevant part of emissions of all pollutants from CHP plants and steam boilers are reported under 1.A.2.g viii, so the whole emissions are adressed
1.A.2.f	NO_x, NMVOC, SOx, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn,	2.A.1, 2.A.2 and 2.A.6	Process related part include complete trends of these emissions instead a fuel based calculation within this category, For a full overview, please see the table within Non-Metallic Minerals.
1.A.2.g viii	B[b]F, B[k]F, I[1,2,3-c,d]P	PAHs 1-4 total	only summarized PAH data available
1.A.3.d i(ii)	all emissions	1.A.3.d ii	no separate AD available for international inland navigation
2.A.1	CO, B[b]F, B[k]F, I[1,2,3-c,d]P	CO: 1.A.2.f; B[b]F, B[k]F, I[1,2,3-c,d]P in PAHs 1-4 total	only summarized PAH data available
2.A.2	NH_3	1.A.2.f	
2.A.5.c	$PM_{2.5}$, PM_{10}, TSP, BC	2.L	emissions from storage, handling and transport of dry bulk products reported in NFR 2.L
2.A.6	CO	1.A.2.f	
2.B.10.b	$PM_{2.5}$, PM_{10}, TSP	2.L	emissions from storage, handling and transport of dry bulk products reported in NFR 2.L
2.C.4	NO_x, NMVOC, SO_2, NH_3, CO	1.A.2.b	emissions from secondary magnesium production reported in NFR 1.A.2.b
2.C.7.d	$PM_{2.5}$, PM_{10}, TSP	2.L	emissions from storage, handling and transport of dry bulk products reported in NFR 2.L
2.I	CO	1.A.2	
3.D.a.2.a	NMVOC	3.B explaination see chapter	
3.D.a.3	NMVOC	3.B explaination see chapter	
2.D.3.b	CO	1.A.2.f	
3.B.4.a	NO_x, NMVOC, NH_3, $PM_{2.5}$, PM_{10}, TSP	3.B.1.a, 3.B.1.b	buffaloes included in the population figures for cattle
3.B.4.f	NO_x, NMVOC, NH_3, $PM_{2.5}$, PM_{10}, TSP	3.B.4.e	mules and asses are included in population figures for horses

Emission data for years before 1990

Consistent time series for emissions for years before 1990 are not available.

Up to 1994, Germany calculates some sector's emissions separately for both parts of Germany in distinct procedures, using different substructures and data sources. From 1995 onward, the emissions were calculated for the unified country only.

All inventory improvements coming from our own QA/QC or review recommendations can not be applied for the years before 1990. Insofar, the long-time series is provided only as additional information and to illustrate the general trend since 1970.



Visual comparison of historic data and inventory data for the years 1985 to 2000

CHAPTER 2: Explanation of Key Trends

This chapter features tabular and graphical representations of emissions and emission trends for CO, NMVOC, NO_x, SO_2, NH_3, TSP, PM_{10}, $PM_{2.5}$ and Black Carbon.

The covered time scale stretches from 1990 to the latest reporting year for data and further back for general explanation. Emission are listed as totals here and detailed by NFR source category in the pollutant-specific subsections, these also include summaries of the main drivers for the pollutant in question. The subsections also feature details on the inventory preparation process for the individual pollutants and source categories, including the tier of the methods applied and data characterisation.

Detailed emission trends

- Nitrogen Oxide (NO_x)
- Sulfur dioxide (SO_2)
- Non-Methane Volatile Organic Compounds (NMVOC)
- Ammonia (NH_3)
- Carbon Monoxide (CO)
- Total suspended particulate matter (TSP)
- Fine Particulate Matter <10µm (PM_{10})
- Fine Particulate Matter <2.5 µm ($PM_{2.5}$)
- Black Carbon (BC)
- Persistent Organic Pollutants (POP)
- Heavy Metals (HM)

Total emission trends

Between the 1950s and 1970s, air pollution in both parts of Germany was considerably higher than today, mainly due to the “traditional” pollutants sulphur dioxide, airborne particulates and to some extend nitrogen oxides. The reduction in the concentration of pollutants has been forced by regulations that induced technological advancements in stationary combustion plants and vehicles and caused the gradual changeover from solid fuels like coal and lignite to oil and gas, the increased use of low-sulphur heating oil, and, later, the desulphurisation of flue gases in large combustion plants (LCP).

Air pollution control measures, regulated by law from 1983 onward, have led to a further major pollutant reduction of average annual levels – to below 25 µg/m³ in the case of SO_2 concentrations. In eastern Germany, decreases in SO_2 and particulate emissions associated with economic restructuring, redevelopment of smokestack industrial areas, and the construction of advanced, state-of-the-art industrial plants are also reflected in the emission concentrations measured. For example, the annual mean SO_2 pollution levels in the industrial and urban conurbations of West Saxony, southern Saxony-Anhalt, and eastern Thuringia fell from about 150–175 µg/m³ to 8–15 µg/m³ between 1990 and 2003. As a result of the reductions achieved, the winter smog alarms that were previously caused by sulphur dioxide emissions have been effectively eliminated. This applies to both East and West Germany, even in topographically unfavourable locations such as valleys and geological basins.

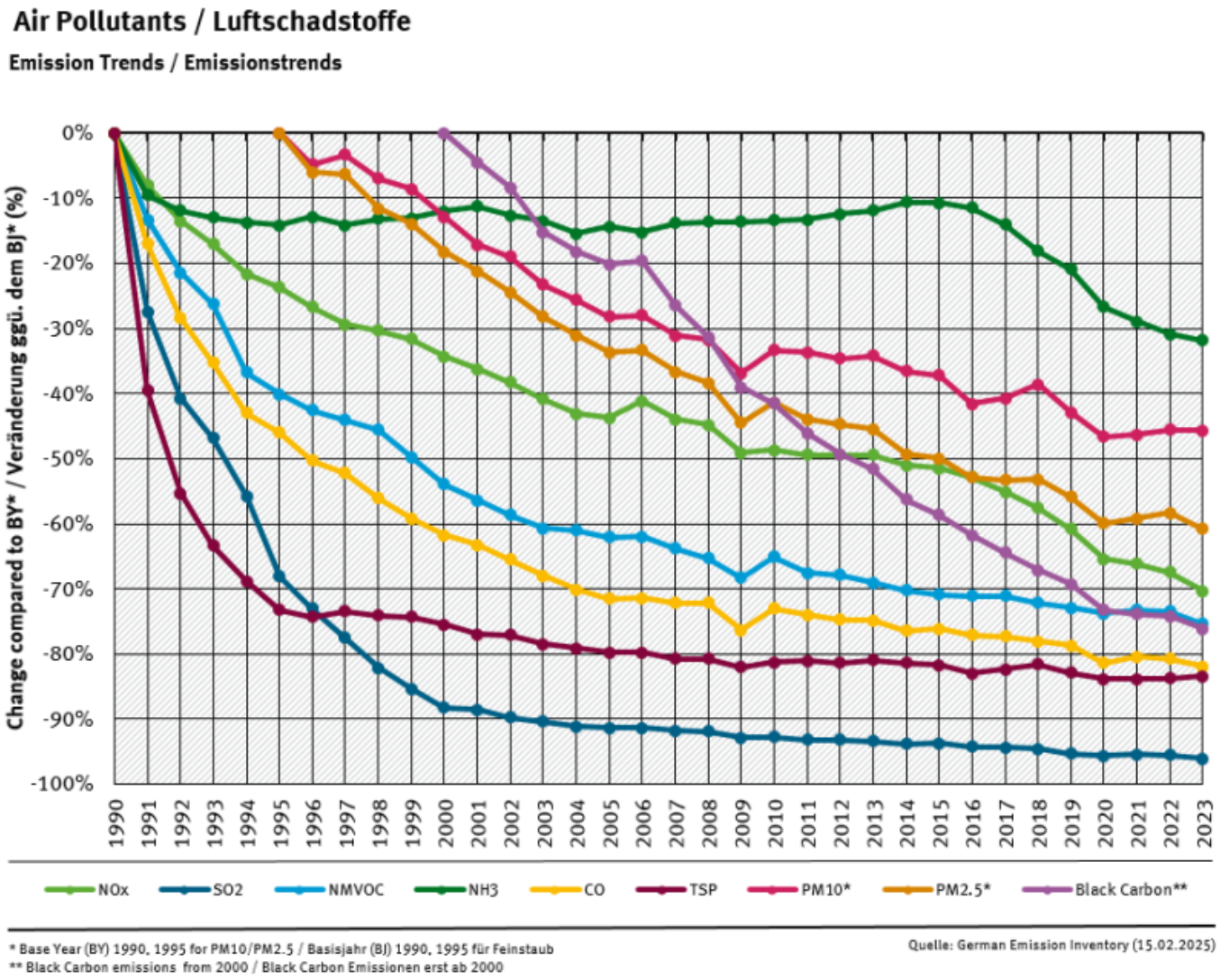


Figure 1: **Total emission trends for the most important pollutants** in percent decrease compared to a base year, set to 1995 for $PM_{2.5}$ and PM_{10}, to 2000 for Black Carbon, and 1990 for all other pollutants.

Due to the fact that air pollution is not being kept within national borders, the issue has been on both the UN's as well as the European Union's agenda for a long time, resulting in increasingly strict regulations for air quality management, as new knowledge and concepts were taken into consideration. The framework for these regulations is the Council “Framework” *Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management*, the objectives and principles of which are set out in concrete terms in so-called daughter directives.

The framework directive and the first two daughter directives were adopted in German law through the *22nd Federal Immission Control Ordinance* (22nd BImSchV). The third daughter directive was subsequently adopted through the *33rd Federal Immission Control Ordinance* (33rd BImSchV), whilst the fourth daughter directive is currently passing through the legislative process. The limit values specified in the daughter directives are based on the work of the *World Health Organisation* (WHO) and, in general, are considerably lower than the limits specified in previous regulations. Where particle emissions are considered, new limit values for fine dust (PM_{10}) have replaced the previous limit values for total suspended particulate matter (TSP). Another new feature compared to the previous EC directives is that the first daughter directive makes it compulsory to make up-to-date information on ambient air quality and air pollution situation routinely available to the public.

In addition to the air quality directives, the *European Commission* has also issued *Directive 2001/81/EC* on national emission ceilings (NEC) for certain atmospheric pollutants, restricting maximum national emission levels for the year 2010. This directive covers sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3), and volatile organic compounds (VOC), and was adopted into German law through the *33rd BImschV*. In late 2016, the revised *NEC Directive EU/2016/2284* has entered into force, establishing emission reduction target for 2020 and 2030.

Explanation of Key Trends - Nitrogen Oxides

Obligations

Within the scope of the LRTAP Convention, the Federal Republic of Germany was obliged to reduce emissions of NO_x to the 1987 level of 3,177kt by 1994. However, this value is inconsistent with the time series data after 1990 because, for example, it does not include any emissions from the agricultural sector. But emissions were successfully reduced by close to 30% to 2,255 kt in this period, exceeding the obligatory requirements of the protocol and also meeting the additional voluntary commitment that was entered into by Germany and 11 other ECE countries (reduction of NO_x emissions before 1998 by 30% compared to 1986 levels).

More recently, Germany has made a commitment under the multicomponent protocol to further minimise NO_x emissions. By 2010, it will no longer be permissible to exceed a National Emission Ceiling of 1,081kt NO_x for Germany as whole. The revised Gothenburg Protocol and the revised NEC Directive both define emission reduction targets relative to a 2005 base year, mandating 39% (2020) and 65% (2030) reductions respectively.

While Germany's compliance with these obligations is not discussed here, further information on this subject can be found in Chapter 9 - Projections and Chapter 11 - Adjustments and Emission Ceiling Exceedance.

Main drivers

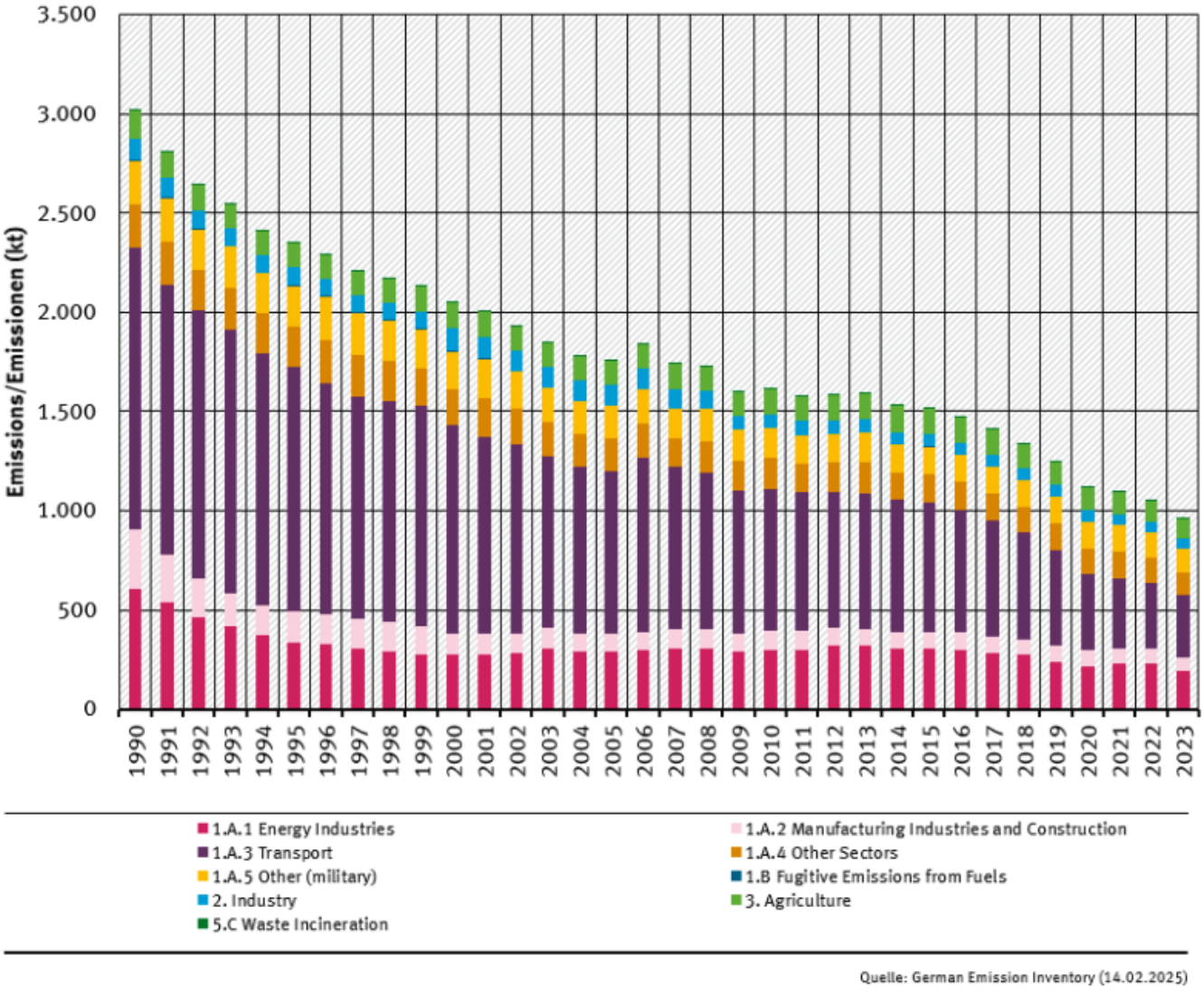
NO_x **total emissions** show a falling trend from 1990 onwards, with emission **reductions of 70.3%** between 1990 and 2023 and steadily falling emissions in the last years.

The Main Driver for NO_x emissions is **Fuel Combustion (NFR 1.A)** with over 91% of 1990 emissions and a 73% reduction from 1990 to 2023. More than half of the 1990 emissions from **Fuel Combustion (NFR 1.A)** and a similar reduction (-79%) between 1990 and 2023 comes from **Road Transportation (NFR 1.A.3.b)**, mainly due to constantly improving fuels and increasingly stricter regulations resulting in technical improvements.

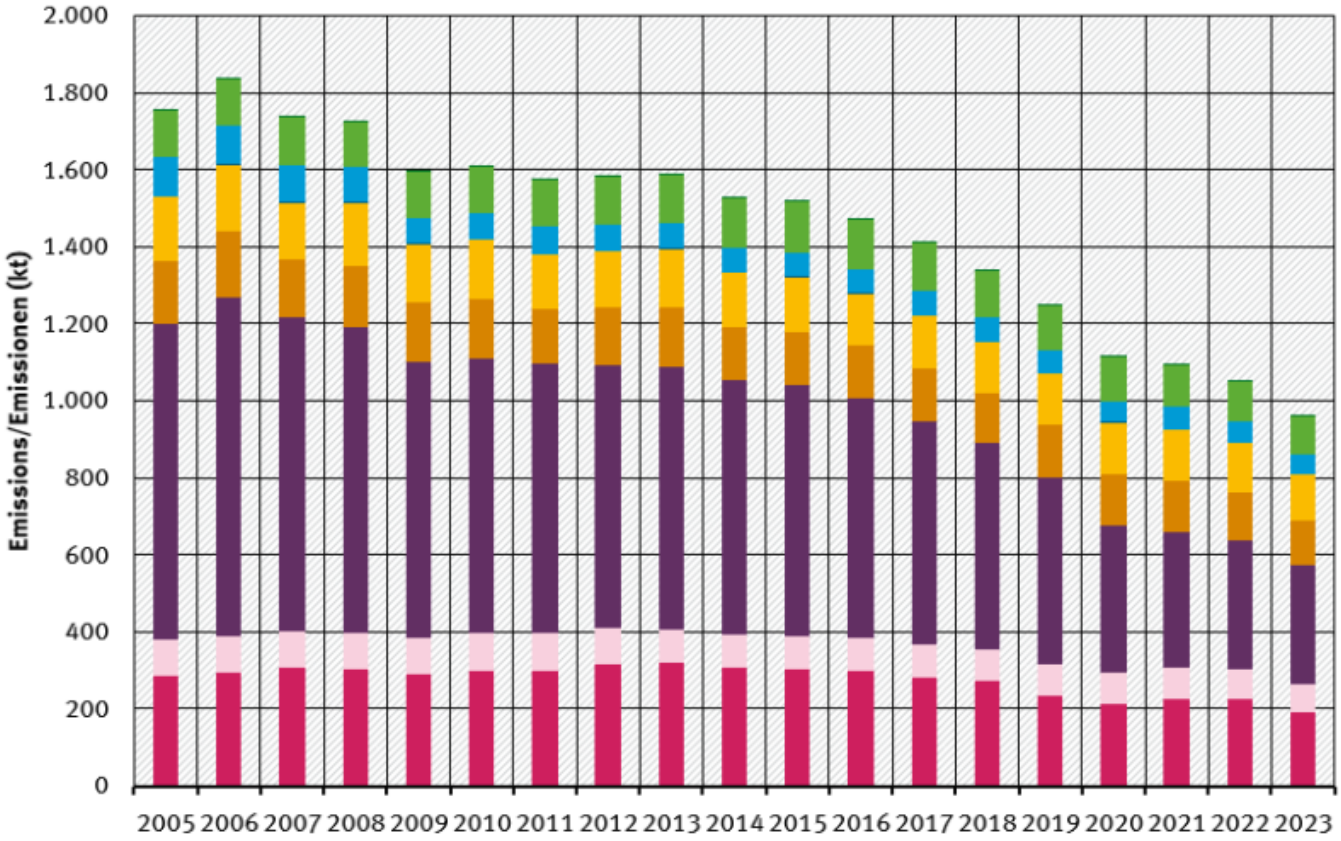
The rest of the 1990 emissions mainly comes from **Energy Industries (NFR 1.A.1)** with a 21% share of 1990 Fuel Combustion (NFR 1.A) emissions and a 68% reduction and to a lesser extend from **Manufacturing Industries and Construction (NFR 1.A.2)** with an 10% share and 76% reduction followed by **Other Sectors (NFR 1.A.4)** with a share of 8% and a 46% reduction between 1990 and 2023. For **Manufacturing Industries and Construction (NFR 1.A.2)** some emissions were reassigned to the **Industrial Processes (NRF 2)** starting from the year 2000, leading to lower emissions from the energy sector and a similar rise in the Industrial processes.

Table: NO_x emissions 1990-2023, in kilotonnes [kt]

																			Trend: latest compared to	
1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**1990**	**previous year**
2 846	2 171	1 869	1 602	1 461	1 439	1 441	1 440	1 394	1 381	1 341	1 278	1 207	1 116	983	964	927	845	-66.9%	-2.4%



Quelle: German Emission Inventory (14.02.2025)



1.A.1 Energy Industries
1.A.2 Manufacturing Industries and Construction
1.A.3 Transport
1.A.4 Other Sectors
1.A.5 Other (military)
1.B Fugitive Emissions from Fuels
2. Industry
3. Agriculture
5.C Waste Incineration

Quelle: German Emission Inventory (14.02.2025)

Explanation of Key Trends - Sulfur Dioxide

Obligations

Under the terms of the UN ECE Geneva Convention on Long-range Transboundary Air Pollution Control (CLTRAP, 1979), the Federal Republic of Germany was obliged by the UN ECE Helsinki Protocol to reduce its annual sulphur emissions by at least 30% by 1993, as compared to 1980 levels. In 1993, the SO_2 emissions were 2.9 Mt, compared to approximately 7.5 Mt in 1980. This represents a reduction of 61%. The second UN ECE protocol on the reduction of sulphur emissions obliged Germany to reduce SO_2 emissions to 1,300 kt by 2000, and to 990 kt by 2005. The targets set for 2000 & 2005 have already been achieved by 1998.

More recently, Germany has made a commitment under the multicomponent protocol to further minimise SO_2 emissions. Since 2010, it is no longer permissible to exceed a National Emission Ceiling of 550 kt SO_2 for Germany as whole. The revised Gothenburg Protocol and the revised NEC Directive both define emission reduction targets relative to a 2005 base year, mandating 21 % (2020) and 58 % (2030) reductions respectively.

While Germany's compliance with these obligations is not discussed here, further information on this subject can be found in Chapter 9 - Projections and Chapter 11 - Adjustments and Emission Ceiling Exceedance.

Main drivers

SO_2 **total emissions** show a falling trend from 1990 onwards, with **emission reductions of over 95% since 1990**.

By far the largest proportion of SO_2 is produced by the oxidation of the sulphur contained in the fuels used in combustion processes, **Fuel Combustion (NFR 1.A)** with a 96% share of total SO_2 emissions in 1990 and a 97% reduction between 1990 and 2023.

In 1990, the biggest source of emissions therein is **Public Electricity and Heat Production (NFR 1.A.1.a)** with about 47% of the emissions from **Fuel Combustion (NFR 1.A)**. Other sources substantially influencing the SO_2 emission trend are **Manufacturing Industries and Construction (NFR 1.A.2)** and **Other Sectors (NFR 1.A.4**, including commercial/institutional and residential sources), each adding about one fifth of 1990 emissions from Fuel Combustion (NFR 1.A).

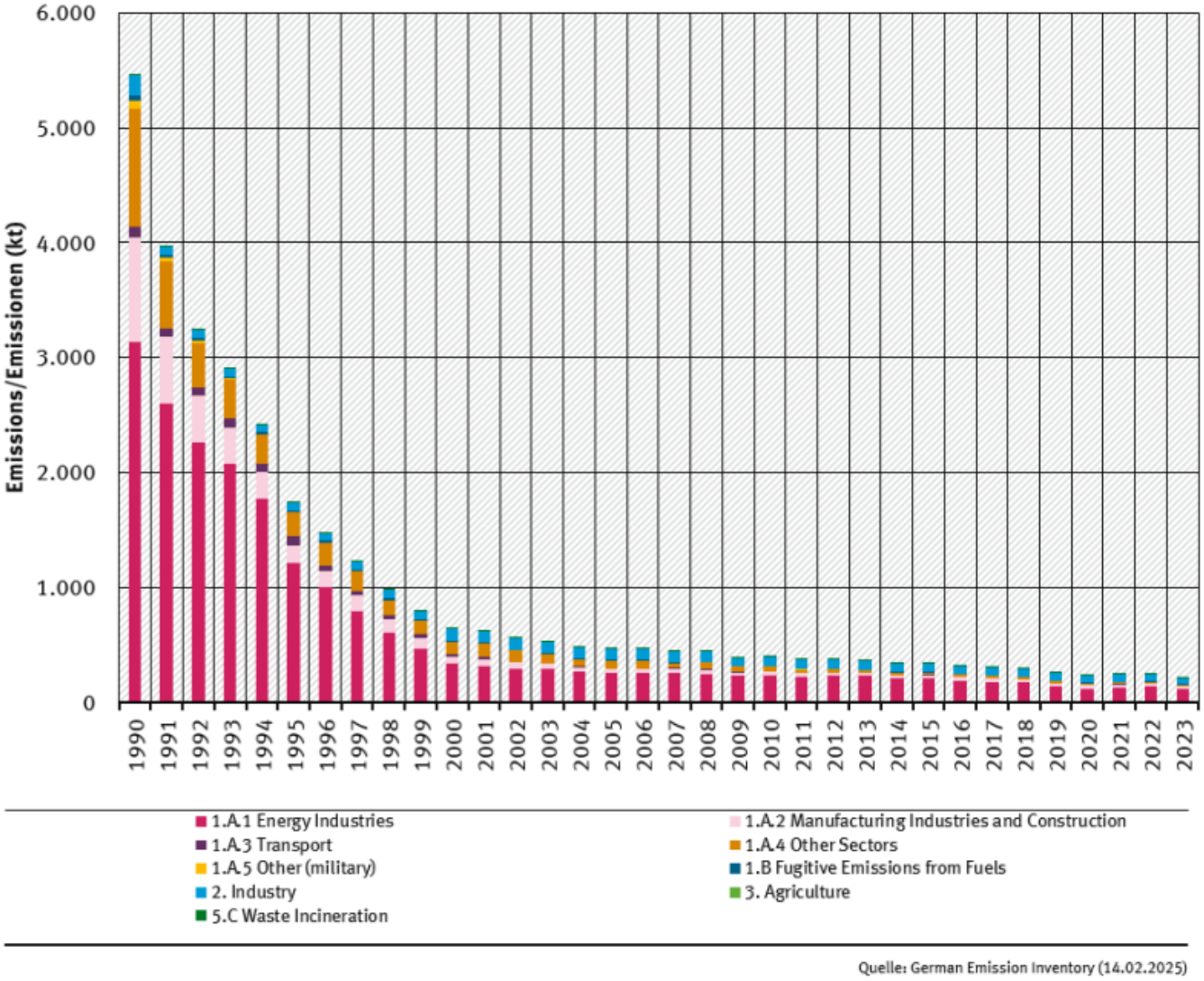
All of these sub-categories show a reduction >95 per cent between 1990 and 2023, due to stricter regulations of West Germany that applied to the New German Länder after the German Reunification and changed the fuel mix from sulphur-rich solid fuels to liquid and gaseous fuels.

Table: SO_2 emissions 1990-2023, in kilotonnes [kt]

																		Trend: latest compared to	
1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**1990**	**previous year**
5 461	1 743	643	472	397	374	371	361	337	341	316	307	294	258	239	249	246	217	-96.0%	-12.0%

Sulfur Dioxide / Schwefeldioxid

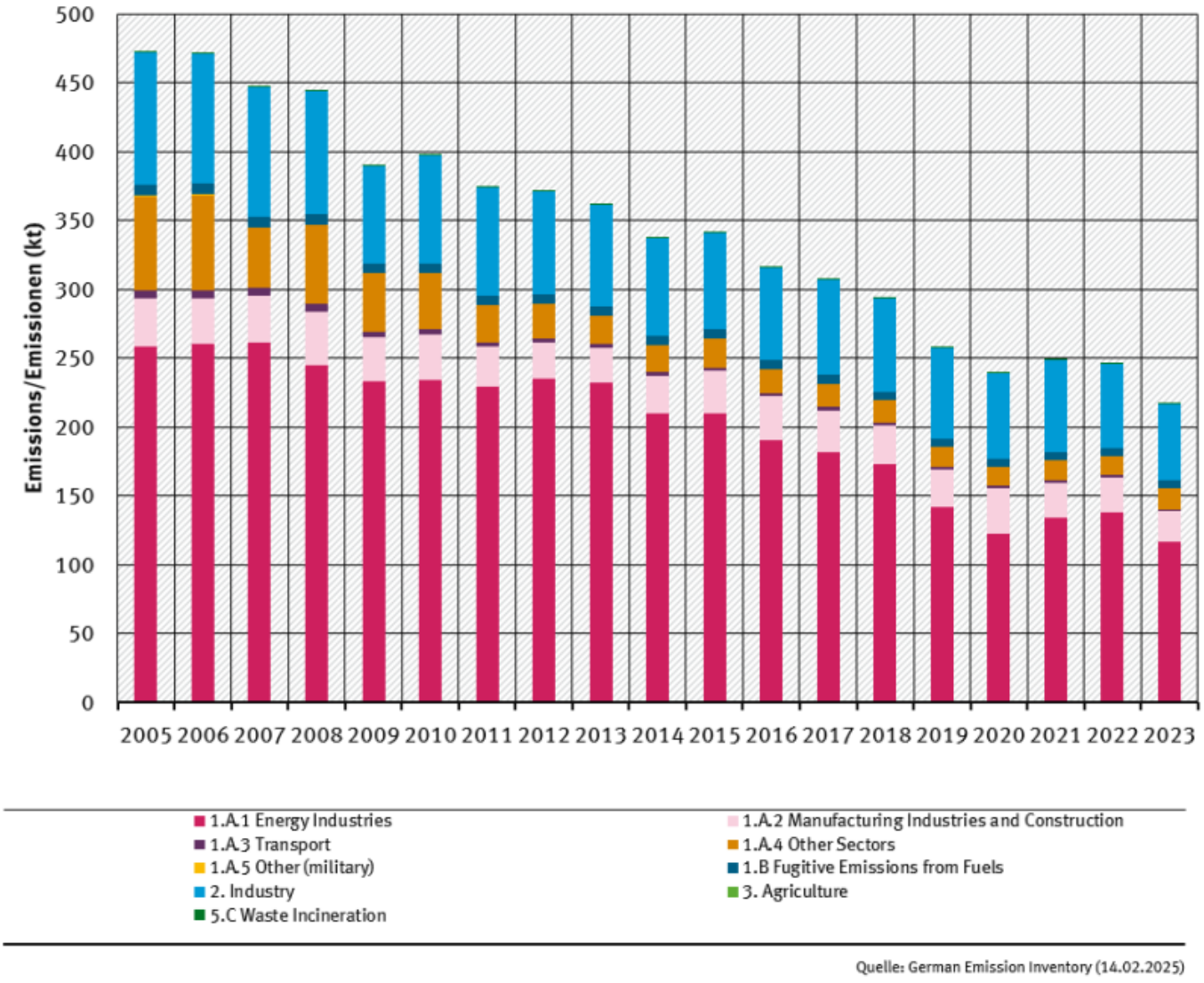
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

Sulfur Dioxide / Schwefeldioxid

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

Explanation of Key Trends - Non Methane Volatile Organic Compounds

Obligations

Germany has made a commitment under the Gothenburg Protocol to reduce NMVOC emissions. Since 2010, it is no longer permissible to exceed a National Emission Ceiling of 995 kt NMVOC for Germany as whole. The revised Gothenburg Protocol and the revised NEC Directive both define emission reduction targets relative to a 2005 base year, mandating 13% (2020) and 28% (2030) reductions respectively.

While Germany's compliance with these obligations is not discussed here, further information on this subject can be found in Chapter 9 - Projections and Chapter 11 - Adjustments and Emission Ceiling Exceedance.

Main drivers

NMVOC **total emissions** show a falling trend from 1990 onwards, with **emission reductions of 75.3% between 1990 and 2023**.

Here, a bump occurs in 2010 after the dent of 2008 and 2009 due to the economic situation. After a period of stagnating emissions, the last few years show a slight annual emission reduction of 3% on average.

The main drivers for NMVOC emissions are **Fuel Combustion (NFR 1.A)** with about half of total 1990 emissions and a 92% reduction between 1990 and 2023.

In the Fuel Combustion category, **Road Transport (NFR 1.A.3.b)** is responsible for about three quarters of the 1990 Fuel Combustion emissions, with **Passenger Cars (NFR 1.A.3.b i)** emitting nearly all of it. Reductions of about 95% in those categories between 1990 and 2023 are mainly due to increasingly stricter regulations, especially incentives for automobile users to retrofit/buy cars with catalytic converters.

Furthermore the implementation of the Technical Instruction on Air Quality Control (TA-Luft 2002), to decreases in emissions from **petrol storage and from fuelling of motor vehicles (1.B.2.a.v)** - as a result of implementation of the 20th and 21st Ordinances on the Execution of the Federal Immission Control Act (BImSchV) - and to reduced petrol consumption play a major role in the reduction of NMVOC emissions within the category **Fugitive Emissions from fossil fuels (NRF 1.B.2)**.

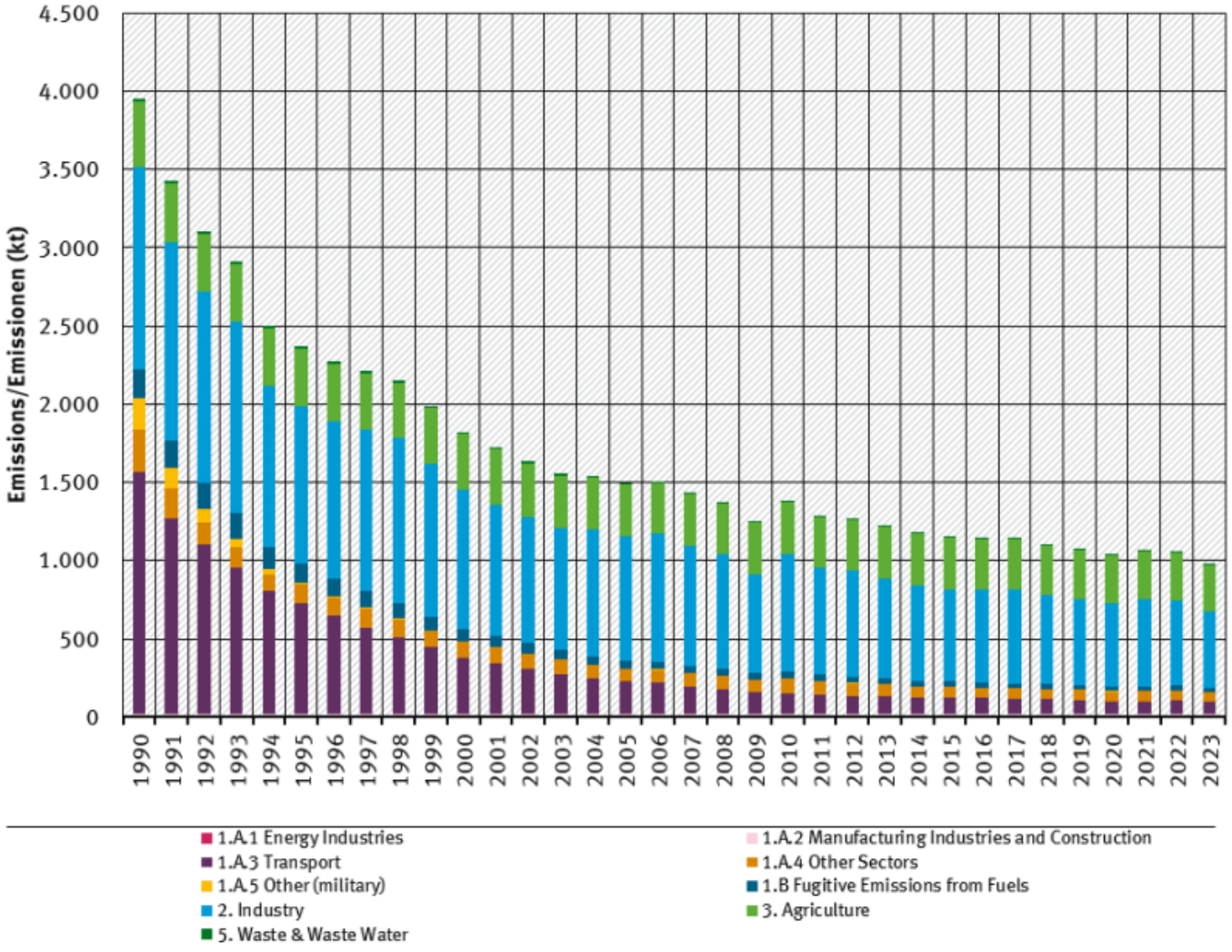
Substantial emissions also come from **Non-Energy Products from Fuels (NFR 2.D)**, emitting 29% of total 1990 emissions and a 64% reduction between 1990 and 2023.

Table: NMVOC emissions 1990-2023, in kilotonnes [kt]

																		Trend: latest compared to	
1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**1990**	**previous year**
3 954	2 370	1 820	1 497	1 380	1 285	1 269	1 222	1 178	1 152	1 144	1 145	1 099	1 071	1 038	1 058	1 051	975	-75.3%	-7.3%

NMVOC

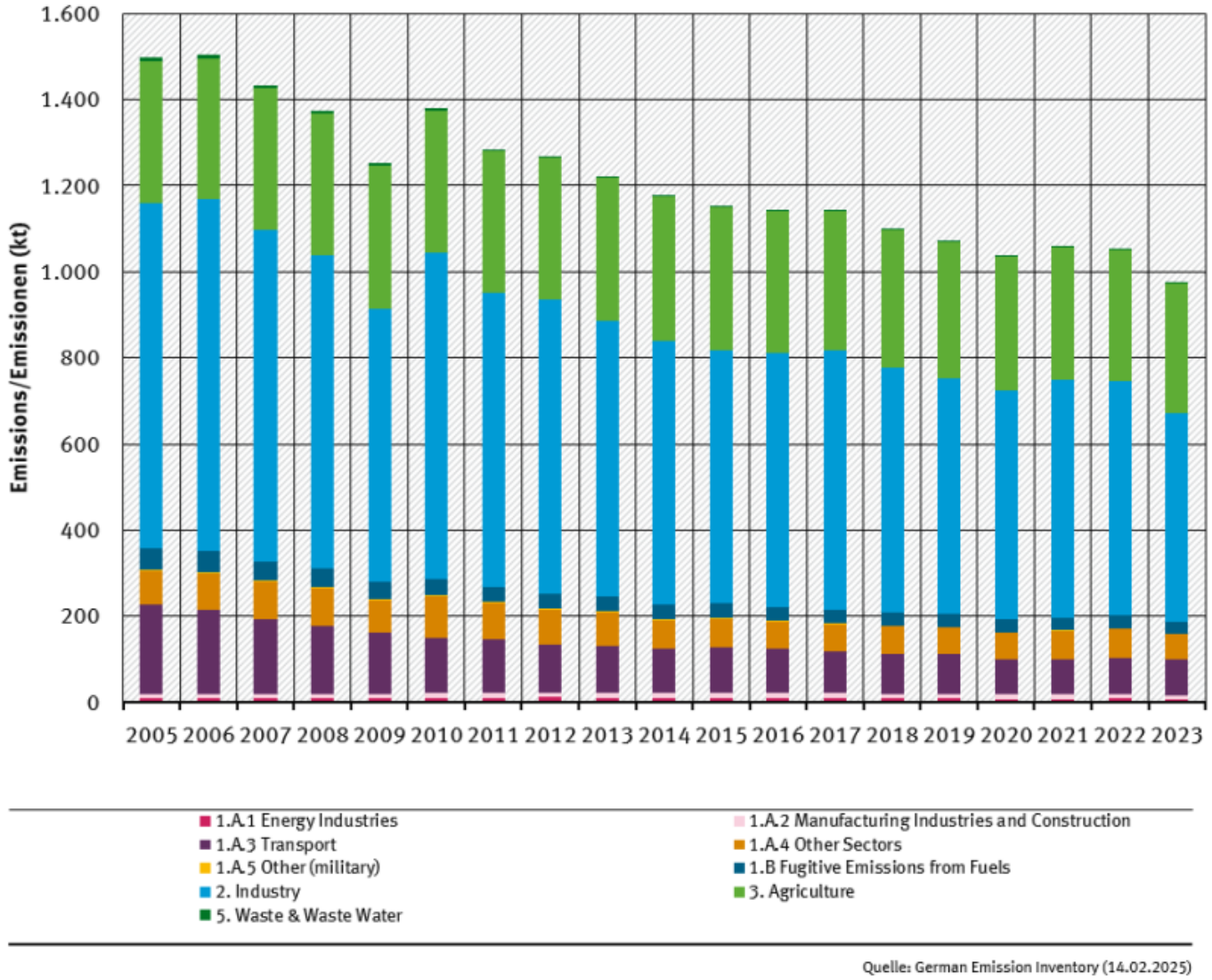
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

NMVOC

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

Explanation of Key Trends - Ammonia

Obligations

Germany has made a commitment under the Gothenburg Protocol to reduce ammonia emissions. Since 2010, it is no longer permissible to exceed a National Emission Ceiling of 550 kt NH_3 for Germany as whole. The revised Gothenburg Protocol and the revised NEC Directive both define emission reduction targets relative to a 2005 base year, mandating 5% (2020) and 29% (2030) reductions respectively.

While Germany's compliance with these obligations is not discussed here, further information on this subject can be found in Chapter 9 - Projections and Chapter 11 - Adjustments and Emission Ceiling Exceedance.

Main drivers

The Main Drivers for NH_3 emissions are agricultural emissions from **Manure Management (NFR 3.B)** with 36% of total 1990 emissions and a 34% reduction between 1990-2023 and **Agricultural Soils (NFR 3.D)** with even 59% of total 1990 emissions and a 33% decrease.

The overall emission trend follows the agricultural emissions closely with a **total reduction of 32% since 1990**.

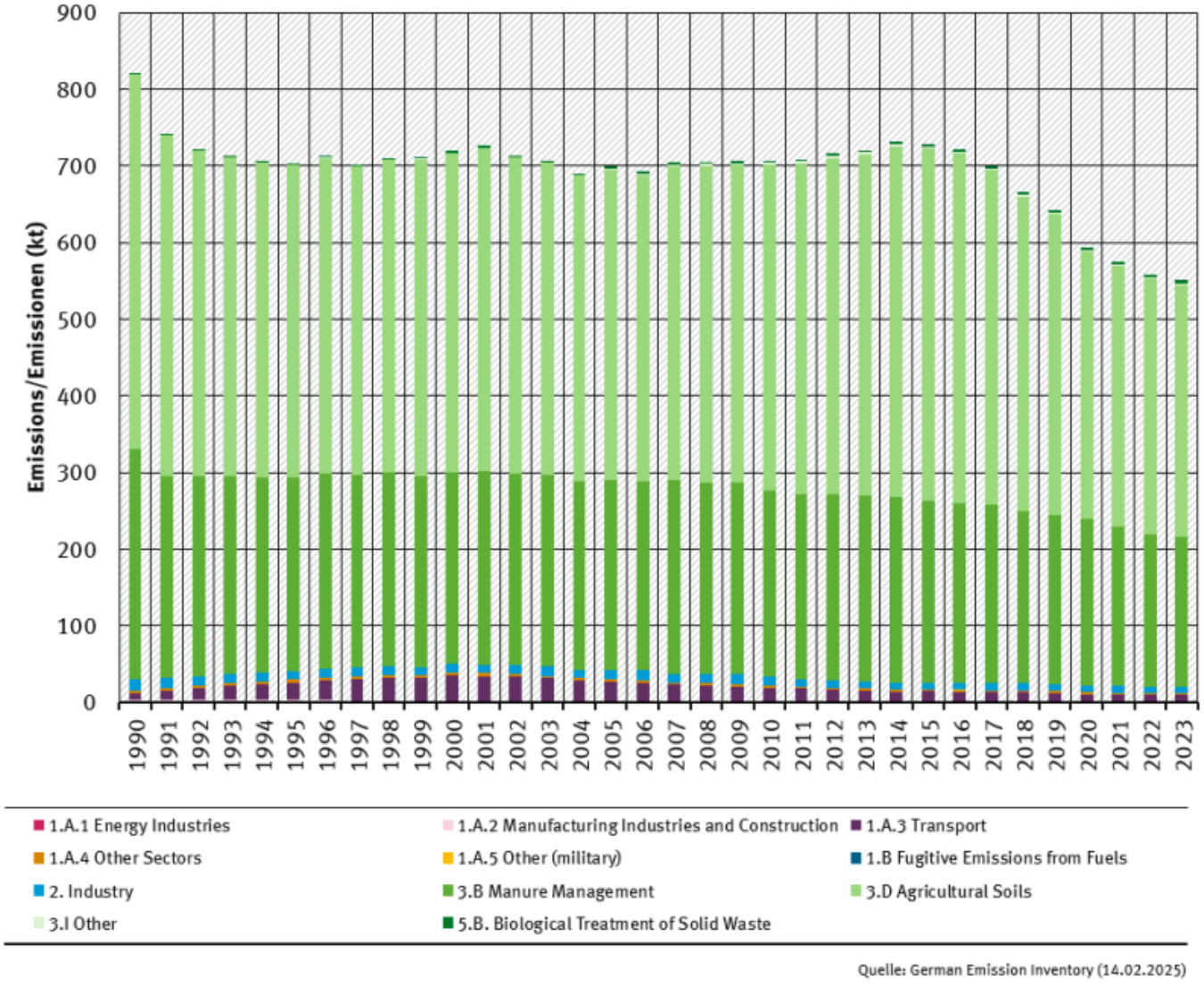
The decrease of NH_3 emission in the year 1991 is due to a reduced livestock population that followed after the German reunification, while no explicit trend is discernible for the years up to 2016. Between 2016 and 2021 the emissions are dropping every year adding up to a 15% drop. Here, emissions dropped by 6.9% between 2019 and 2020, an decrease only topped by the reduction between 1990 and 1991 (minus 10%).

Table: Ammonia emissions 1990-2023, in kilotonnes [kt]

																			Trend: latest compared to	
1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**1990**	**previous year**
834	717	734	714	722	724	731	735	746	745	739	717	683	660	611	593	577	569	-31.8%	-1.3%

Ammonia / Ammoniak

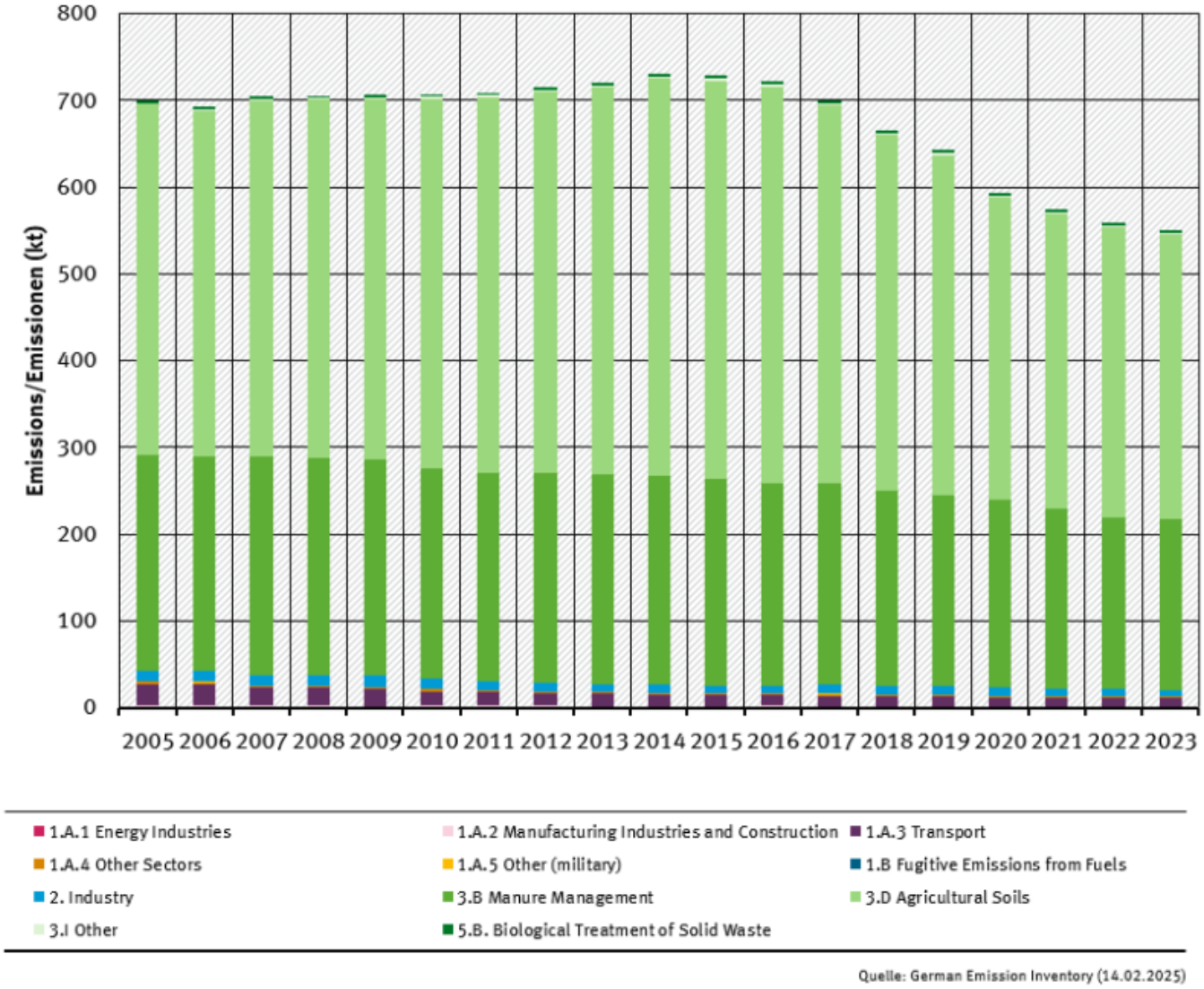
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

Ammonia / Ammoniak

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

Explanation of Key Trends - Carbon Monoxide

Main drivers

CO total emissions show a falling trend over the whole interval, with emission **reductions of 81.9 %** between 1990 and 2023 and a renewed interval of emission reductions in the last years.

The Main Driver for CO emissions is **Fuel Combustion (NFR 1.A)** with 90% of total 1990 emissions and an 86% reduction between 1990 and 2023. In the Fuel Combustion category, **Road Transport (NFR 1.A.3.b)** is responsible for 57% of the 1990 emissions, with **Passenger Cars (NFR 1.A.3.b.i)** emitting nearly all of it. Reductions of about 90% in those categories between 1990 and 2023 are mainly due to constantly improving fuels and increasingly stricter regulations resulting in technical improvements.

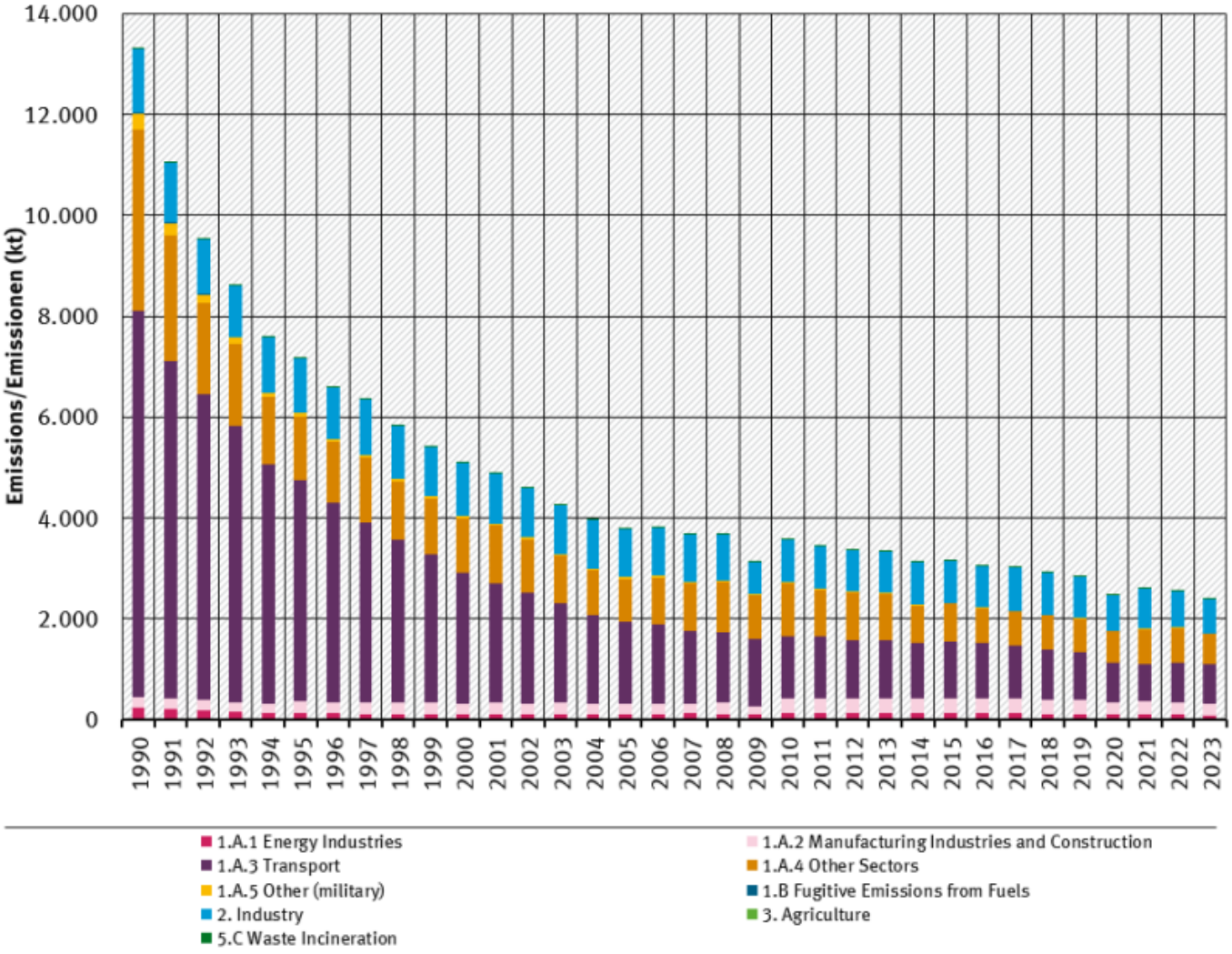
Other Sectors (NFR 1.A.4, including commercial/institutional and residential sources) are responsible for about 27% of 1990 Fuel Combustion emissions with a 84% reduction between 1990 and 2023.

Table: Carbon monoxide emissions 1990-2023, in kilotonnes [kt]

																		Trend: latest compared to	
1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**1990**	**previous year**
13 321	7 188	5 097	3 790	3 590	3 462	3 364	3 349	3 134	3 177	3 050	3 030	2 927	2 839	2 479	2 607	2 568	2 409	-81.9%	-6.2%

Carbon Monoxide / Kohlenmonoxid

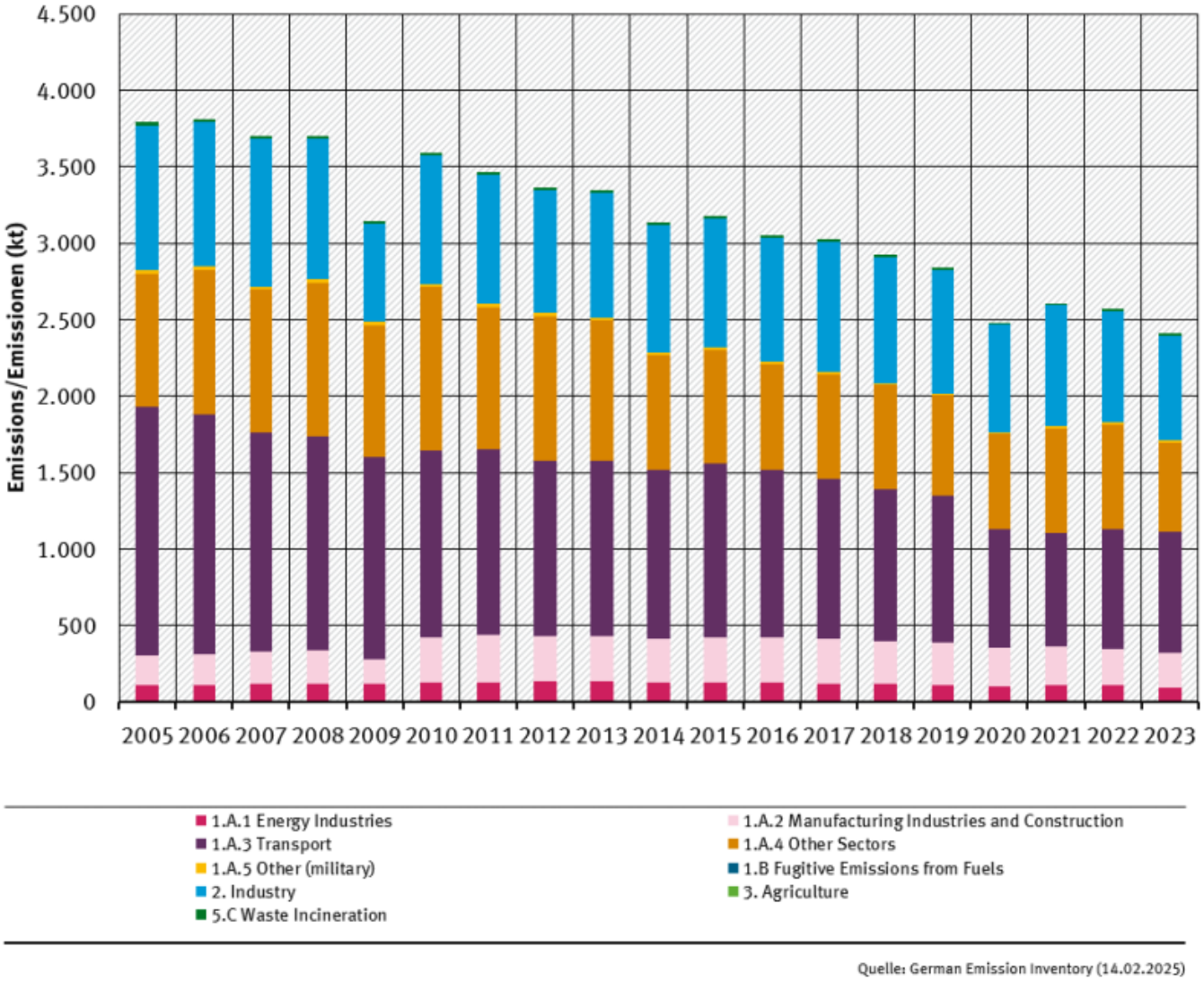
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

Carbon Monoxide / Kohlenmonoxid

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

Explanation of Key Trends - Total Suspended Particulate Matter

Main drivers

Between 1990 and 2023, **total TSP emissions dropped by 83.5%**, mainly due to stricter regulations of the Old West Germany that applied to the New German Länder after the German Reunification and realized a change-over from solid to gaseous and liquid fuel, as well as advancements in filter technologies of combustion plants and industrial processes.

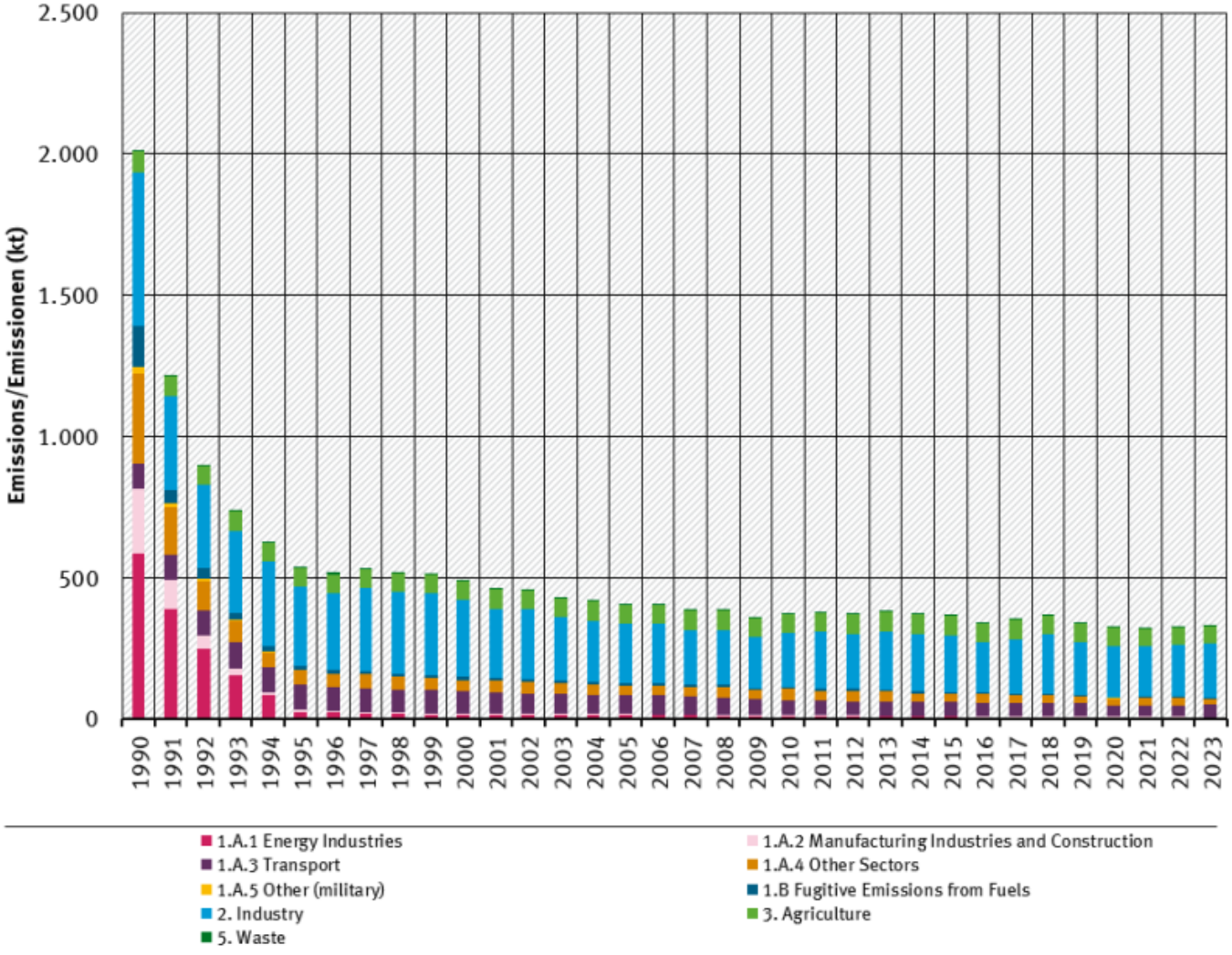
The Main Drivers for TSP emissions are **Fuel Combustion (NFR 1.A)** with 62% of total 1990 emissions and a 94% reduction between 1990 and 2023 and, as a sum, the **Industrial Processes (NFR 2)** with 27% of the total 1990 emissions and a 65% reduction between 1990 ans 2023.

Table: TSP emissions 1990-2023, in kilotonnes [kt]

																			Trend: latest compared to	
1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**1990**	**previous year**
2016	540	494	407	377	381	375	384	375	369	342	355	370	344	326	325	328	334	-83.5%	+1.7%

Total Suspended Particulate Matter / Gesamtstaub (TSP)

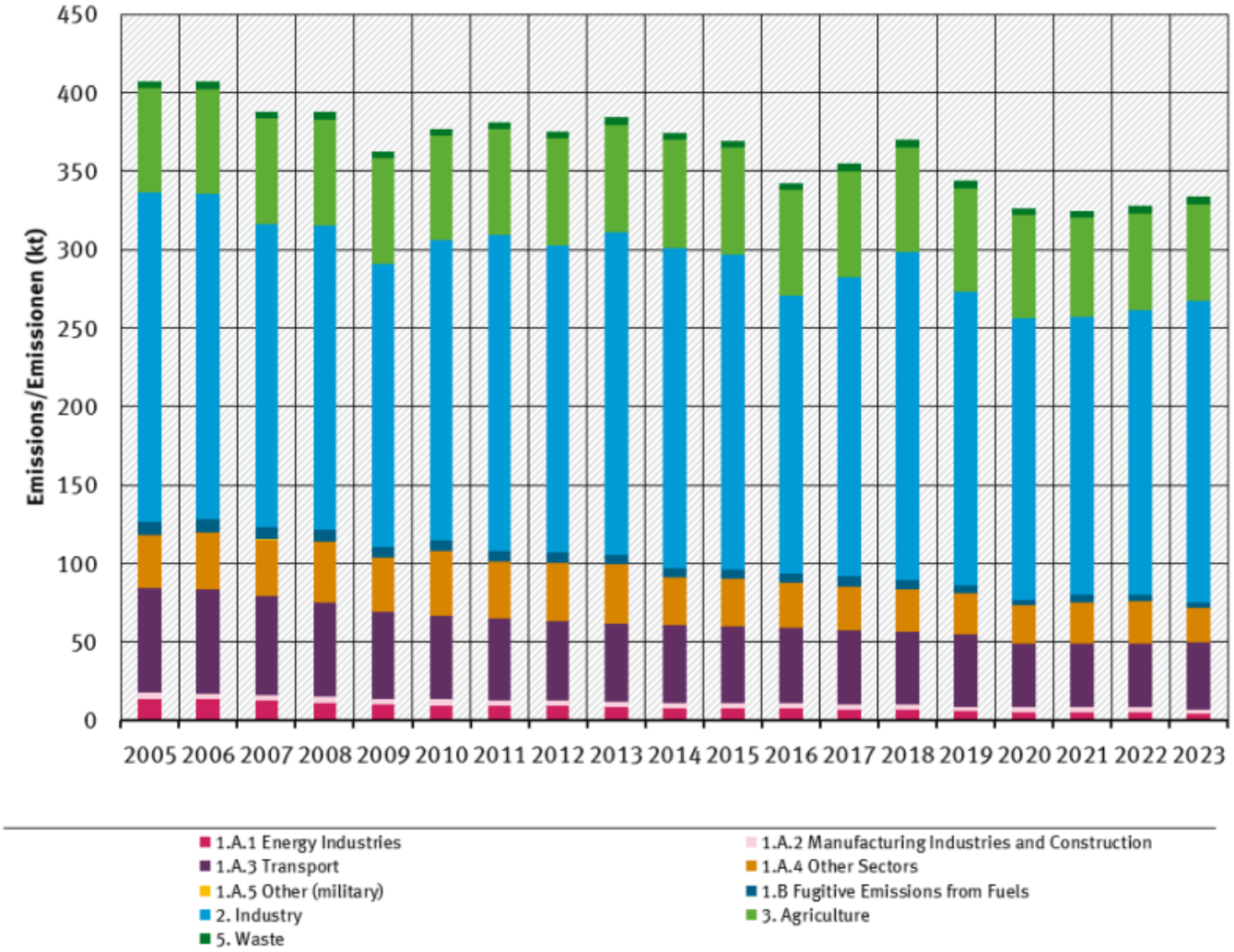
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

Total Suspended Particulate Matter / Gesamtstaub (TSP)

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

]

Explanation of Key Trends - Fine Particulate Matter (PM_{10})

Main drivers

Between 1995 and 2023, **total PM_{10} emissions dropped by 46%**.

The Main Drivers for PM_{10} emissions are **Fuel Combustion (NFR 1.A)** with 48% of total 1995 emissions and a 63% reduction between 1995 and 2023 and as a sum the **Industrial Processes (NFR 2)** (and especially **Handling of Bulk Products NFR 2.L** therein) with 38% of total 1995 emissions and a 37% reduction.

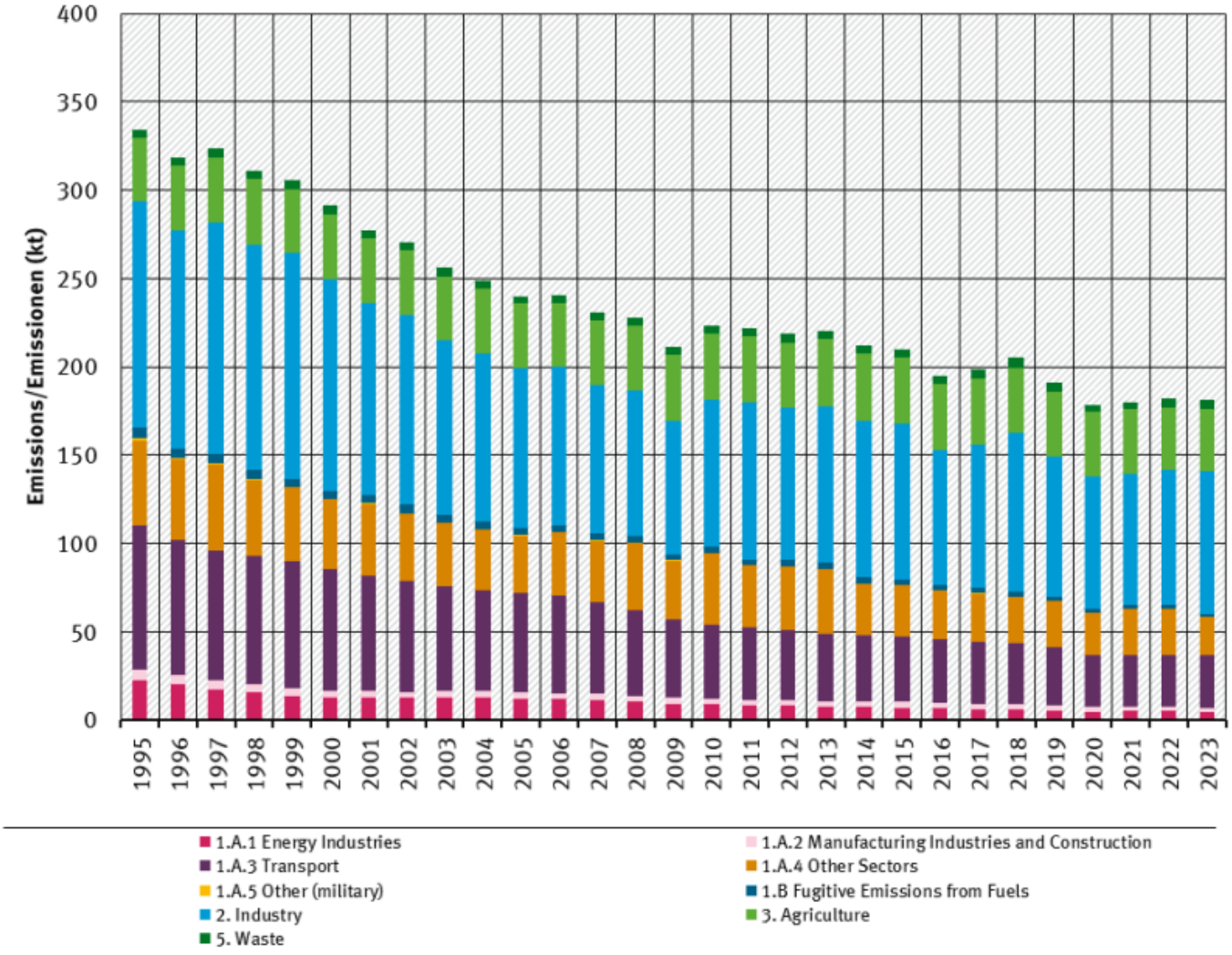
Within NFR 1.A, **Transport (NFR 1.A.3)** produces the biggest part of PM_{10} emissions. Here, about three quarters of the 2023 Transport PM_{10} emissions are produced by **Road Transport (NFR 1.A.3.b)**, half of which is directly caused by **fuel combustion (NFR 1.A.3.b.i - iv)** and the other half by **road abrasion and tyre and brake wear (NFR 1.A.3.b.vi - vii)**.

Table: PM_{10} Emissions 1990-2023, in kilotonnes [kt]

																		Trend: latest compared to	
1995	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**1995**	**previous year**
334	291	240	223	222	219	220	212	210	195	198	205	191	179	180	182	182	-45.7%	0.2%

Fine Particulate Matter / Feinstaub (PM10)

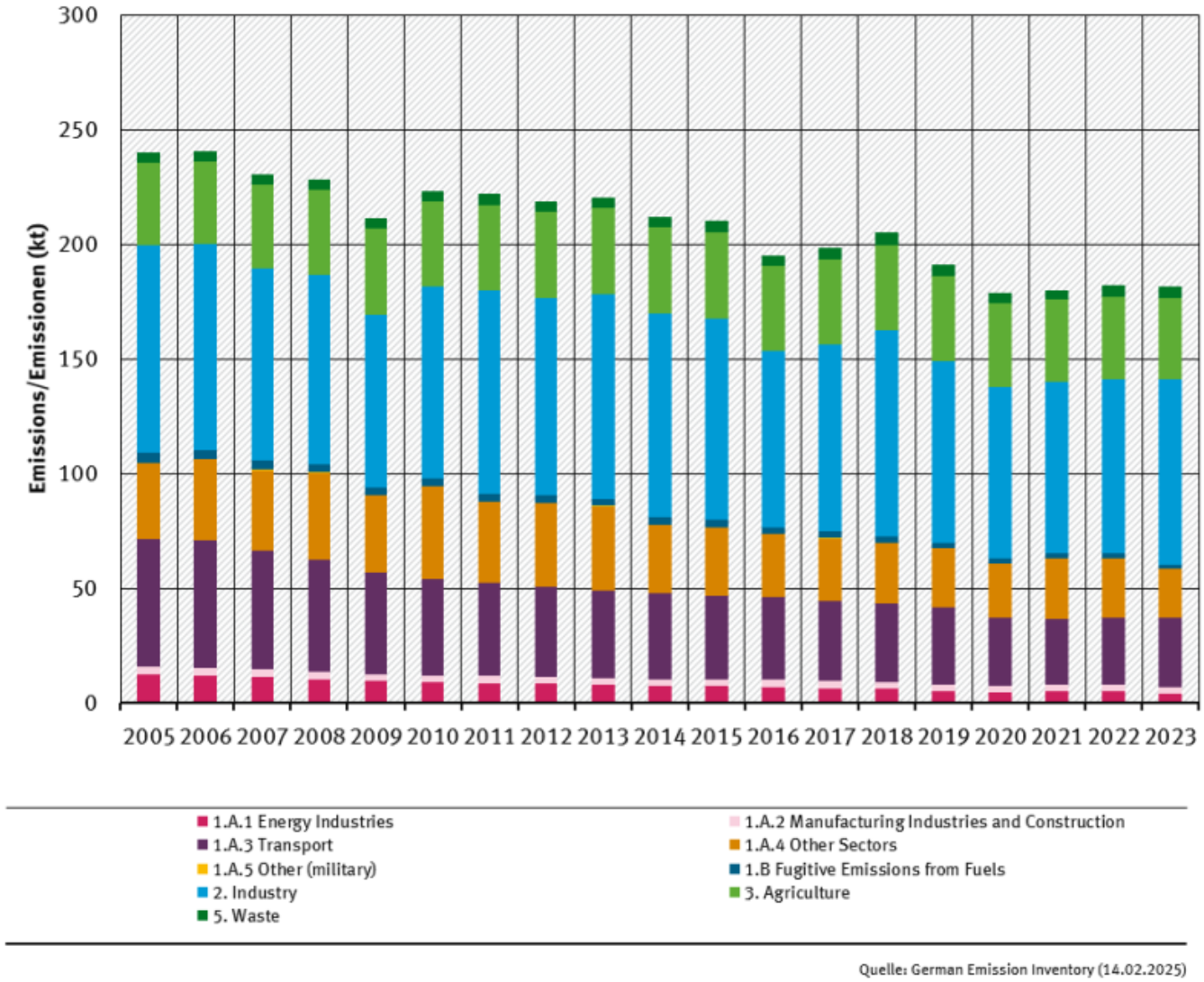
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

Fine Particulate Matter / Feinstaub (PM10)

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

Explanation of Key Trends - Fine Particulate Matter ($PM_{2.5}$)

Obligations

Germany has made a commitment to reduce particulate matter emissions. The revised Gothenburg Protocol and the revised NEC Directive both define emission reduction targets relative to a 2005 base year, mandating 26% (2020) and 43% (2030) reductions respectively.

While Germany's compliance with these obligations is not discussed here, further information on this subject can be found in Chapter 9 - Projections and Chapter 11 - Adjustments and Emission Ceiling Exceedance.

Main drivers

Between 1995 and 2023, **Total $PM_{2.5}$ emissions declined by 60.8%**.

The Main Drivers for $PM_{2.5}$ emissions are **Fuel Combustion (NFR 1.A)** with 73% of total 1995 emissions and a 69% reduction between 1995 and 2023 and, as a sum, the **Industrial Processes (NFR 2)** with about 21% of total 1995 emissions and a 48% reduction between 1995 and 2023.

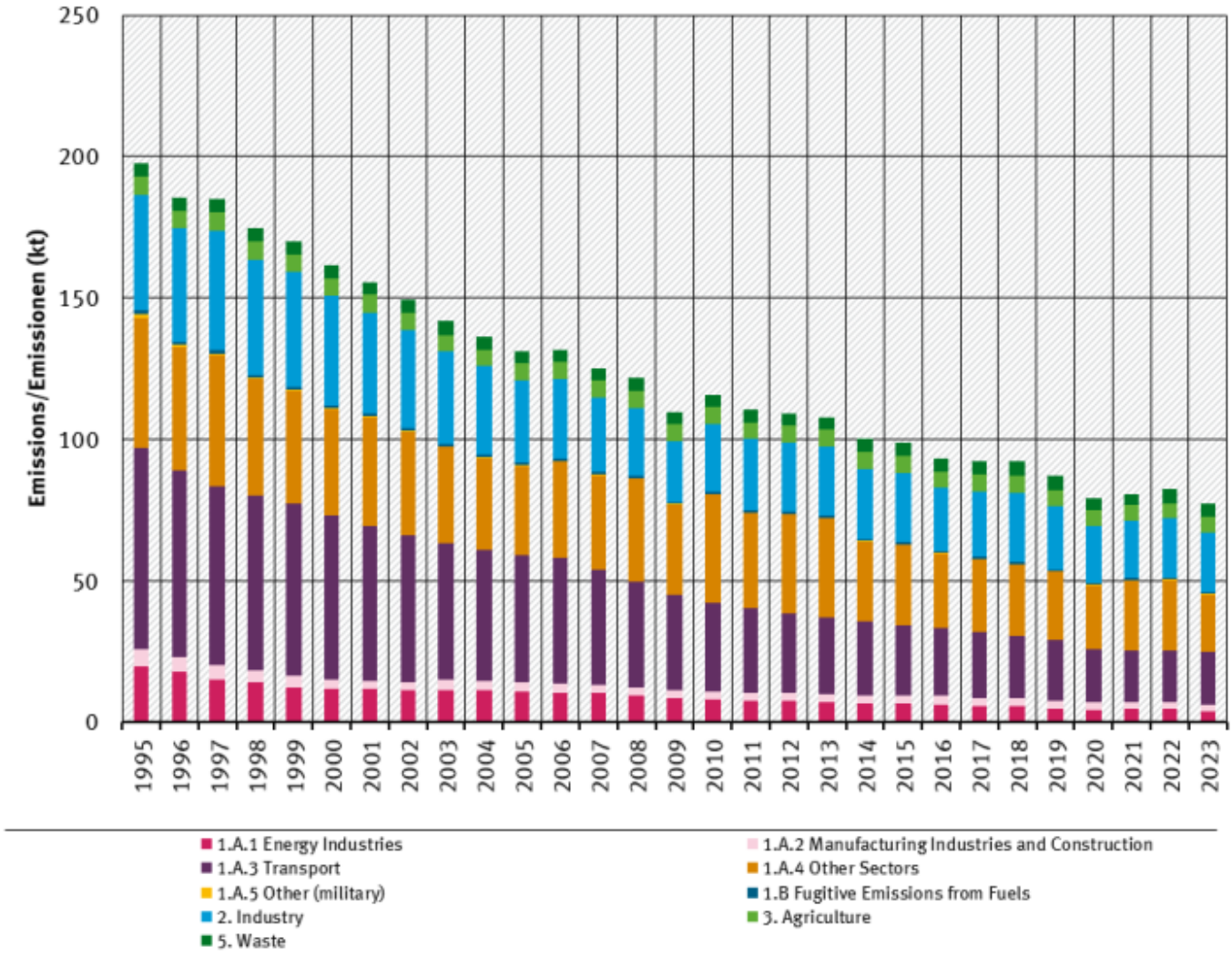
Within both National totals and NFR 1.A, **Transport (NFR 1.A.3)** is responsible for the biggest part of $PM_{2.5}$ emissions. Here, about 77% of 2019 $PM_{2.5}$ transport emissions are induced by **Road Transport (NFR 1.A.3.b)**, caused by two third directly by fuel consumption **(NFR 1.A.3.b.i - v)** and the other third by road abrasion and tyre and brake wear **(NFR 1.A.3.b.vi - vii)**.

Table: $PM_{2.5}$ emissions 1990-2023, in kilotonnes [kt]

																	Trend: latest compared to	
1995	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**1995**	**previous year**
197	162	131	116	111	109	108	100	99	93	92	92	87	79	81	82	77	-60.8%	-5.9%

Fine Particulate Matter / Feinstaub (PM2.5)

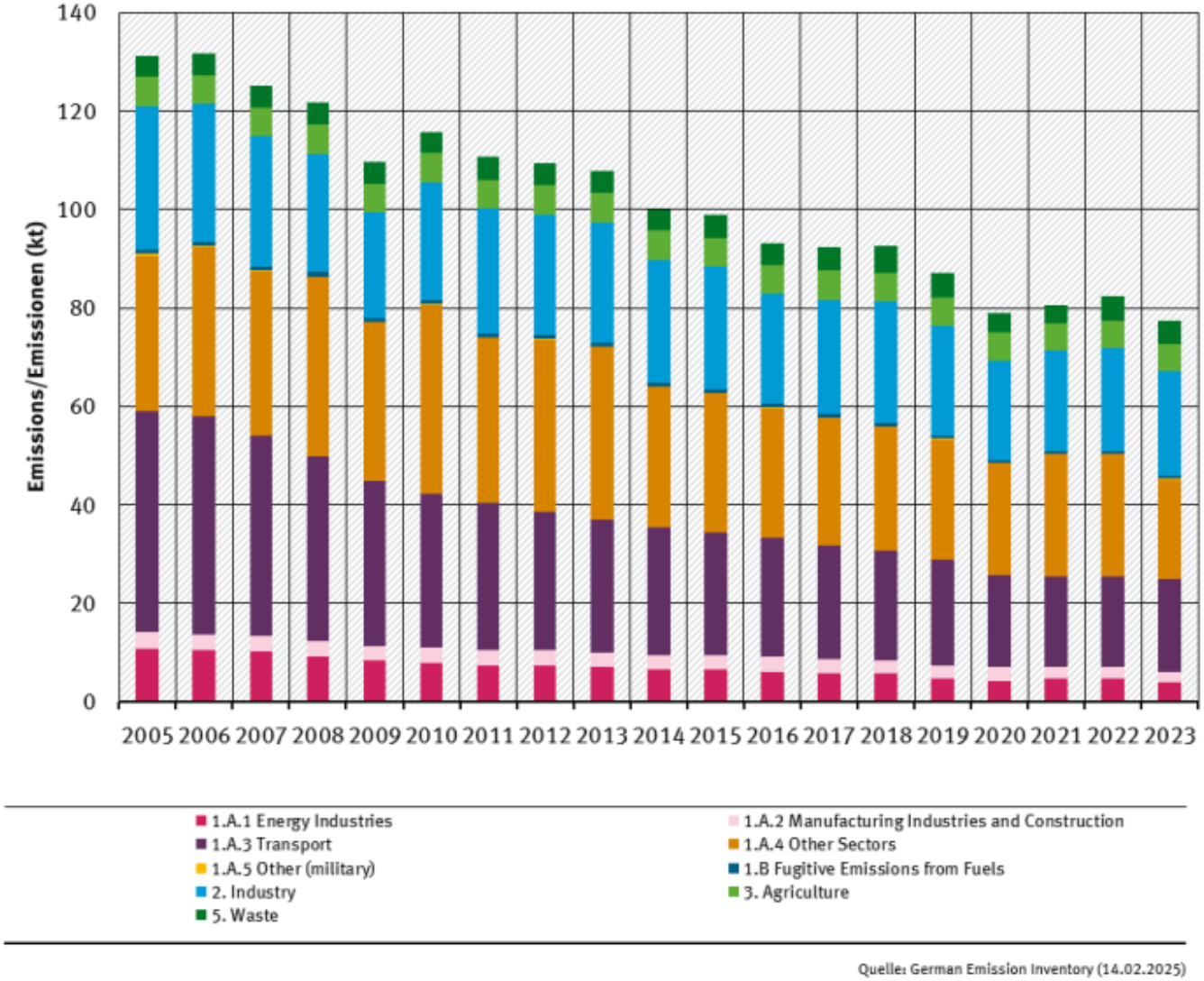
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (14.02.2025)

Fine Particulate Matter / Feinstaub (PM2.5)

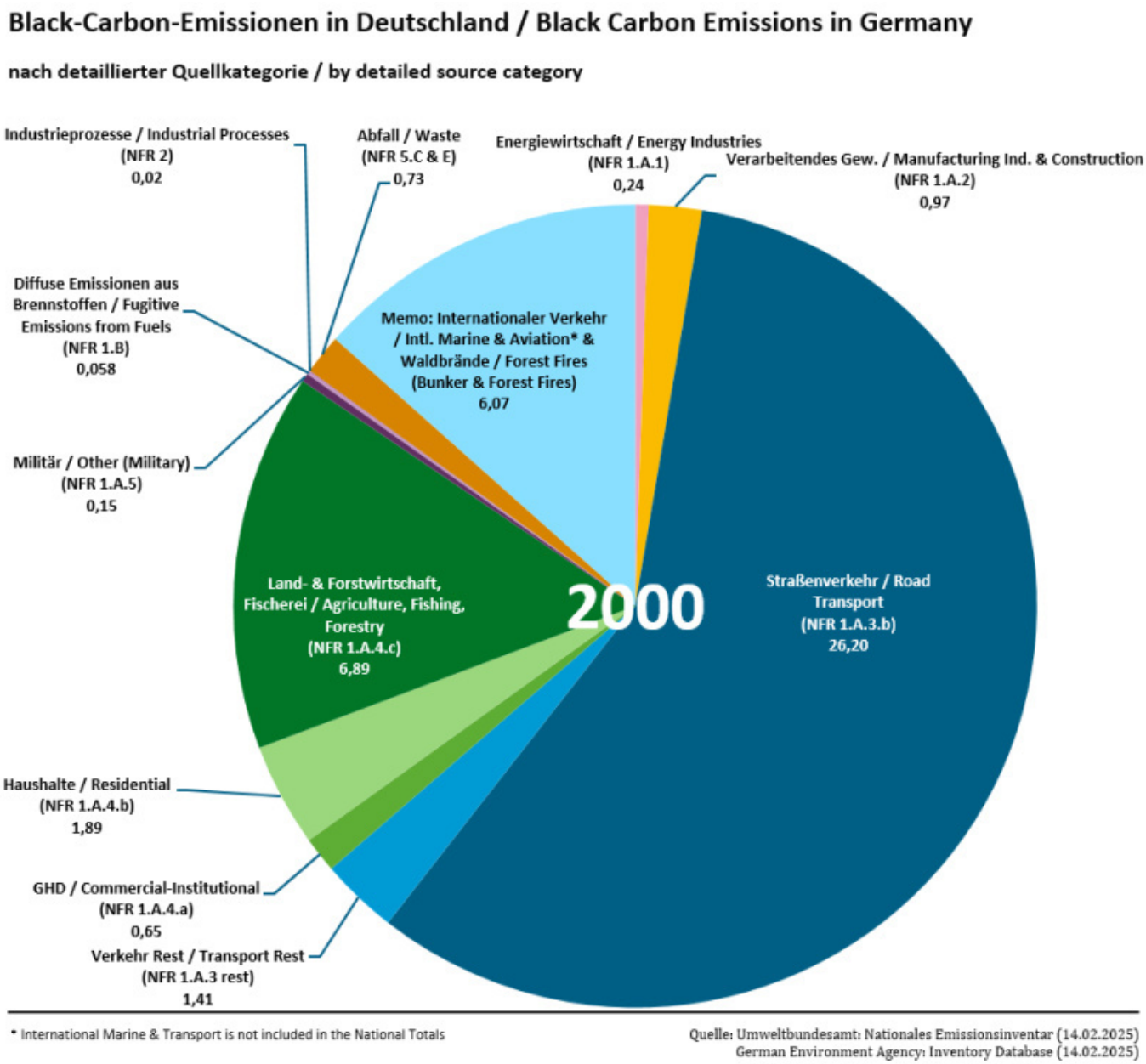
Emissions per Sector / Sektorale Emissionen

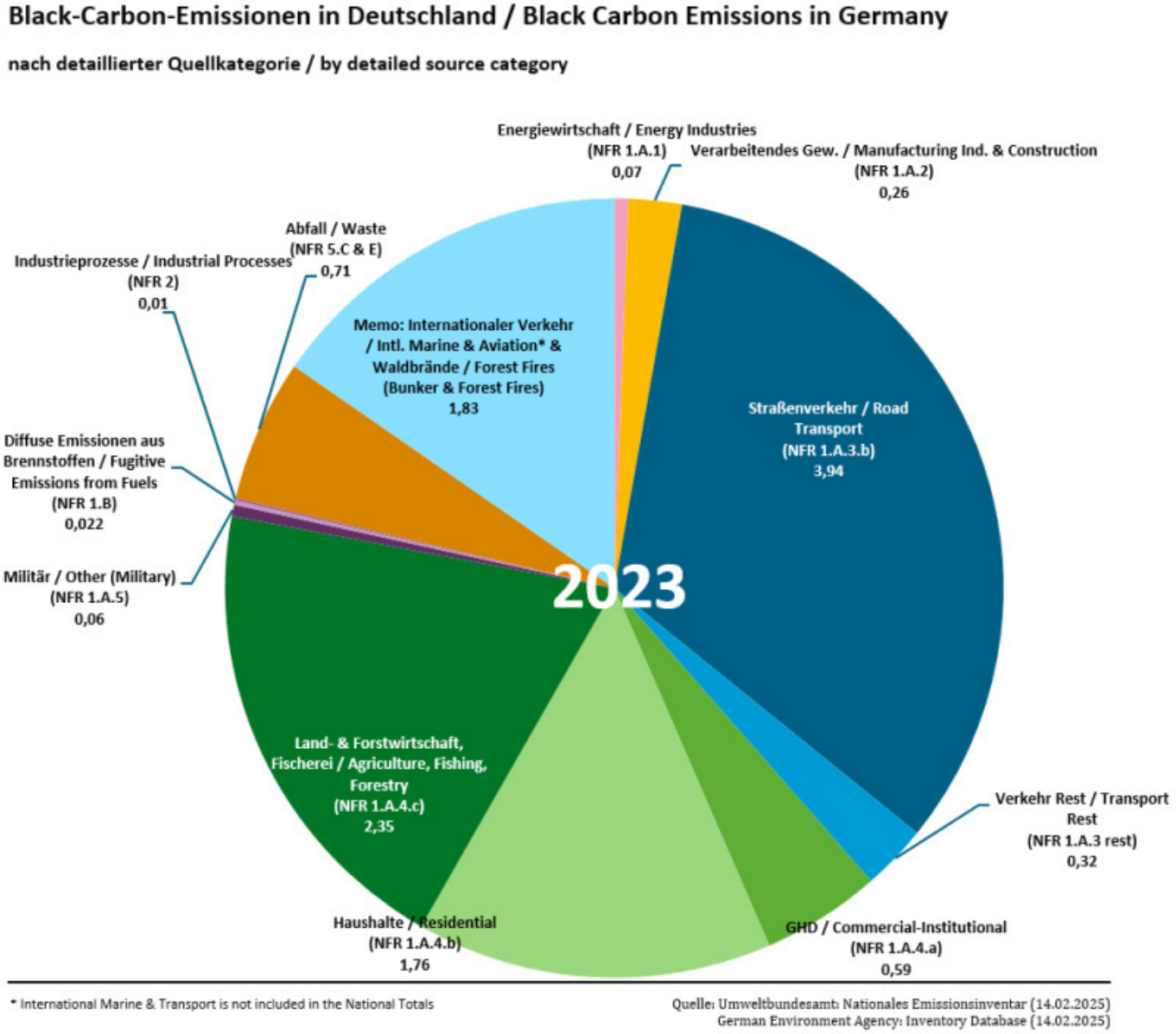


Quelle: German Emission Inventory (14.02.2025)

Emission Trends BC

Germany reports Black Carbon (BC) emissions for all years from 2000 onward. The main sources are transport as well as mobile and stationary combustion. Germany uses the EMEP/EEA 2016 Guidebook to estimate BC emissions, augmented by some country specific emission factors, i.e. split factors for the BC portion of $PM_{2.5}$, in particular in road transport. The following figure provides an overview on the sources and their respective contribution to the German national total.





Main drivers

Between 2000 and 2023, **Total Black Carbon emissions dropped by 76%**.

The main drivers are the **transport emissions (NFR 1.A.3)** with 70% of total 2000 emissions, and a 85% reduction between 2000 and 2023. Over the entire time series, 90% of the transport emissions come from **Road Transport (NFR 1.A.3.b)**. The overlying trend towards more diesel cars in the German fleet slowed the decrease in emission over this period (see figure below).

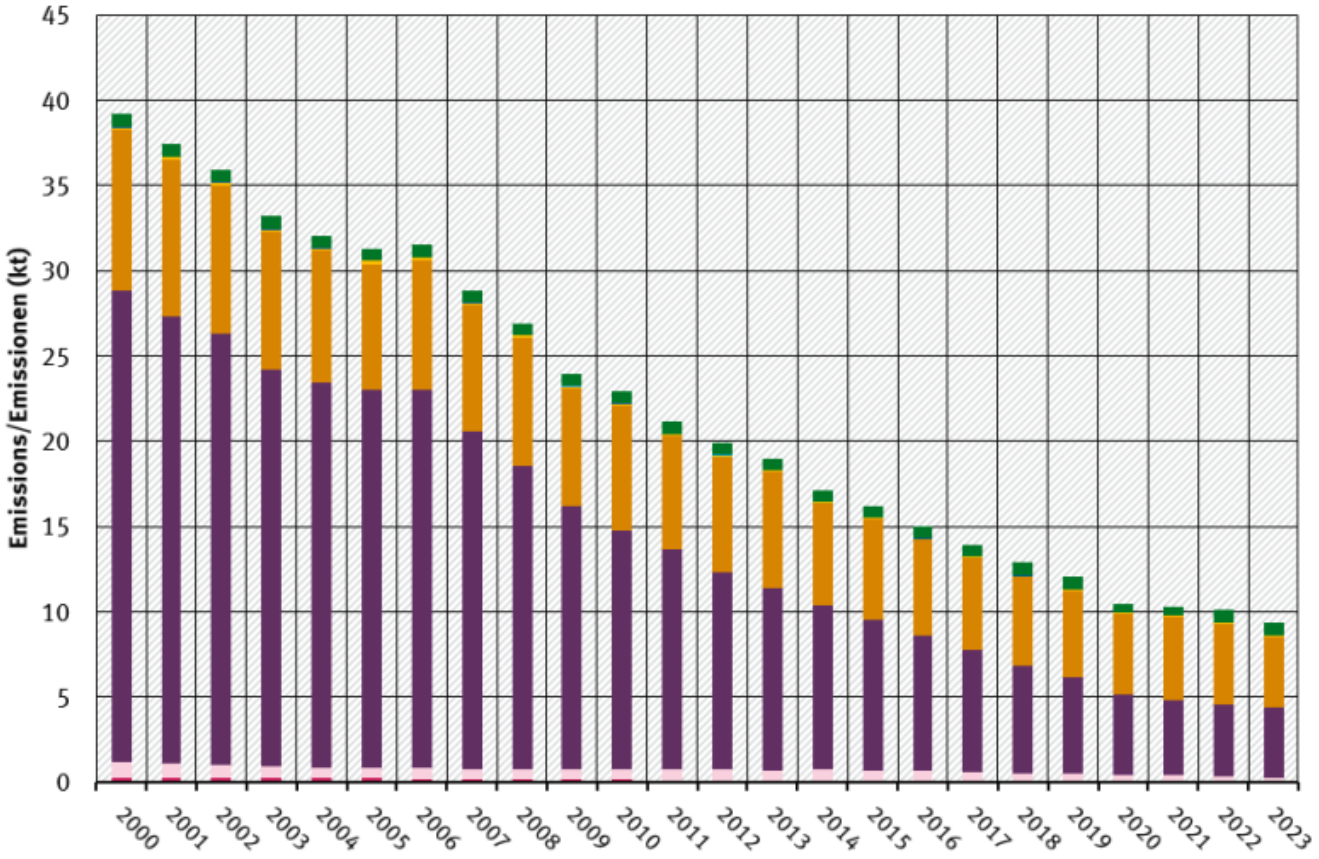
24% of the 2000 total emissions result from **Other Sectors (NFR 1.A.4)**, mostly from residential stationary combustion and mobile sources therein, with a 56% reduction between 2000 and 2023.

Table: Black Carbon emissions 1990-2023, in kilotonnes [kt]

																Trend: latest compared to	
2000	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2000**	**previous year**
39	31	23	21	20	19	17	16	15	14	13	12	10	10	10	9	-76.1%	-7.3%

Black Carbon (BC)

Emissions per Sector / Sektorale Emissionen



- 1.A.1 Energy Industries
- 1.A.2 Manufacturing Industries and Construction
- 1.A.3 Transport
- 1.A.4 Other Sectors
- 1.A.5 Other (military)
- 1.B Fugitive Emissions from Fuels
- 2. Industry
- 3. Agriculture
- 5. Waste

Black Carbon emissions from 2000 / Black Carbon Emissionen erst ab 2000

Quelle: German Emission Inventory (14.02.2025)

Explanation of Key Trends - Persistent Organic Pollutants

Please note: Data for persistent organic pollutants may have issues such as missing sources. It features considerably higher uncertainties then data for other pollutants covered in this report. Read more...

Obligations

The 1998 Aarhus Protocol on Persistent Organic Pollutants under the CLRTAP entered into force late in 2003. It focuses on a list of 16 substances that have been singled out according to agreed risk criteria. The substances comprise eleven pesticides, two industrial chemicals and three by-products/contaminants. The ultimate objective is to eliminate any discharges, emissions and losses of POPs.

The Protocol bans the production and use of some products outright (aldrin, chlordane, chlordecone, dieldrin, endrin, hexabromobiphenyl, mirex and toxaphene). Others are scheduled for elimination at a later stage (DDT, heptachlor, hexaclorobenzene, PCBs).

Finally, the Protocol severely restricts the use of DDT, HCH (including lindane) and PCBs. The Protocol includes provisions for dealing with the wastes of products that will be banned. It also obliges Germany to reduce its emissions of dioxins, furans, PAHs and HCB below their levels in 1990. For the incineration of municipal, hazardous and medical waste, it lays down specific limit values.

Main drivers

Persistent organic pollutants give a mixed picture both in terms of development and sources.

All POP emissions **decreased substantially between 1990 and 2022**:

- Dioxins (Teq) by 86,6%,
- PCBs by 87,7%,
- HCB by 99.8%

and

- the PAH Total by 33,7%

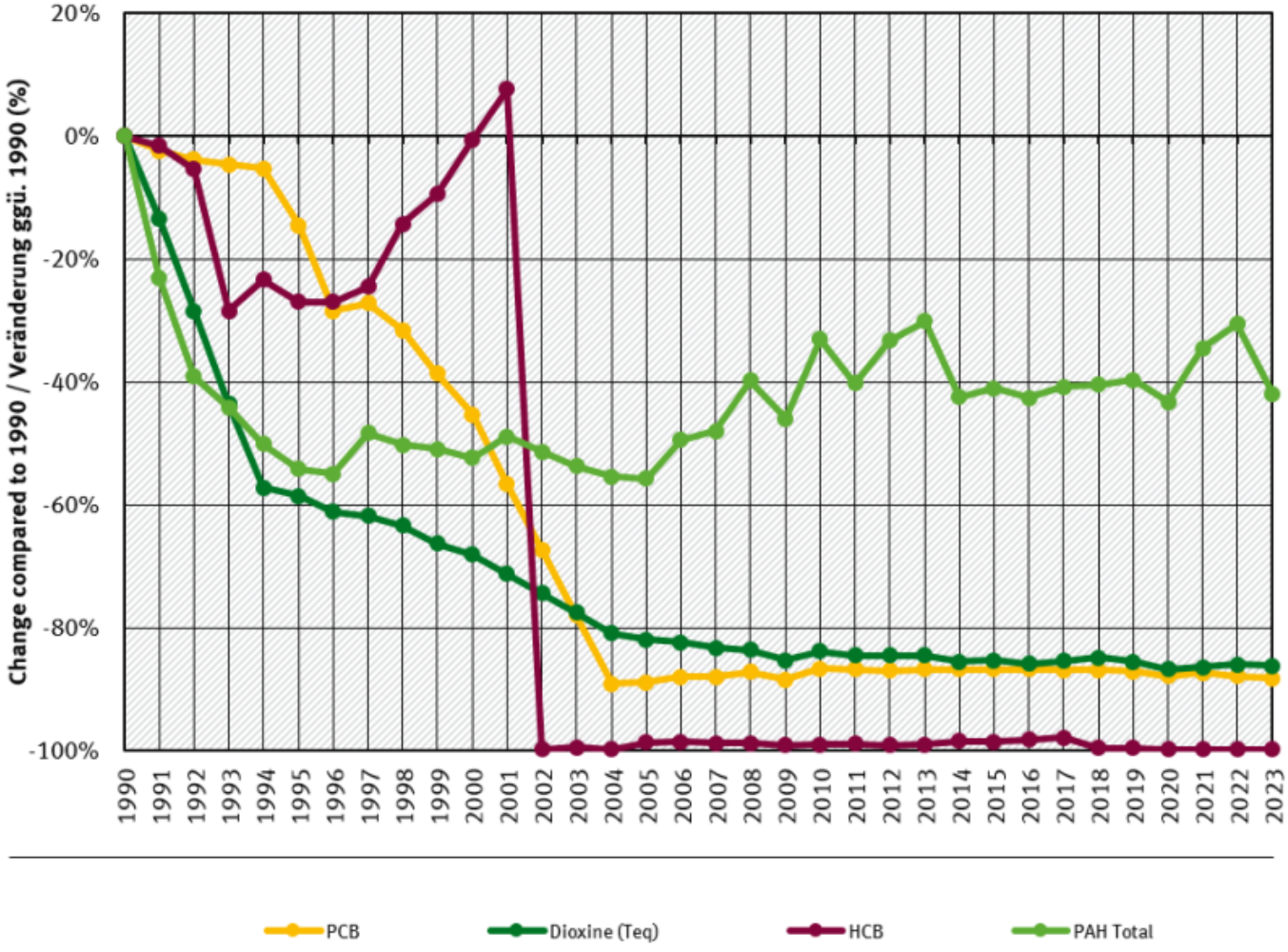
However, uncertainties are significantly higher than for the other air pollutants reported.

Trends

The figure below shows trends for the main groups of persistent organic pollutants:

Persistant Organic Pollutants (POP)

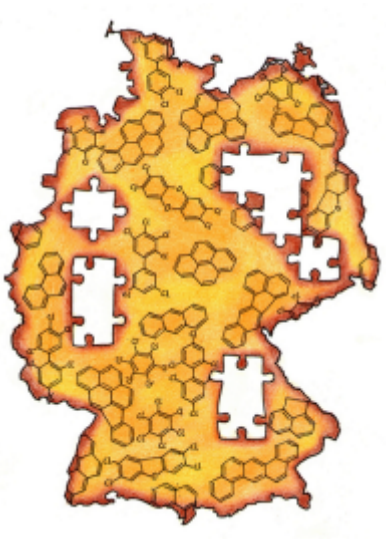
Emission Trends / Emissionstrends



Quelle: German Emission Inventory (14.02.2025)

State of the German POP inventory

Generally, and despite a lot of improvements implemented in recent years, the German POP inventory is still incomplete. There are some source categories missing, in particular those where data availability is an issue. Measurement data for POP emission factors is hard to come by, and where available these are regularly annotated with high uncertainties. Moreover, creating consistent time series for POP emission factors is challenging, even for sources with EFs measured recently, since historic data (e.g. for 1990) is even harder to find. Not in any case it's possible to fill the gaps with default values, since default POPs emission factors are often very high and not in line with German legislation. In such cases, the default value would be an important source of inconsistency, which may cause an infringement procedure.



Current reporting

The quality of reporting varies greatly inside the POP inventory, depending on the (group of) pollutant in question:

Dioxins/ Furans

Due to current legislation, data availability is relatively good. There are measurement data for waste incineration plants and steel industry installations both for 1990 and current years. Therefore, the two most important sources are well covered. For small combustion (in particular wood), where total activity and emissions increased in recent years, measurement data is available. These emission factors come with high uncertainties, since dioxin emissions depend largely on the fuel used and on combustion conditions. Since we have to cover about 9 million small wood combustion installations in Germany, it is hard to model a consistent usage pattern. Furthermore there is a high degree of uncertainty regarding the quality of the firewood, which is used in small combustion plants. Actually the fuel quality is required by law, controlled by the chimney sweeper. However, illegal waste wood burning cannot be averted. But it's not possible to estimate the resulting emissions. Despite these problems, the German POP inventory is reasonably complete for dioxins and furans. The only known missing sources are small scale waste burning (in particular gardening waste burning) and accidental fires (which are very hard to quantify regarding dioxin emissions). Both small scale waste burning and fires are considered to show a decreasing trend and to be less common then in other counties.

PAHs

PAHs result from incomplete combustion. The by far most important source category in the German inventory for PAHs is small combustion. The same problems as for dioxins apply: emission factors are available but show high uncertainties, usage pattern are hard to model and regulate. Other sources include steel and mineral industry, power plants, and waste incineration plants. The quality of emission factors for these categories is very diverse. Moreover, different PAHs are given for different sectors (Borneff, US EPA, or others). For the 4 expected single substances, very few data are available, with the possible exception of benzo(a)pyrene. As a result, the PAHs emissions in the inventory are likely to be overestimated. Overall, the German PAH inventory is quite complete, since most emission come from relatively well regulated combustion processes. As for dioxins and furans, small scale waste burning and forest fires are not covered.

HCB

Data availability for HCB is considerably worse than for dioxins/furans and PAHs. The pollutant is currently not measured at

installations, since it is not subject to regulation. Therefore, the German inventory uses mainly default factors from the EEA/EMEP Guidebook, which do not fit well into time series. In addition, some important sources are missing, such as HCB emission from smoke munitions. With submission 2016 HCB emissions from pesticide use in the agricultural sector are reported the first time. Other categories that might have HCB emission, but are currently not covered due to missing measurements include chemical industry, metal industry and cement production. Nonetheless, some country specific emission factors for key categories are available.

PCBs

PCBs from waste incineration is well covered and regularly measured at facility level due to current legislation. Data availability is appropriate. For other industry sectors very few measurements are taken and, again, have considerable uncertainties. In particular information for 1990 is hard to come by, rendering the creation of a consistent time series a tough task. All together, the data availability is slightly better than for HCBs. Nevertheless, the PCB inventory is still incomplete and misses out on probably important source categories, such as PCB emissions from electrical equipment (capacitors and transformers). Furthermore, in Germany mainly the Ballschmiter value is measured, which is: (PCB 28, 52, 101, 138, 153, 180)* 5. In contrast to the WHO 2005: (77, 81, 126, 169, 105, 114, 118, 123, 156, 157, 167, 189) TEQ. The measured congeneres are completely different. On the basis of currently available information (only a few measurements), Ballschmiter PCBs seem to be remarkable higher than the associated WHO TEQ.

Future improvements

The first step towards an improved German POP inventory is to thoroughly check existing information (mainly EFs), to bring these up to date and to identify sources and pollutant combinations that need new measurements most. Correlation to immission data (POP trends measured in the local environment) can help to check for trends to be expected for each pollutant. Examination of regional differences in immission data can also give clues pointing at key categories. Working closely with the industry, the German inventory team already had the chance to improve some sources and acquire measurement result for some categories (e.g. HCB from waste incineration and the copper industry). This work should continue. More generally, the goal should be to carry out new measurements in respect to the priorities identified in step 1. This is of course subject to resource availability, since POP measurements are quite expensive. The new measurements should cover the whole spectrum of POPs in order to get a consistent resulting inventory. More knowledge on the relationship between different POPs (in terms of values for emission factors) would possibly allow to close gaps and to infer on historic values currently not available.

Due to the lack of measurement data it's necessary to collect all available information and to exchange experiences at international level. Therefore the “informal network of POPs inventory compiler” is a good opportunity for all participants to varify inventory data.

Explanation of Key Trends - Heavy Metals



Please note: Data for heavy metals may have issues such as missing sources. It features considerably higher uncertainties then data for other pollutants covered in this report.

Obligations

The 1998 Aarhus Protocol on Heavy Metals under the CLRTAP entered into force late in 2003. It targets three particularly harmful metals: cadmium, lead and mercury. According to one of the basic obligations, Germany has to reduce its emissions for these three metals below their levels in 1990.

The Protocol aims to cut emissions from industrial sources (iron and steel industry, non-ferrous metal industry), combustion processes (power generation, road transport) and waste incineration. It defines stringent limit values for emissions from stationary sources and suggests best available techniques (BAT) for these sources, such as special filters or scrubbers for combustion sources or mercury-free processes. The Protocol requires Parties to phase out leaded petrol.

It also introduces measures to lower heavy metal emissions from other products, such as mercury in batteries, and proposes the introduction of management measures for other mercury-containing products, such as electrical components (thermostats, switches), measuring devices (thermometers, manometers, barometers), fluorescent lamps, dental amalgam, pesticides and paint.

Main drivers

Emission of priority heavy metals (cadmium, lead and mercury) **decreased significantly since 1990**. Most values show reductions by about 50 to 93% compared to the base year, with the majority of the achievements originating from the early 1990's though.

Overview of percental decreases in HM emissions since 1990:

- Arsenic: -94.1%
- Cadmium: -67.8%
- Copper: -5.7%
- Chrome: -60.4%
- Mercury: -84.7%
- Nickel: -63.0%
- Lead: -92.0%
- Selenium: -53.3%
- Zinc: -40.0%

2019 and 2020 emissions saw a substantial reduction trend for most heavy metals.

The main source for most heavy metals is fuel combustion and production processes: **Energy Industries (NFR 1.A.1)** and **Industrial Processes (NFR 2)**, especially, of course, the Metal Industries (NFR 2.C) emit the majority of **arsenic, cadmium, chrome, lead, mercury and nickel**.

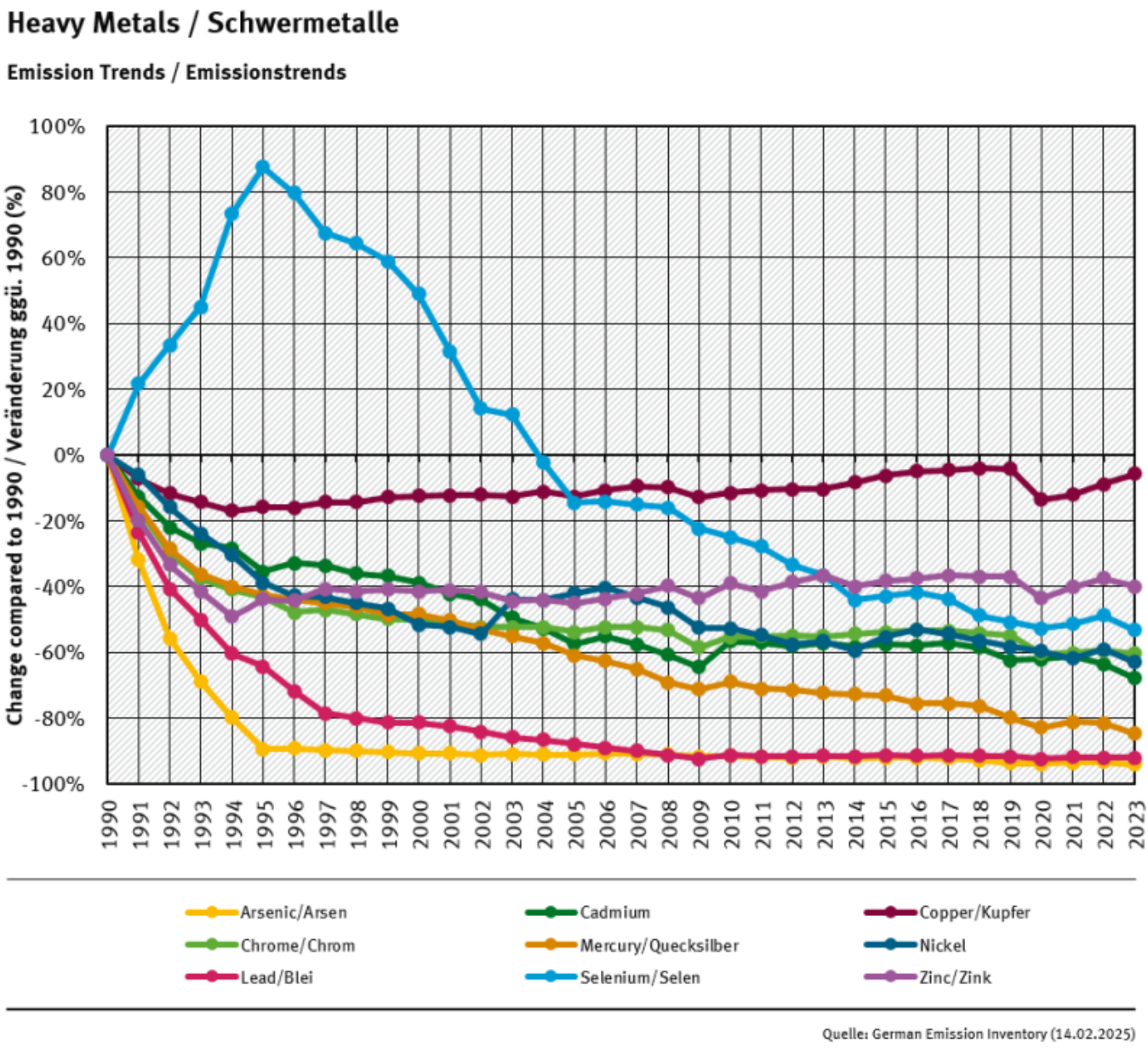
In contrast, **copper and zinc** emissions are mostly governed by the **Transport (NFR 1.A.3)** sector, resulting mostly from brake and tyre wear. Thus, trends are connected directly with the annual mileage.

Selenium on the other hand originates mainly from **Mineral Industry (NFR 2.A)** and to a lesser degree from Transport (NFR 1.A.3).

Other sources are still to be investigated but generally expected to add little to the total trend.

Trends

The figure below shows emission trends for heavy metals:



SECTROR CHAPTERS - OVERVIEW

The folling table provides a comprehensive list of the separate sector chapters included in this Informative Inventory Report.

NFR 1 - ENERGY
1.A - FUEL COMBUSTION ACTIVITIES
1.A.1 - Energy Industries
1.A.1.a - Public electricity and heat production
1.A.1.b - Petroleum refining
1.A.1.c - Manufacture of solid fuels and other energy industries
1.A.2 - Fuel Combustion Activities in Industries and Construction
1.A.2.a - Stationary combustion in manufacturing industries and construction: Iron and Steel
1.A.2.b - Stationary combustion in manufacturing industries and construction: Non-ferrous Metals
1.A.2.c - Stationary combustion in manufacturing industries and construction: Chemicals
1.A.2.d - Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print
1.A.2.e - Stationary combustion in manufacturing industries and construction: Food Processing, Beverages and Tobacco
1.A.2.f - Stationary combustion in manufacturing industries and construction: Non-Metallic Minerals
1.A.2.g viii - Stationary Combustion in Manufacturing Industries & Construction: Other
1.A.2.g vii - Mobile Combustion in Manufacturing Industries & Construction
1.A.3 - Transport
1.A.3.a - Civil Aviation
1.A.3.a i (i) - International Civil Aviation: LTO
1.A.3.a ii (i) - Domestic Civil Aviation: LTO
1.A.3.a i (ii) - International Civil Aviation: Cruise
1.A.3.a ii (ii) - Domestic Civil Aviation: Cruise
1.A.3.b - Road Transport
1.A.3.bi-iv - Emissions from Fuel Combustion in Road Vehicles (Overview)
1.A.3.b i - Road Transport: Passenger Cars
1.A.3.b ii - Road Transport: Light duty vehicles
1.A.3.b iii - Road Transport: Heavy duty vehicles
1.A.3.b iv - Road Transport: Mopeds & Motorcycles
1.A.3.b v - Gasoline Evaporation
1.A.3.b vi-vii - Emissions from Wear and Abrasion in Road Transport (Overview)
1.A.3.b vi - Road Transport: Tyre and Brake Wear
1.A.3.b vii - Road Transport: Road Abrasion
1.A.3.c - Railways
1.A.3.d - Navigation
1.A.3.d i - International Maritime Navigation
1.A.3.d i (ii) - International Inland Navigation
1.A.3.d ii - National Navigation
1.A.3.e - Other Transport
1.A.3.e i - Pipeline Transport
1.A.4 - Small Combustion
1.A.4.a i - Commercial and Institutional - Stationary Combustion
1.A.4.b i - Residential - Stationary Combustion
1.A.4.c i - Agriculture, Forestry, Fishing - Stationary Combustion
1.A.4.a ii - Commercial / Institutional: Mobile
1.A.4.b ii - Residential: Household and Gardening: Mobile
1.A.4.c ii - Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery
1.A.4.c iii - Agriculture/Forestry/Fishing: National Fishing
1.A.5 - Other (including Military)
1.A.5.a - Other: Stationary (including Military)
1.A.5.b - Other: Mobile (including Military)
1.B - FUGITIVE EMISSIONS FROM FUELS
1.B.1 - Solid Fuels

NFR 1 - ENERGY
1.B.2.a - Oil
1.B.2.b - Natural Gas
1.B.2.c - Flaring
NFR 2 - INDUSTRIAL PROCESSES & PRODUCT USE (IPPU)
2.A - MINERAL INDUSTRY - Overview
2.A.1 - Cement Production
2.A.2 - Lime Production
2.A.3 - Glass Production
2.A.5.a - Quarrying and Mining of Minerals other than Coal
2.A.5.b - Construction and Demolition
2.A.5.c - Storage, Handling and Transport of Mineral Products
2.A.6 - Other Mineral Products
2.B - CHEMICAL INDUSTRY
2.B.1 - Ammonia Production
2.B.2 - Nitric Acid Production
2.B.3 - Adipic Acid Production
2.B.5 - Carbide Production
2.B.6 - Titanium Dioxide Production
2.B.7 - Soda Ash Production
2.B.10.a - Other
2.B.10.b - Storage, Handling and Transport of Chemical Products
2.C - METAL PRODUCTION
2.C.1 - Iron and Steel Production
2.C.2 - Ferroalloys Production
2.C.3 - Aluminum Production
2.C.4 - Magnesium Production
2.C.5 - Lead Production
2.C.6 - Zinc Production
2.C.7.a - Copper Production
2.C.7.b - Nickel Production
2.C.7.c - Other Metal_Production
2.C.7.d - Storage, Handling and Transport of Metal Products
2.D - OTHER SOLVENT & PRODUCT USE
2.D.3.a - Domestic Solvent Use including fungicides
2.D.3.b - Road Paving with Asphalt
2.D.3.c - Asphalt Roofing
2.D.3.d - Coating Applications
2.D.3.e - Degreasing
2.D.3.f - Dry Cleaning
2.D.3.g - Chemical Products
2.D.3.h - Printing
2.D.3.i - Other Solvent Use
2.G - OTHER PRODUCT USE
2.G.4 - Use of Fireworks
2.G.4 - Use of Tobacco
2.G.4 - Charcoal
2.H - Other (Pulp & Paper, Food)
2.H.1 - Pulp and Paper Industry
2.H.2 - Food and Beverages Industry
2.H.3 - Other Industrial Processes
2.I - Wood Processing
2.J - Production of POPs
2.K - Consumption of POPs and Heavy Metals
2.L - Other Production, Consumption, Storage, Transportation or Handling of Bulk Products
2.L(a) - Handling of Bulk Products

NFR 1 - ENERGY
2.L(b) - Diffuse Emissions From Industrial Establishments
NFR 3 - AGRICULTURE
3.B - Manure Management
3.D - Agricultural Soils
3.F - Field Burning Of Agricultural Residues
3.I - Agricultural: Other
NFR 5 - WASTE
5.A - Biological Treatment of Waste - Solid Waste Disposal on Land
5.B.1 - Biological treatment of waste - Composting
5.B.2 - Biological treatment of waste - Anaerobic digestion at biogas facilities
5.C.1.b.v - Cremation
5.C.2 - Open Burning of Waste
5.D.1 - Domestic & Commercial Wastewater Handling
5.D.2 - Industrial Wastewater Handling
5.E.1 - Other Waste: Mechanical-biological Treatment of Waste
5.E.2 - Building and Car Fires
NFR 6 - OTHER SOURCES
6.A.1 - Emissions from human sweating and breathing
6.A.2 - Ammonia emissions from pets
NFR 11 - NATURAL SOURCES
11.B - Forest Fires

CHAPTER 3: NFR 1 - Energy

Energy and heat generation constitute the most important sources of emissions in Germany. This holds true for almost every pollutant (a prominent exception of this rule being ammonia, mainly from agriculture). Consequently, this section will look into the sub-sectors making up the *NFR 1 - Energy* sector with great detail. For overview information on key activity statistics and the basis for fuel based estimates please refer to Chapter 1.4 - Methods and Data Sources.

NFR 1 consists of the following sub-categories:

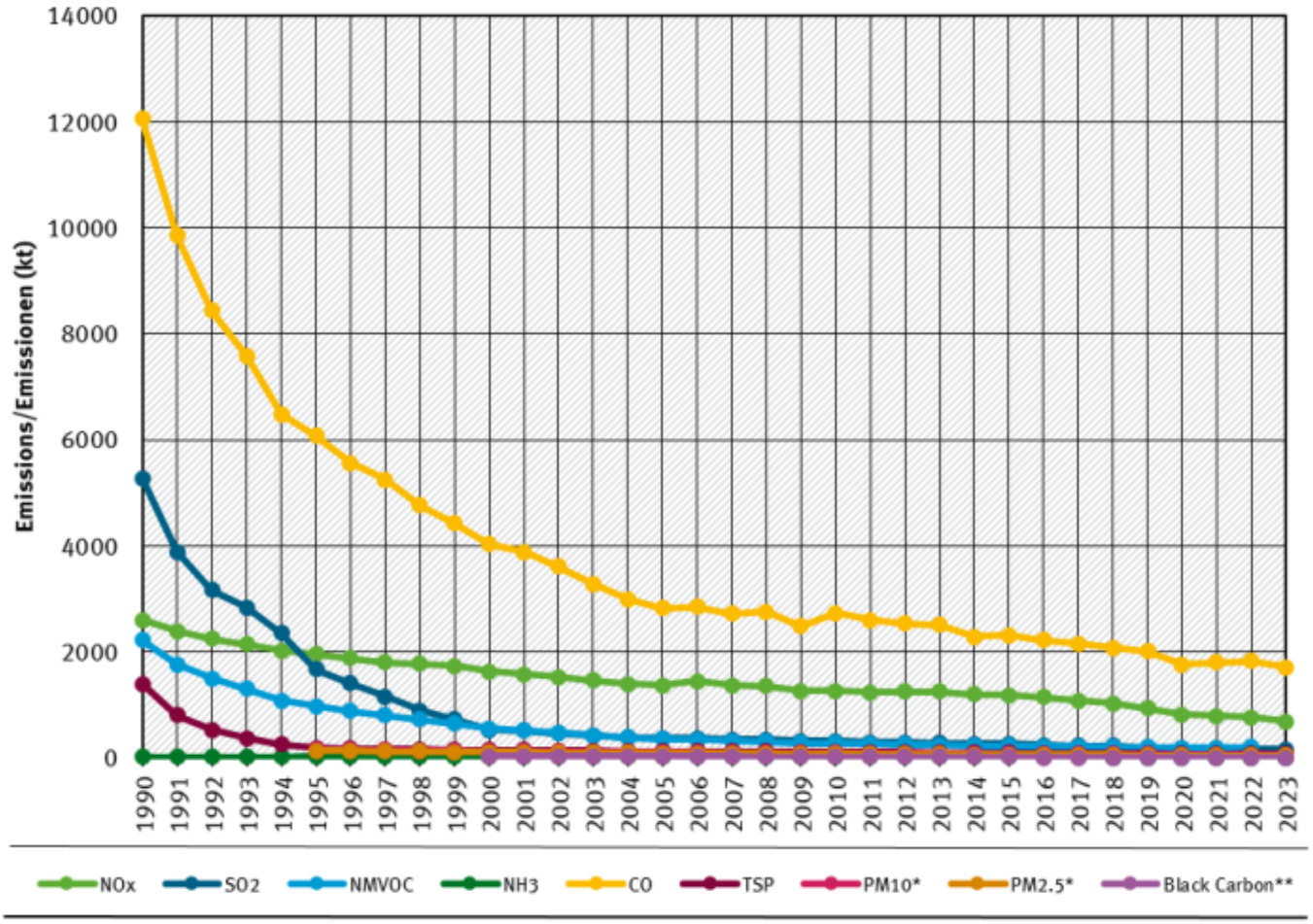
NFR-Code	Name of category
1.A	**Fuel Combustion Activities**
1.A.1	Energy Industries
1.A.2	Fuel Combustion Activities in Industries and Construction
1.A.3	Transport
1.A.4	Small Combustion
1.A.5	Other (including Military)
1.B	**Fugitive Emissions**
1.B.1	Solid Fuels
1.B.2.a	Liquid Fuels
1.B.2.b	Gaseous Fuels
1.B.2.c	Flaring
1.B.3	Geothermal Energy

Visual overview

Emission trends for main pollutants in *NFR 1 - Energy*:

Energy/Energie (NFR 1)

Emissions by pollutant / Emissionen nach Schadstoff

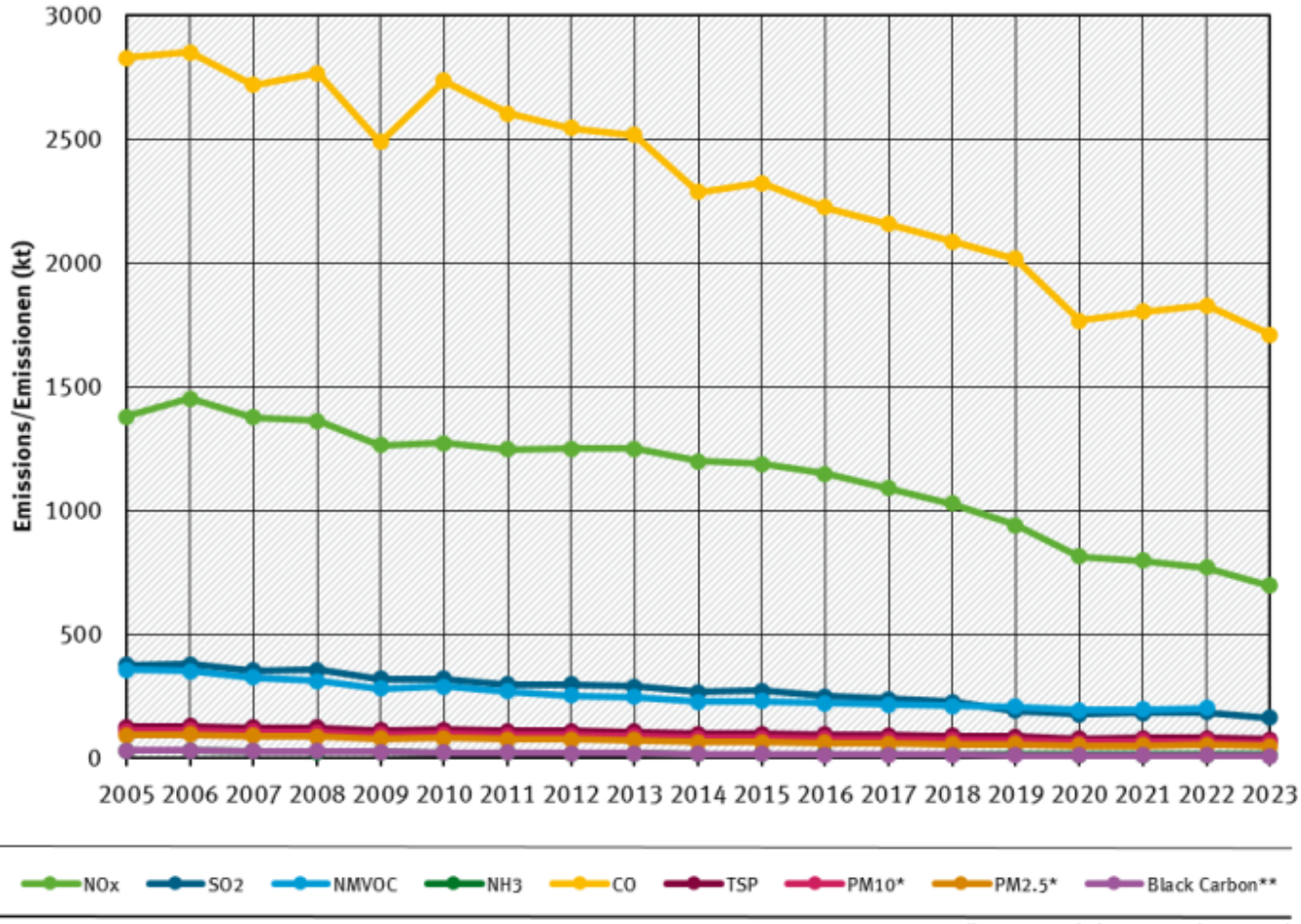


* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995
** Black Carbon emissions from 2000 / Black Carbon Emissionen erst ab 2000

Quelle: German Emission Inventory (14.02.2025)

Energy/Energie (NFR 1)

Emissions by pollutant / Emissionen nach Schadstoff



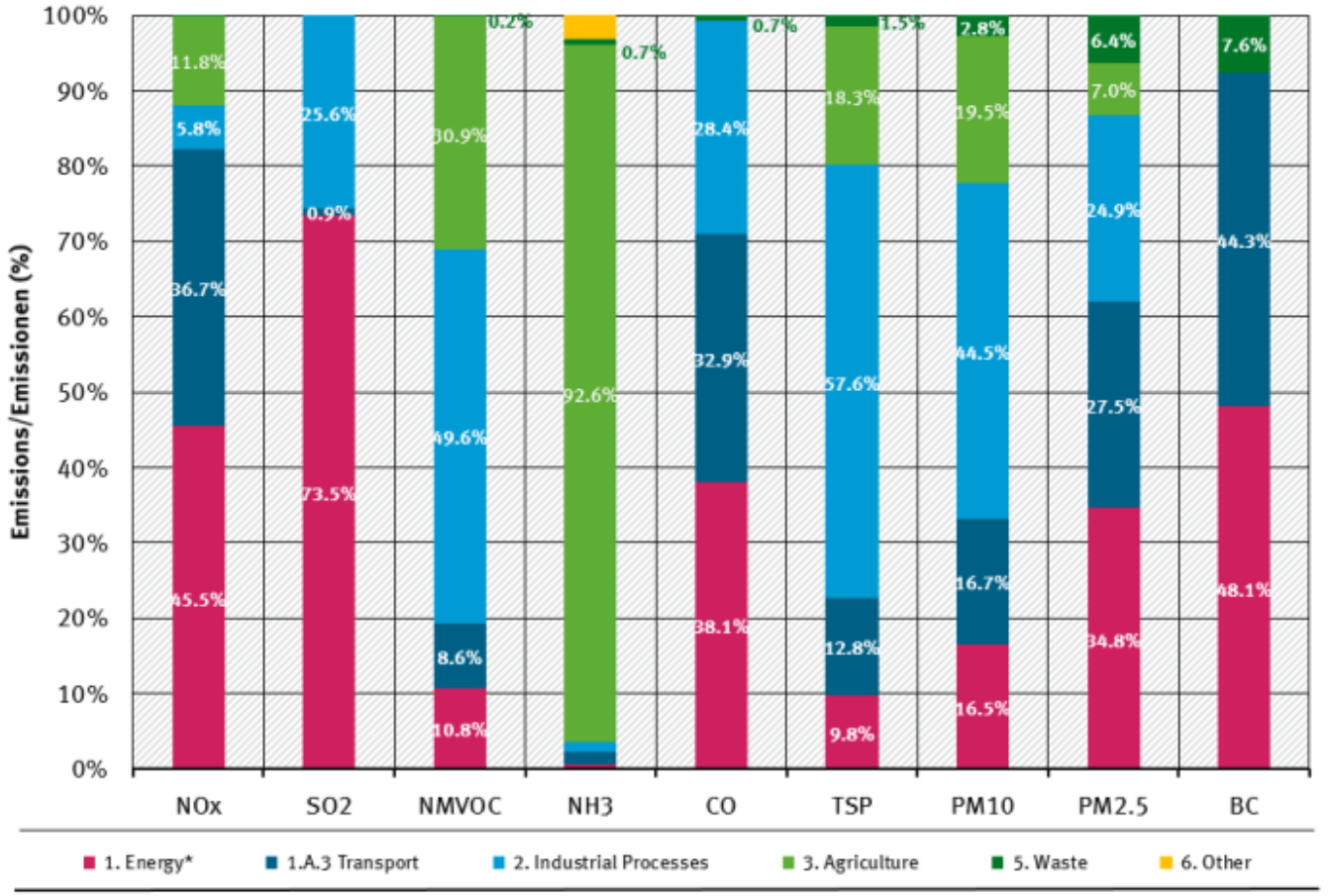
* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995
** Black Carbon emissions from 2000 / Black Carbon Emissionen erst ab 2000

Quelle: German Emission Inventory (14.02.2025)

Contribution of NFRs 1 to 6 to the National Totals, for 2023

Contribution of NFR categories to the emissions

percentages per air pollutant, 2023



* w/o Transport / ohne Verkehr (1.A.3)

Quelle: German Emission Inventory (17.03.2025)

1.A - Fuel Combustion Activities (OVERVIEW)

NFR-Code	Name of Category
1.A	**Fuel Combustion**
consisting of / including source categories	
1.A.1	Energy Industries
1.A.2	Fuel Combustion Activities in Industries and Construction
1.A.3	Transport
1.A.4	Small Combustion
1.A.5	Other (including Military)

1.A.1 - Energy: Energy Industries (OVERVIEW)

NFR-Code	Name of Category	Method	AD	EF	Key Category
1.A.1	**Energy - Energy Industries**	*see sub-category details*			
consisting of / including source categories					
1.A.1.a	Public electricity and heat production	*see sub-category details*			
1.A.1.b	Petroleum refining	*see sub-category details*			
1.A.1.c	Manufacture of solid fuels and other energy industries	*see sub-category details*			

1.A.1.a - Public Electricity And Heat Production

Short description



Source category *1.A.1.a - Public Electricity and Heat Production* comprises district heating plants and electricity and heat production of power plants. Waste incineration is also included.

NFR Code	Method	AD	EF
1.A.1.a	T2	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	**SO_2**	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	**CO**	Pb	**Cd**	**Hg**	As	Cr	Cu	Ni	Se	Zn	**PCDD/F**	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	**HCB**	PCBs
L/T	-/-	**L/T**	-/-	**L/T**	**L/T**	**L/T**	-/-	**L/-**	-/-	**L/T**	**L/T**	**L/T**	**L/T**	**L/T**	**L/T**	-/-	**L/T**	**L/T**	-/-	-/-	-/-	-/-	-/-	**L/-**	**L/T**

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

A method amounting to Tier 2 is used for emission reporting. This means the use of country-specific data at a more detailed level. Emission factors and activity data are available for different fuel types, different technologies, plant size, etc. The use of plant-specific data for a bottom-up approach is not possible. There are fuel data including NO_x, SO_x and TSP emissions for large combustion plants, but only measured and verified data were used.

Activity data

Conventional fuels

The key source of all conventional fuels is the National Energy Balance (NEB) [1)]. The fuel input for electricity production is given in line 11 (“Public thermal power stations”) of the National Energy Balance. The fuel inputs for public heat production are given in lines 15 (“Public cogeneration plants”) and 16 (“District heating stations”). Above-mentioned data from the NEB are summarised fuel consumption data. To get technical details which are needed for calculating emissions, additional statistical data are used.

All the data is filled in to the calculation model “Balance of Emission Sources” which is part of the central database (CSE). The aim of this database is to produce more detailed fuel consumption data which are adjusted to the special technical characteristics of electricity and heat production. As a result, fuel-specific and technology-specific emission factors may be applied to the relevant activity rates. As a result, 142 so called time series were implemented in the database CSE. The year 1990 required a different structure within the database with 154 additional time series, since this was the year of the re-unification in Germany with two different statistical offices and two data systems.

When the calculations for submission 2024 were done, the Energy Balance 2022 was not yet available in its final version. Therefore, for the year 2022 data from the preliminary Energy Balance are used, provided by the Working Group on Energy Balances. Normally, finalization of the energy balance data lead to recalculations for the previous year (for the latest submission also for the years between 2003-2021 due to the updates, please see the recalculations section).

For waste incineration plants, both energy and waste statistics are used to ensure completeness and to avoid double counting.

Biomass

The database for the calculation model consists of the National Energy Balance. Line 14 (“Hydro, wind, photovoltaic and other power stations”) comprises all systems/ plants that generate electricity from biogas, landfill gas, sewage-treatment gas or solid biomass and feed the electricity into the public grid. Since no cut-off limit applies for such systems, this category includes very small systems, too. German statistics provide only electricity generation data of those biomass plants, who feed into the public grid. But the Renewable Energy Act (EEG) does allow a full registration of electricity generation from renewable energies. However, the calculation of fuel data is connected with high uncertainties, since an average generation efficiency is necessary for the conversion.

Waste

Activity data from waste incineration plants are given by the waste statistics of the Federal Statistical Office [2)].

Waste quantities are available at a very detailed level for different economic sectors. Municipal and industrial waste were classified in keeping with the Ordinance on the European Waste Catalogue (AVV), with industrial waste including all waste with waste-classification numbers beginning with the numbers 01 through 19.

Emission factors

Large and medium combustion plants

The underlying data for the emission factors used is provided by the report on the research project “Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010” (Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010“; RENTZ et al, 2002)[3)].

The values for the intermediate years 1996-1999 and 2001-2008 are obtained via linear interpolation.

The project, along with the linear interpolation for the intermediate years, has also provided the underlying data for the source categories 1.A.1.b, 1.A.1.c and 1.A.2.f i, where the factors include power plants, gas turbines or boilers for production of steam and hot/warm water. The research project was carried out by the Franco-German Institute for Environmental research (Deutsch-Französisches Institut für Umweltforschung - DFIU) at the University of Karlsruhe and was completed in late 2002. The project's aim was to determine and evaluate representative emission factors for the years 1995, 2000 and 2010 for the main air pollutants produced by combustion plants and gas turbine plants in Germany that are subject to licensing requirements. This process consists primarily of analysing and characterising the relevant emitter structures, and the pertinent emission factors, for the year 1995, and then of updating the data for the years 2000 and 2010. This procedure systematically determines emission factors for the substances SO_x, NO_x, CO, NMVOC, dust, and N_2O. The process differentiates between 12 coal fuels, 4 liquid fuels, 7 gaseous fuels and firewood. In addition, the available data relative to emission factors of other substances are also compiled; these other substances include PAH, PCDD/F, As, and Cd for combustion systems subject to licensing requirements.

As part of another research project, completed in February 2007, for updating the National Programme in the framework of directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants (“NEC Directive”), individual emission factors for the components SO_2, NO_x and dust were revised in keeping with recent findings.

In 2018 and 2019 SO_2, NO_x, TSP, PM, CO, NH_3 and Hg emission factors were revised for all large combustion plants.[4)] completed in 2011. Since the data set was not complete that time, in some cases a revision until 2004 was necessary.

Heavy metal emission factors are mainly the result of a comprehensive study of PRTR data, which provide information about emissions and the quality (measurement/estimated/calculated data) of large combustion plants. The combination of emission from PRTR and the relevant fuel data, which contains additional data of large combustion plants (EU legislative), allows the determination of plant-specific emission factors. Due to the fact, that only some plants do really measure heavy metals, the determined emission factors were used for the whole sector (1.A.1.a).

HCB emission factors of hard coal were taken from the EMEP/EEA Guidebook 2009. Black carbon emission factors for all fuels are given by the EMEP/EEA Guidebook 2019.

Regarding natural gas and light fuel oil SO_2 emission factors were calculated by using data on the sulfur content. In terms of natural gas sulfur content has been measured during a project. Data on all important regions is available. The sulfur of the odorization is also considered, which is a slightly conservative, since not all plants use natural gas with odorization. Concerning light fuel oil, the limit value is used for emission reporting. It can be assumed that large combustion plants mainly use light fuel oil with a sulfur content of 1000 mg/kg while low-sulfur fuel oil is mainly used in small combustion plants.

Engines

Emission factors for gas engines were determined by the project: “Processing of data in emissions declarations pursuant to the 11th Ordinance on the Execution of the Federal Immission Control Act”. Additional data were provided by the local

authorities (results of emission monitoring). All emission factors used for reporting are derived from plants which are subject of licensing and reviewed by the competent authorities.

However, a large number of the 7,500 biogas plants in Germany does not require a license. Due to the small size of the plants the total fuel consumption of small biogas plants is lower than fuel consumption of those plants who need a permit. Since emission behaviour of small and medium sized plants is completely different, it's necessary to use specific emission factors for each plant type. The calculation of activity data of small and medium sized plants is based on data from the Federal Network Agency. Emission factors are a result of different regional measurement compaigns in Saxony and Bavaria and the project: “Analysis of the emissions from biogas plants, and quantification of material flows through such plants, for ecological assessment of agricultural-sector biogas production and for inventories of the German agricultural sector” (DBFZ 2014). Emission factors for liquid fuels are given by the project: “Determination of the state-of-the-art of emission control techniques for stationary internal combustion engines”, carried out by (Müller-BBM, 2010).

Waste incineration plants

Data source for emission factors of waste incineration plants is the project: “Review of the emission factors for waste incineration”, carried out by Daschner et al. (2010)[5)]. The aim of the study was to determine emission factors for municipal waste, industrial waste, hazardous waste, waste wood and sewage sludge incineration. Emission factors for 25 pollutants are available. The different fuel categories are consistent with the waste statistic. The fuel category “industrial waste” has different meanings: substitute fuel originate from municipal or industrial waste or untreated production waste. This kind of fuels were basically incinerated in so called waste-to-energy-plants (in German EBS-Kraftwerke). Compared to conventional municipal waste incineration plants, “EBS-Kraftwerke” are mostly smaller and more efficient. There are also some technical differences. All these plants have to comply with the same limit values. Nevertheless emission factors are different due to different abatement technology and operating conditions. HCB emission factors of municipal waste are derived from a measurement project initiated by the industrial association. The 1990 value for waste incineration plants is an expert judgement derived from the development of legislative regulation.

Furthermore it was necessary to develop a method to calculate emissions from co-incineration systems. In Germany there is a large number of coal fired power plants, which also use a relevant amount of different waste fuels like sewage sludge, industrial waste (for example from paper industry), conditioned municipal waste etc. Since plant-specific data cannot be used, it's necessary to calculate emissions at a more aggregated level. Fuel data are available from ETS. Furthermore the information about the coal qualities is available. Therefore it's possible to calculate specific emission factors for co-incinerated waste fuels.

Table 1: Implied emission factors for public electricity and heat production for 2023

	SO_x	**NO_x**	**TSP**	**CO**	**Pb**	**Hg**	**Cd**
	[kg/TJ]				[g/TJ]		
Hard Coal	36.9	48.5	1.5	6.4	3.67	1.03	0.50
Lignite	43.5	70.0	1.6	32.1	2.79	2.49	0.38
Natural gas	0.1	39.9	0.3	12.5	NA	0.01	NA
Liquid fuels	57.9	88.5	3.4	27.5	2.87	0.55	0.10
Biomass (excluding waste)	53.6	164.5	4.2	133.3	4.23	0.13	0.10
Waste fuels	7.1	60.3	0.5	6.5	2.06	0.84	0.28

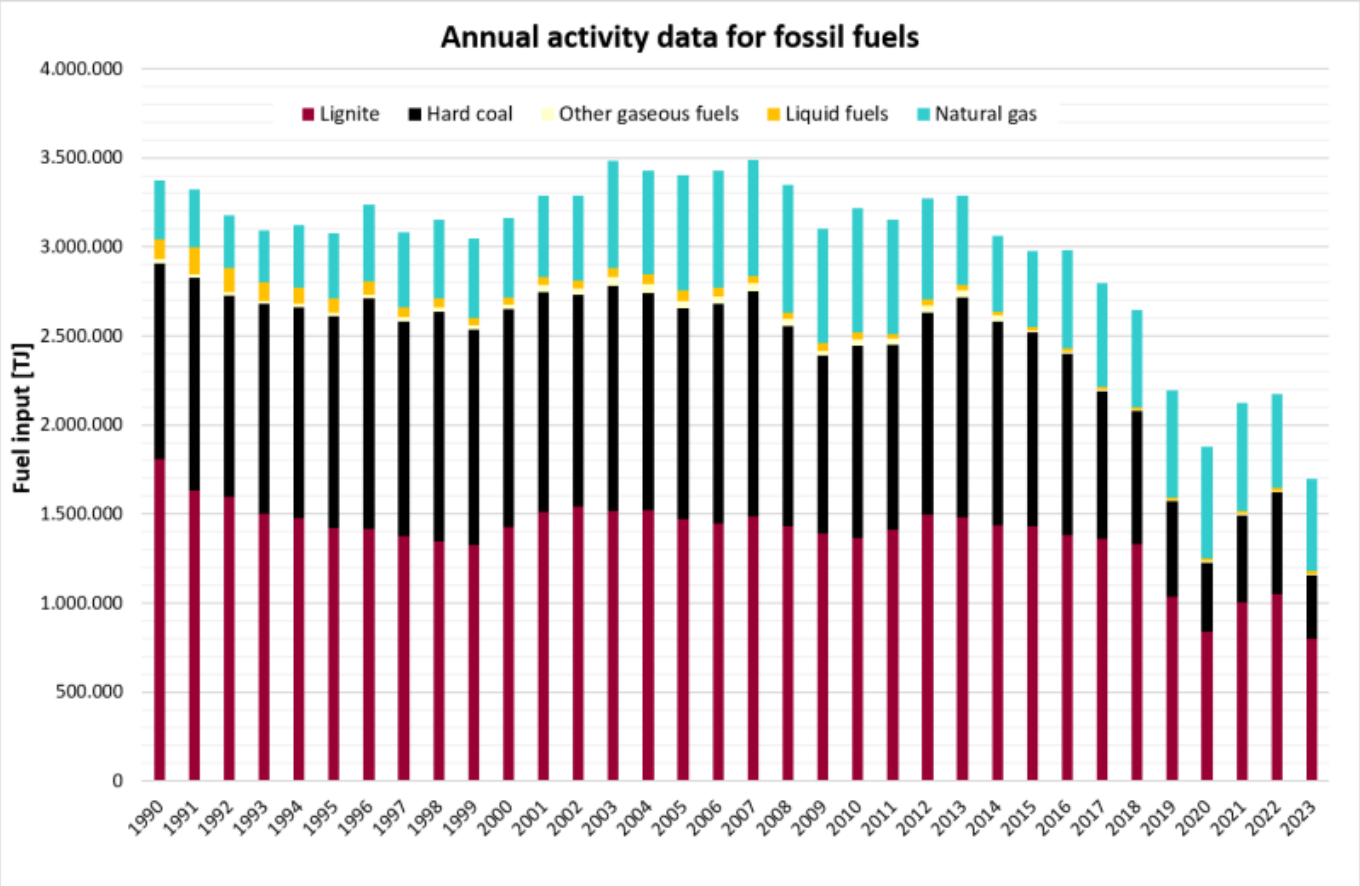
The table gives an overview of the implied emission factors. In reality, the German inventory compiling process is very complex and includes the use of a considerable number of emission factors, which cannot be published completely in the IIR. There are different emission factors available for diverse fuel types, various techniques and licensing requirements. However, the implied emission factor may give an impression about the order of magnitude. PM_{10} and $PM_{2.5}$ emission factors are calculated as a fraction of TSP. Regarding all solid fuels the share of PM_{10} is 90 % and the share of $PM_{2.5}$ is 80 %. This is a simple but also conservative approach, knowing that, in reality, PM emissions depend on fuel, combustion and abatement technologies. In terms of natural gas and biogas PM_{10} and $PM_{2.5}$ fractions are considered as 100 % of TSP. Regarding wood a share of 100% PM_{10} and 90% $PM_{2.5}$ is used. For liquid fuels the default share of 100% PM_{10} and $PM_{2.5}$ is used. In the cases of co-incineration, where liquid fuels are only used for ignition in coal fired plants, the share of coal fired plants is used. PM emission reporting starts in 1995, since no sufficient information about the dust composition of the early 1990s is available.

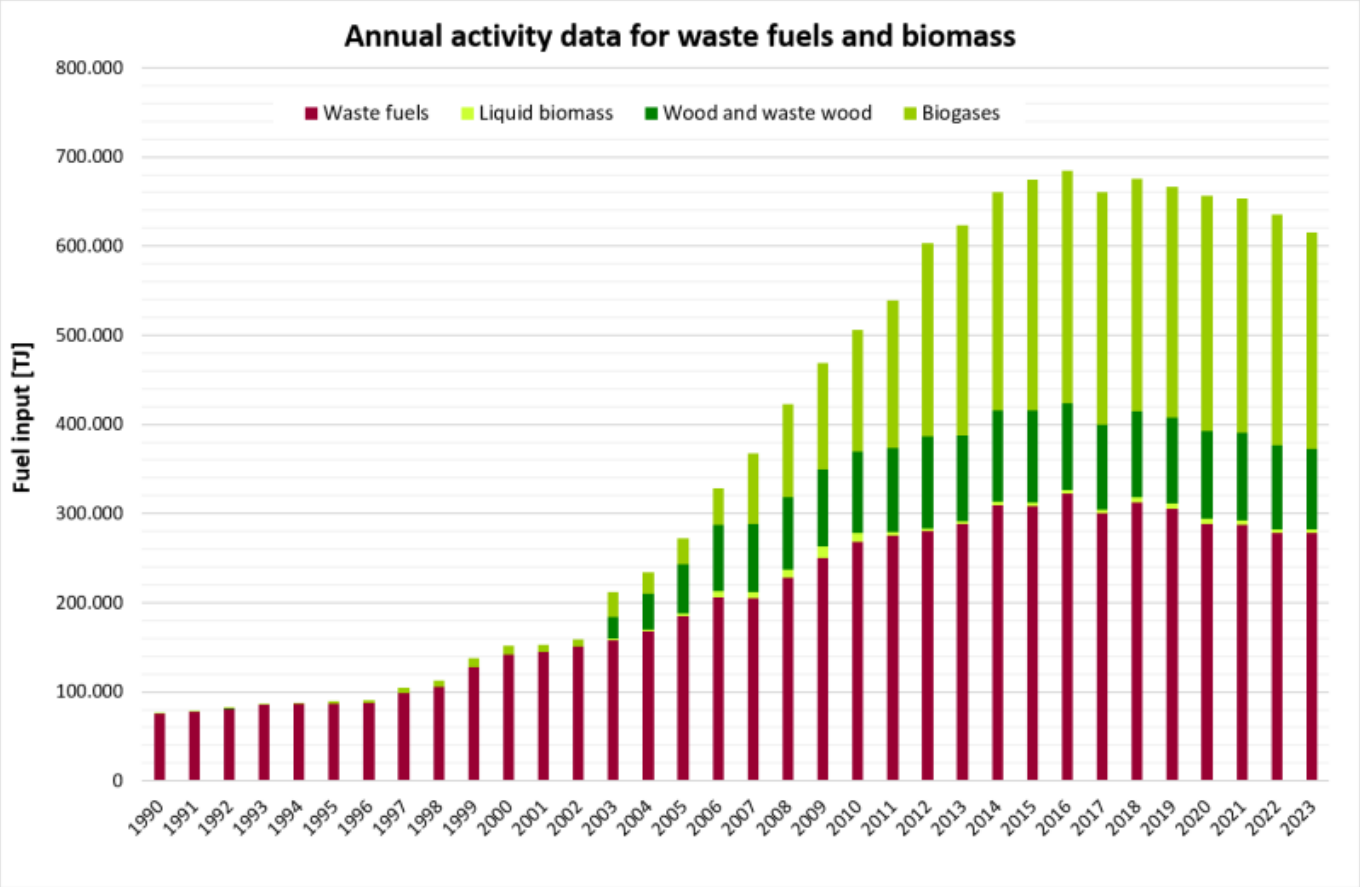
Trend discussion for Key Sources

The following diagrams give an overview of the dominant emission trends of selected pollutants.

Fuel Consumption

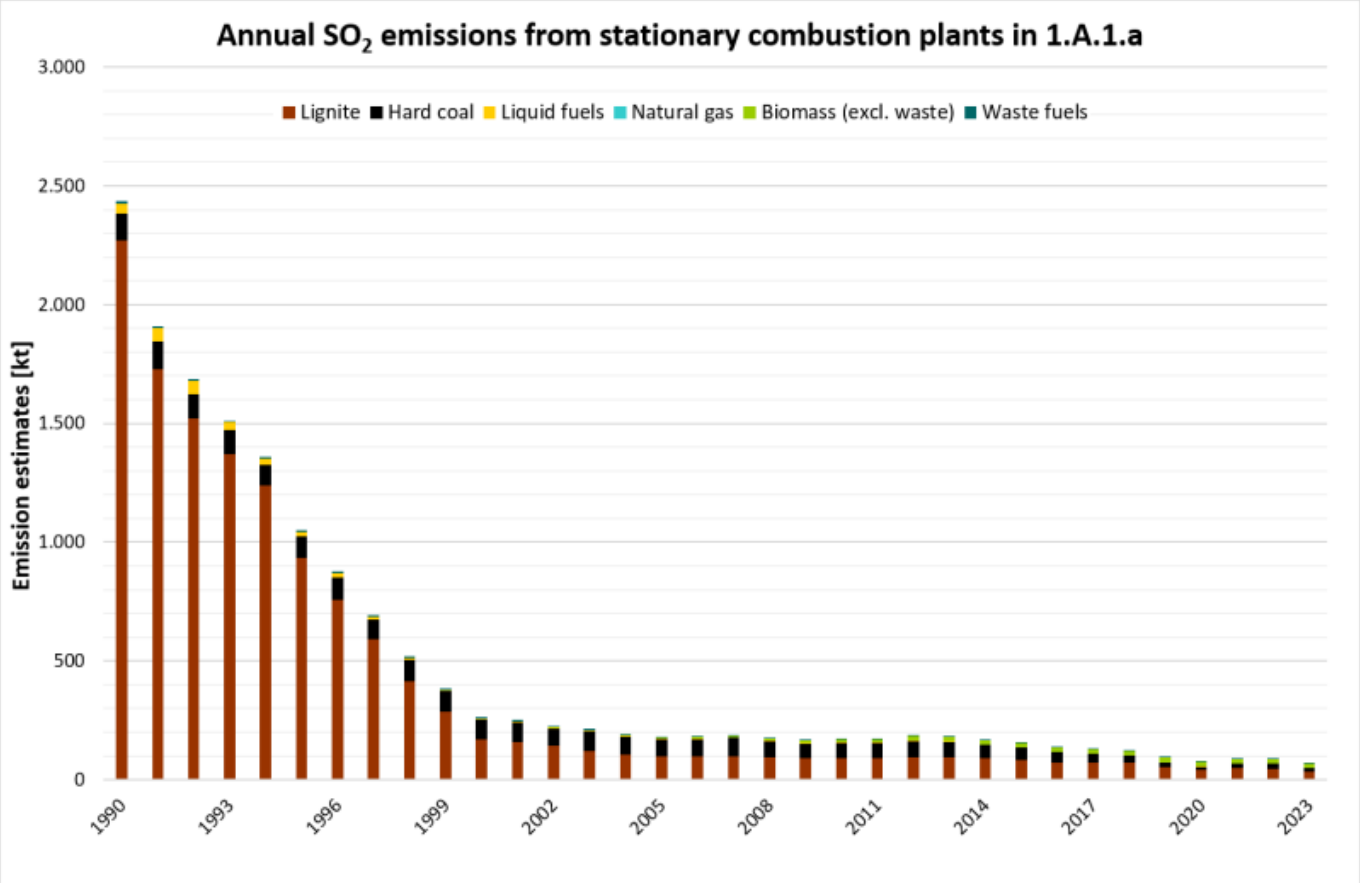
The first graph shows that the total energy consumption of fossil fuels for public electricity and heat consumption didn't change very much since 1990. The main reasons are the rising electricity demand and a great number of industrial power plants whose emissions are now reported in source category 1.A.1.a. From 1990 to the present time, a slight fuel switch from coal to natural gas was observed. In 2009 fuel consumption of all fossil fuels decreased remarkably as a result of the economic crisis. The economic recovery in 2010 led to an increasing fuel consumption because of the increasing electricity demand. From 2003 biomass consumption rises considerably due to the legislative aid of renewable energies.

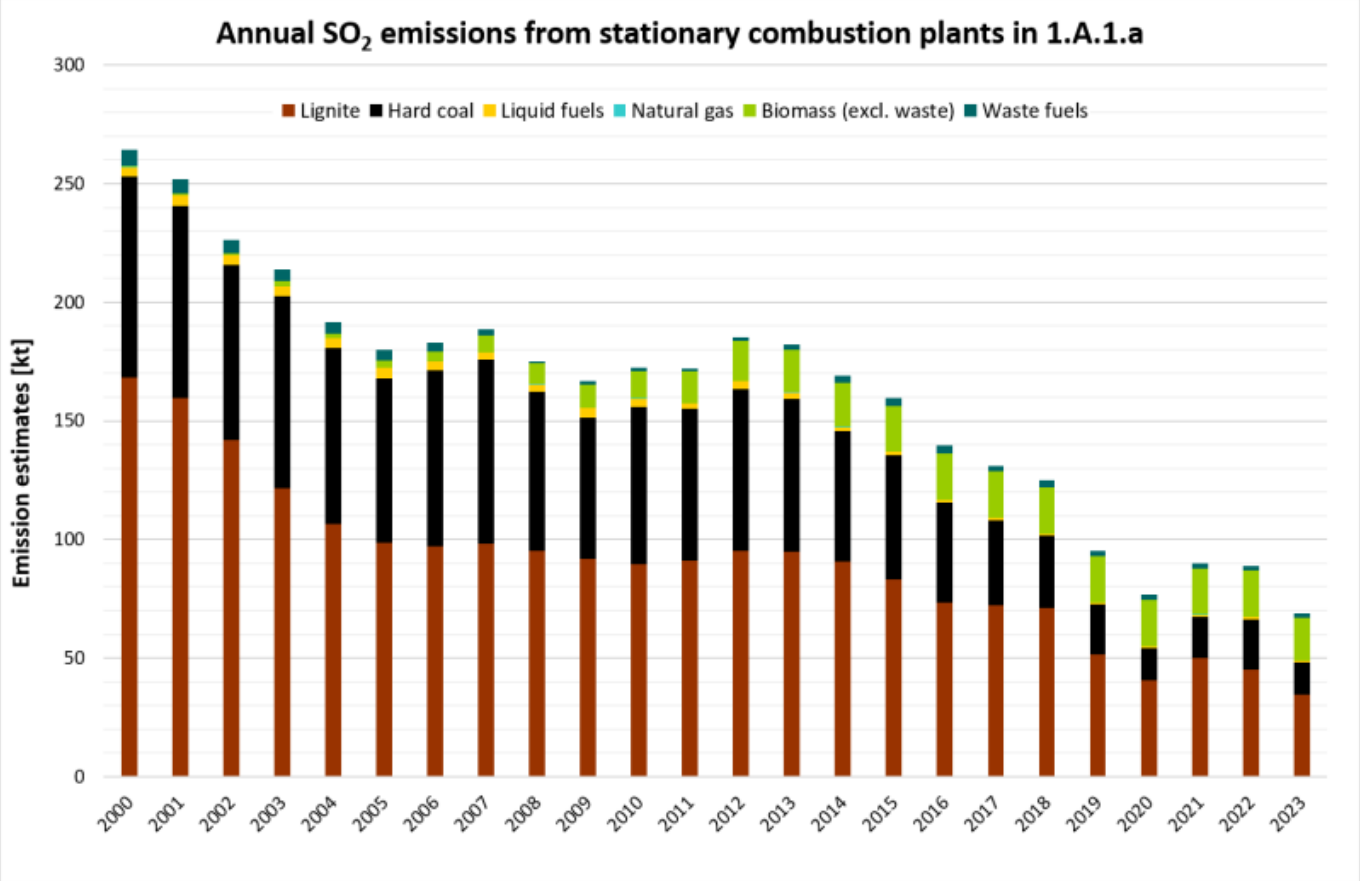




Sulfur Oxides - SOx

SO_x emission trend shows the big dominance of lignite due to high Sulphur content of lignite fuels. However SO_x emissions decrease more than lignite consumption does. Before the German Reunification in 1990, lignite fired public power plants in Eastern Germany didn't use flue gas desulphurisation plants. The implementation of stricter regulations in the New German Länder resulted in considerably decreasing emissions. In recent years the development of SO_2 emissions is mainly influenced by coal consumption. From 2005 onwards biogas which has a considerable sulphur content gained in importance. In 2016 emissions from coal fired plants decreased considerably due to a stricter regulation related to the limit values and the reduction efficiency of desulfurization plants. The emission reduction in 2019 and 2020 is a result of the decreasing coal consumption.

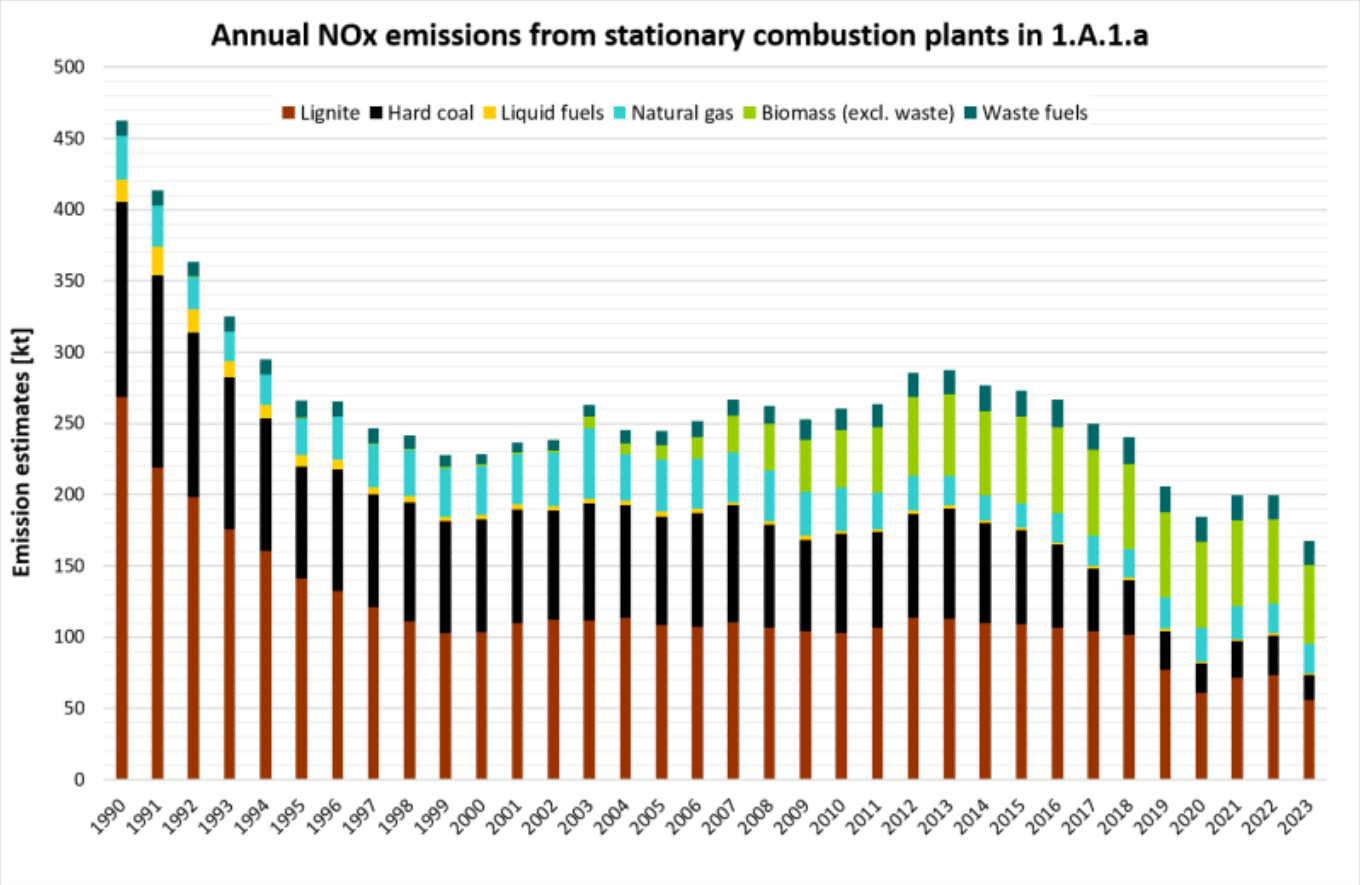




Nitrogen Oxides - NOx

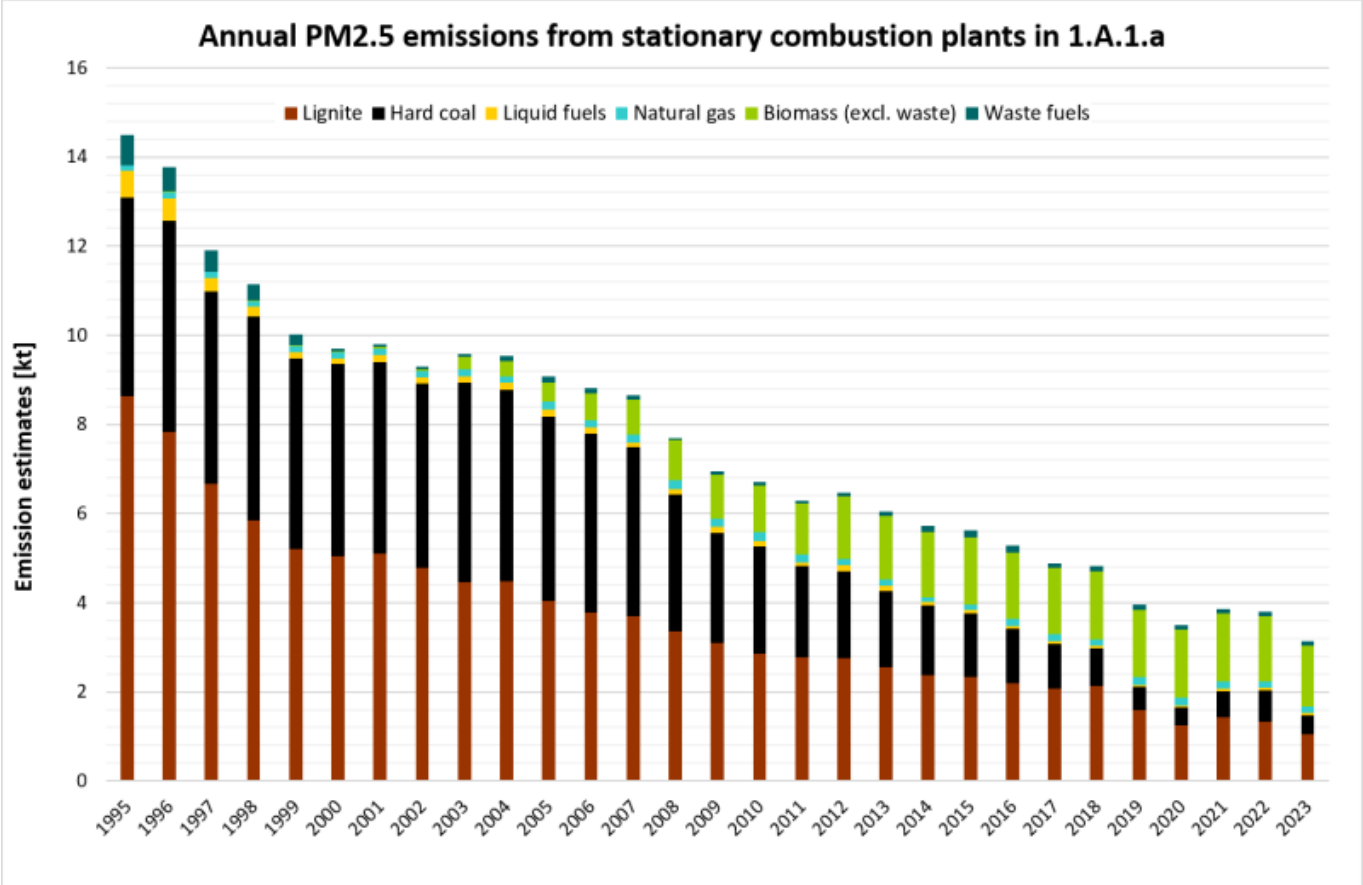
Nitrogen oxides emissions decreases due to declining lignite consumption in the early 1990s and due to NO_x emission reduction measurements in the New German Länder. After 2002 the increasing consumption of natural gas biogas, wood and other biomass in the public sector gain influence and increases NO_x emissions. The upward trend was only interrupted by the

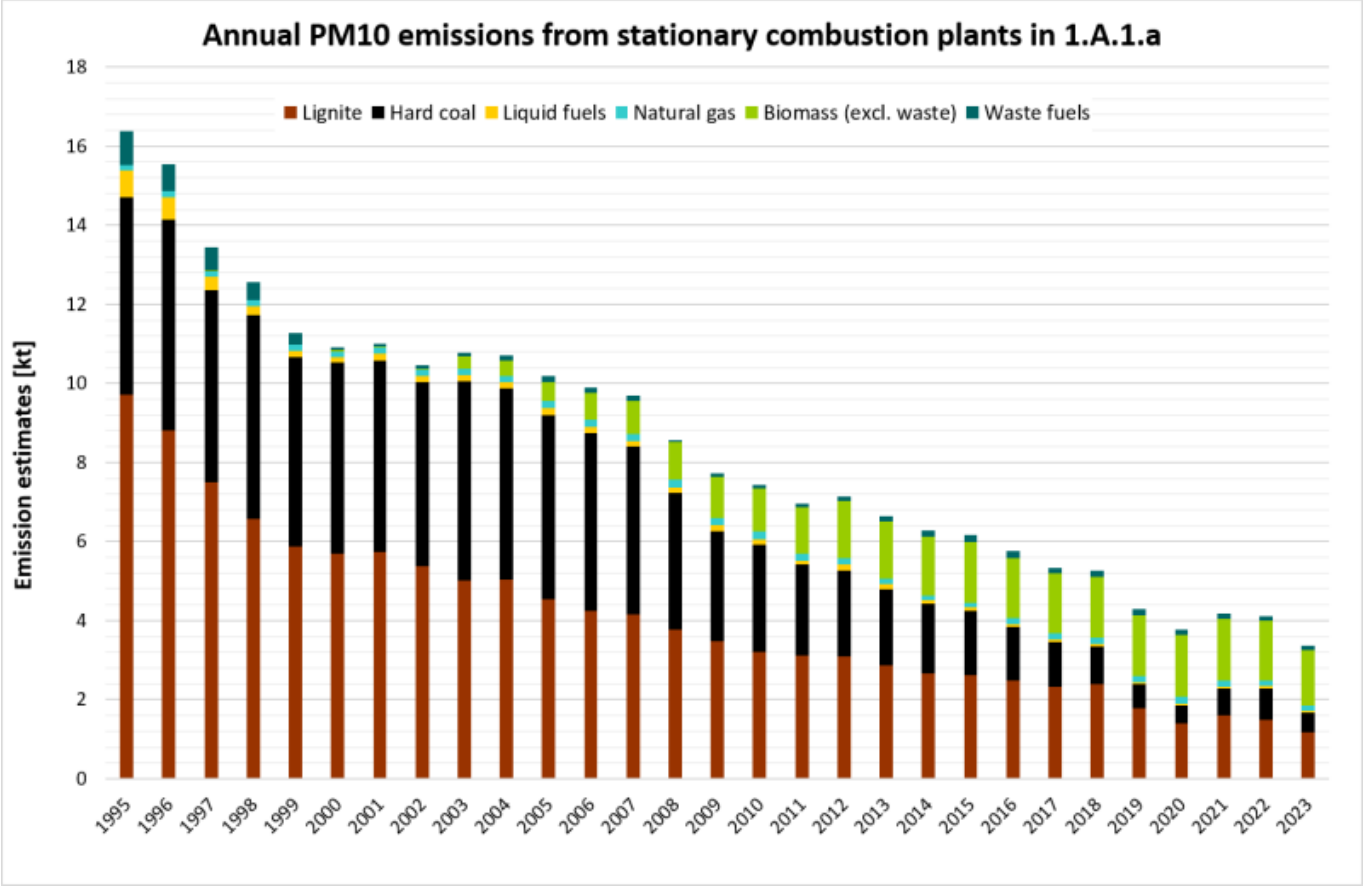
economic crises in 2009. From 2014 onwards NO_x emissions decreases mainly caused by the decreasing hard coal consumption.

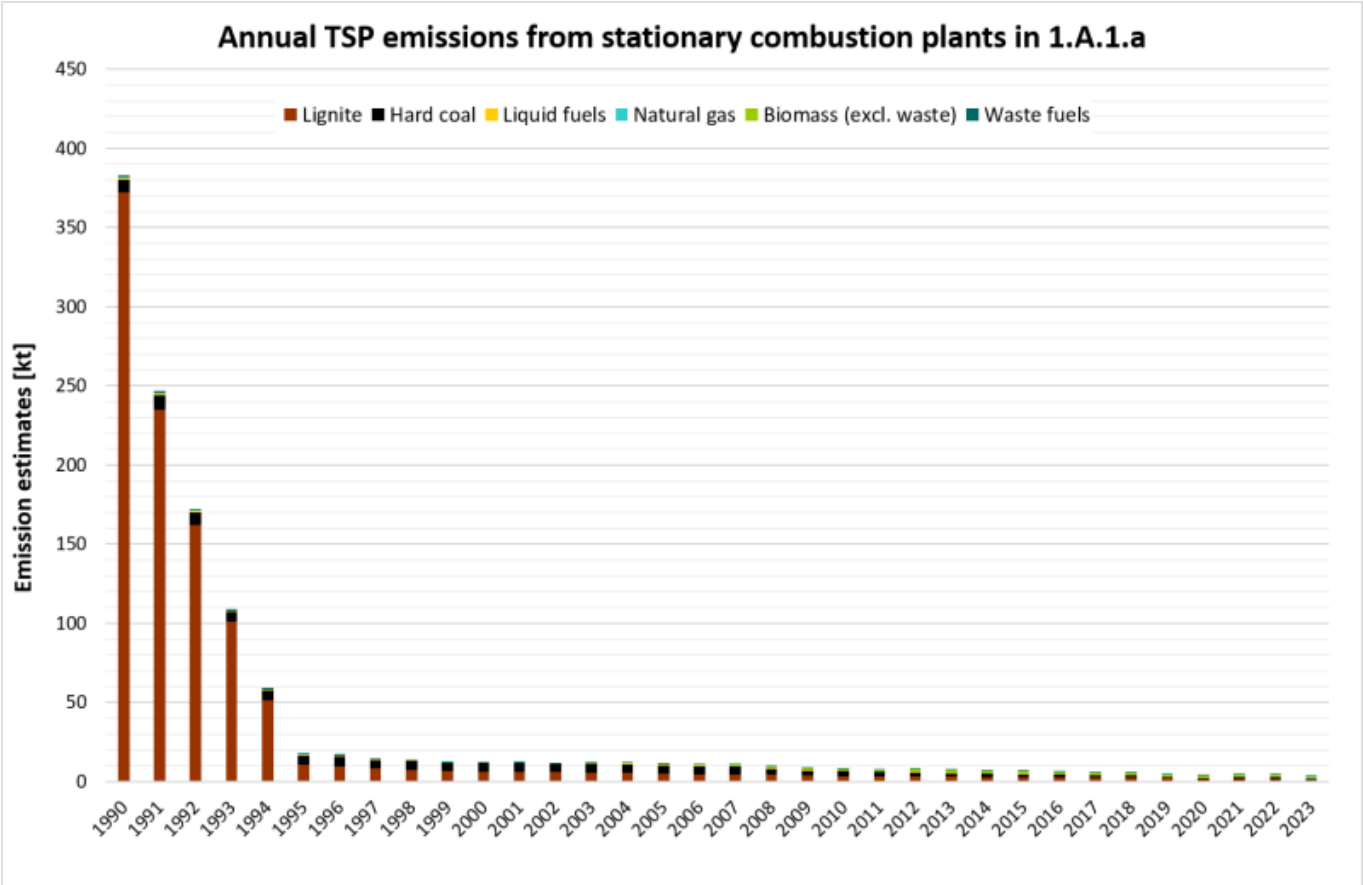


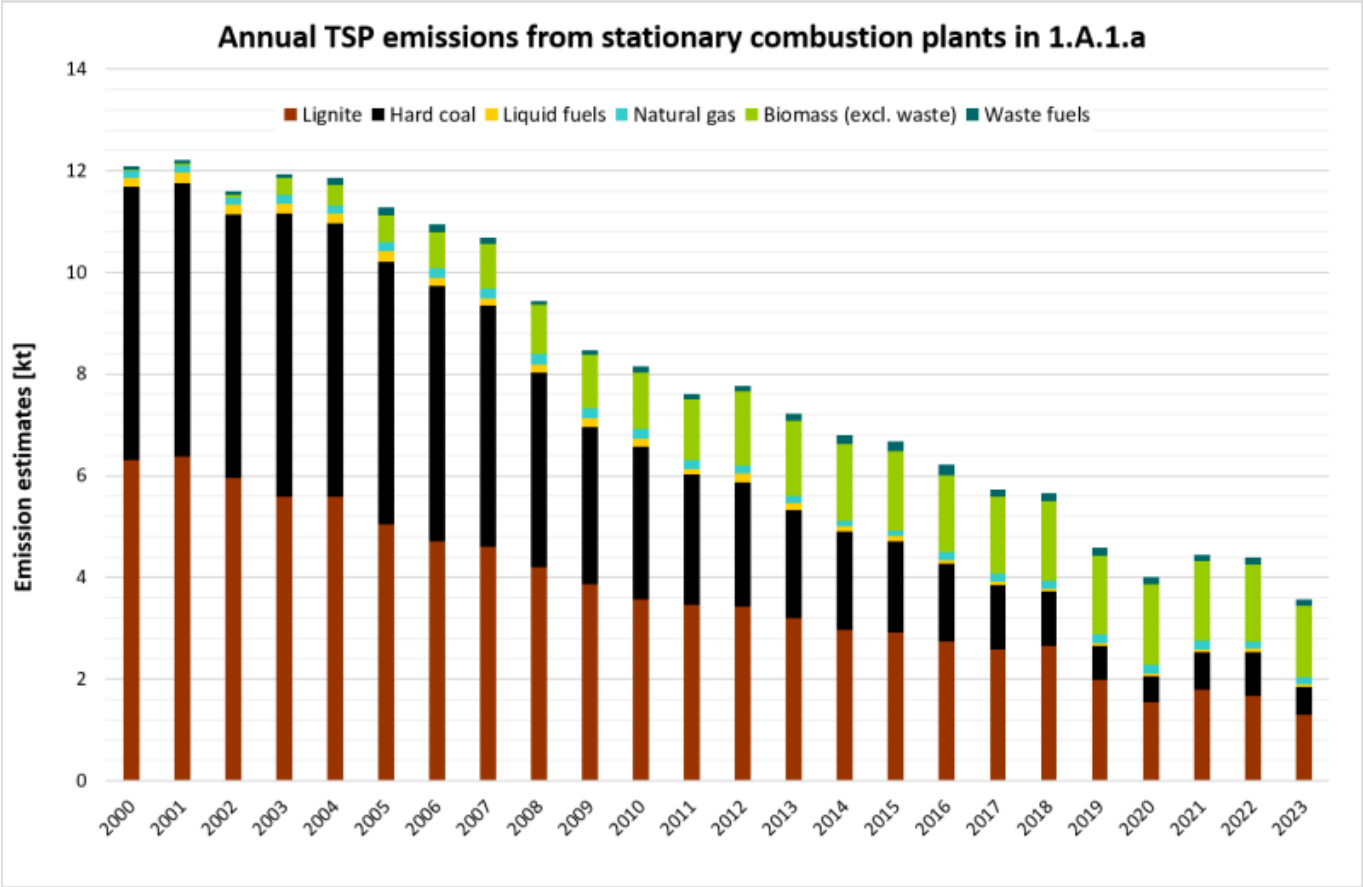
Particulate Matter - PM2.5 & PM10 & TSP

Similar to SO_x emissions, Particulate Matter emissions decreases considerably since 1990 due to stricter regulations in eastern Germany. After 2002 PM_{10} and $PM_{2.5}$ emission trends were influenced by the increasing use of biomass for public electricity and heat production. TSP and PM emissions from coal fired plants show a decreasing trend from 2005 onwards due to improvements of abatement systems. The remarkable emission reduction in 2019 and 2020 is a result of the deacreasing coal consumption.


Annual PM2.5 emissions from stationary combustion plants in 1.A.1.a
Lignite
Hard coal
Liquid fuels
Natural gas
Biomass (excl. waste)
Waste fuels
Emission estimates [kt]
0
2
4
6
8
10
12
14
16
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023


Annual PM10 emissions from stationary combustion plants in 1.A.1.a
Lignite
Hard coal
Liquid fuels
Natural gas
Biomass (excl. waste)
Waste fuels
Emission estimates [kt]
0
2
4
6
8
10
12
14
16
18
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
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2014
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2016
2017
2018
2019
2020
2021
2022
2023

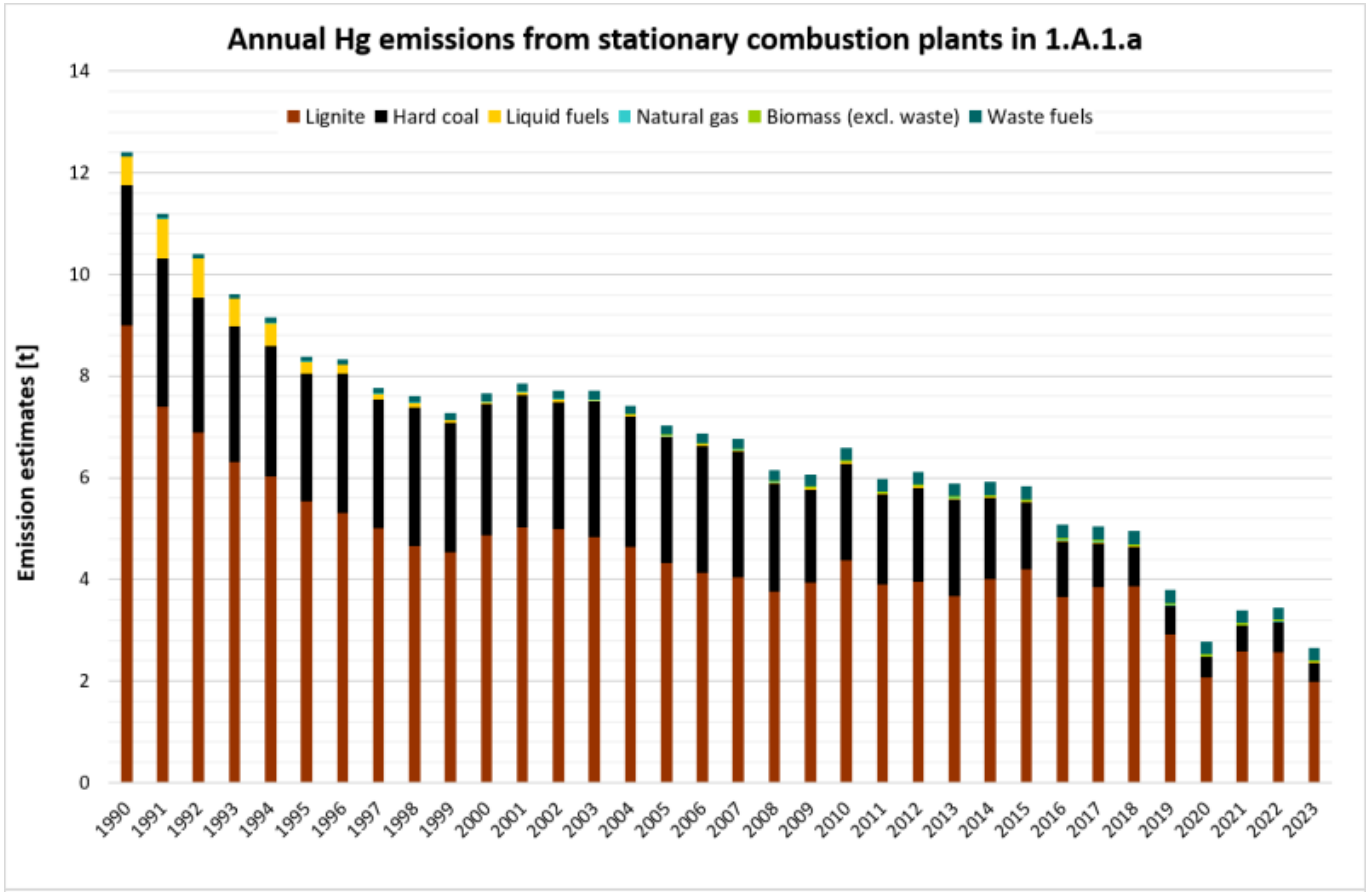


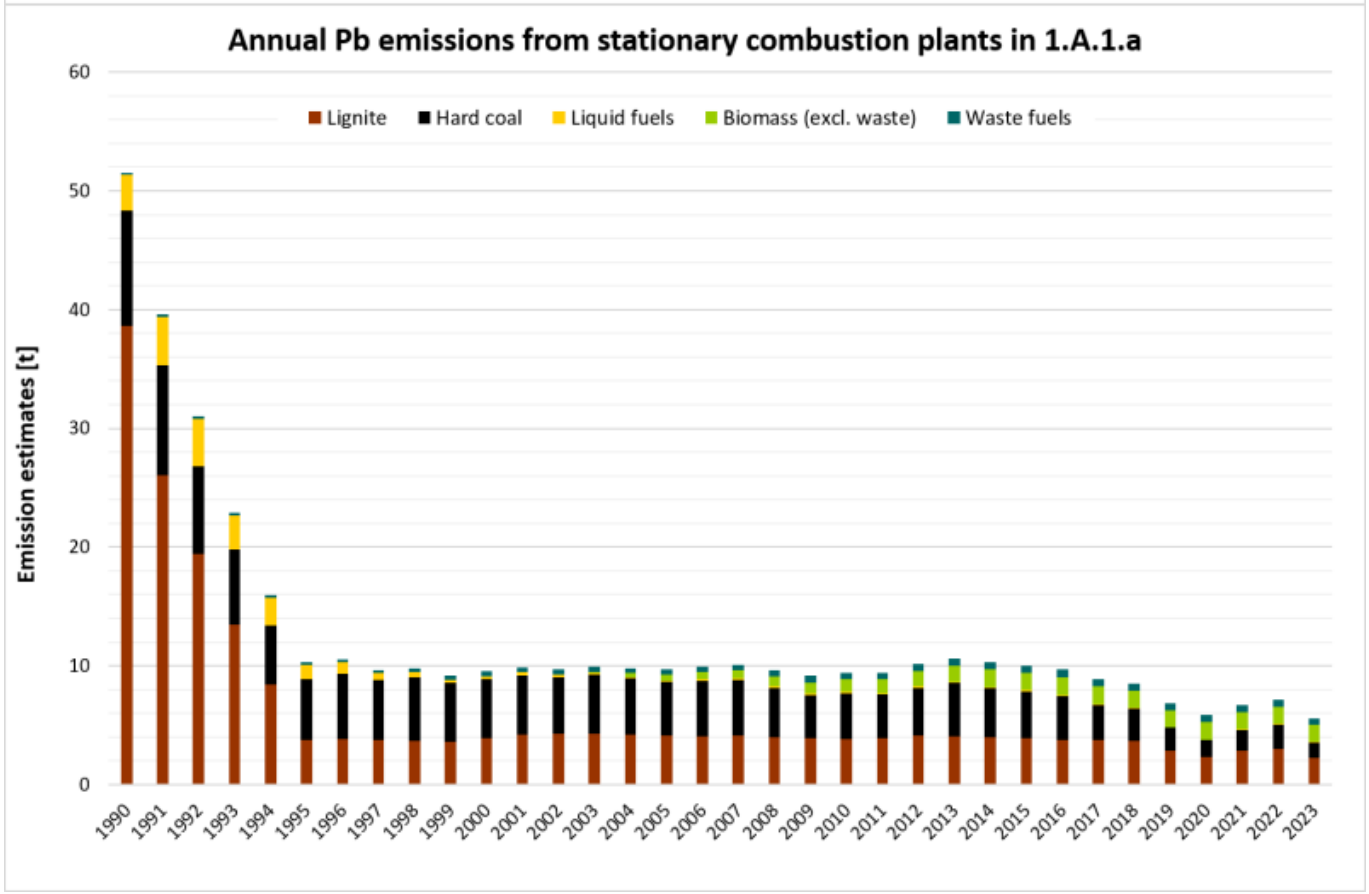


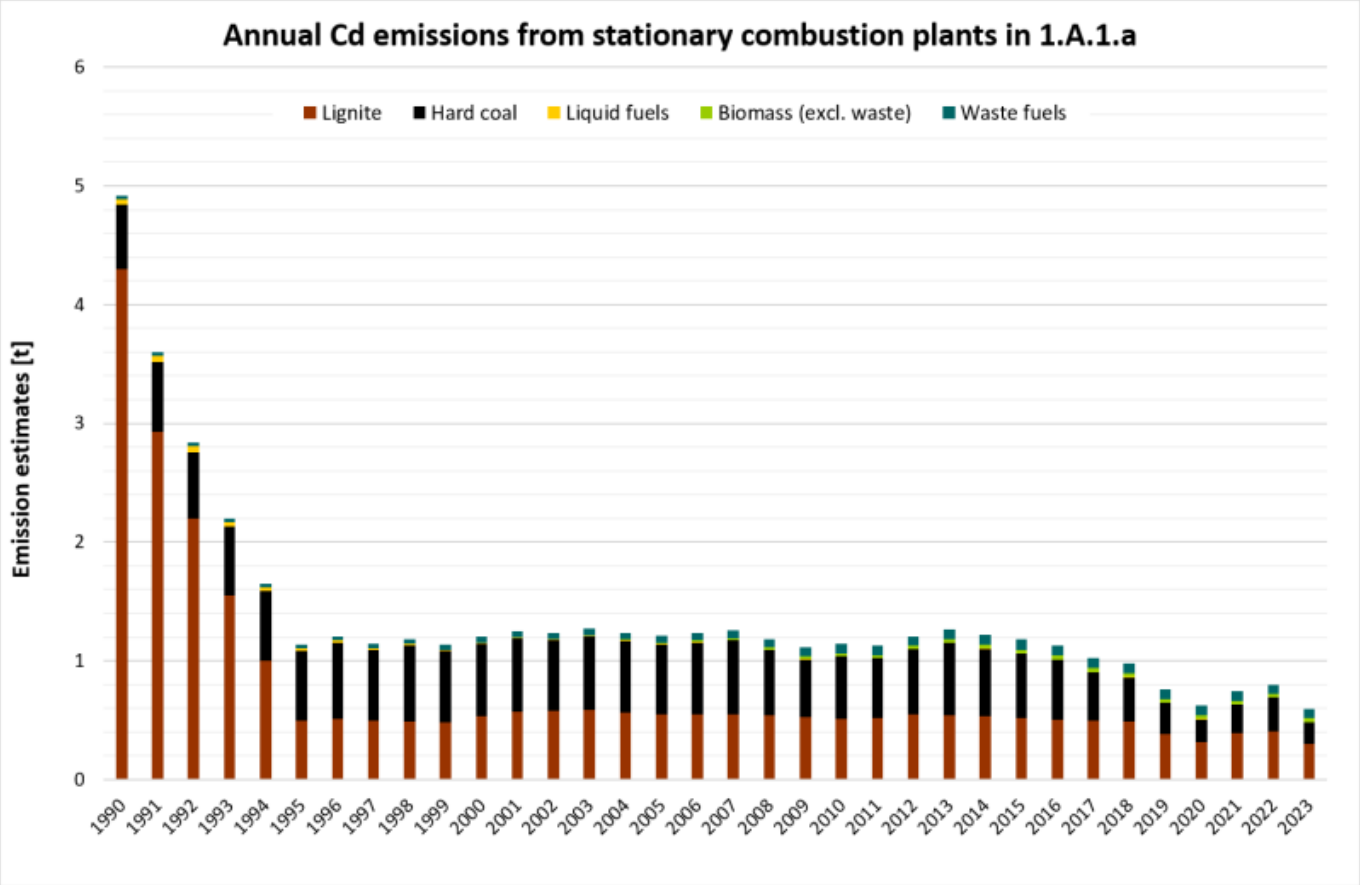
Priority Heavy metal - Hg, Pb & Cd

Emission trends of all priority heavy metals are mostly influenced by the emissions from lignite use. The reasons of the declining emissions are on the one hand the decreasing lignite consumption and on the other hand the implementation of stricter regulations in eastern Germany. Due to the fact, that heavy metal emission factors for waste incineration plants are

constant, emission trends solely depend on coal consumption. In reality emission trends of all heavy metals would be more influenced by the emissions from waste fuels, since the emission factors for waste incineration plants in 1990 are expected to be high. In recent years emissions from Biomass combustion gain more and more influence on the trend.

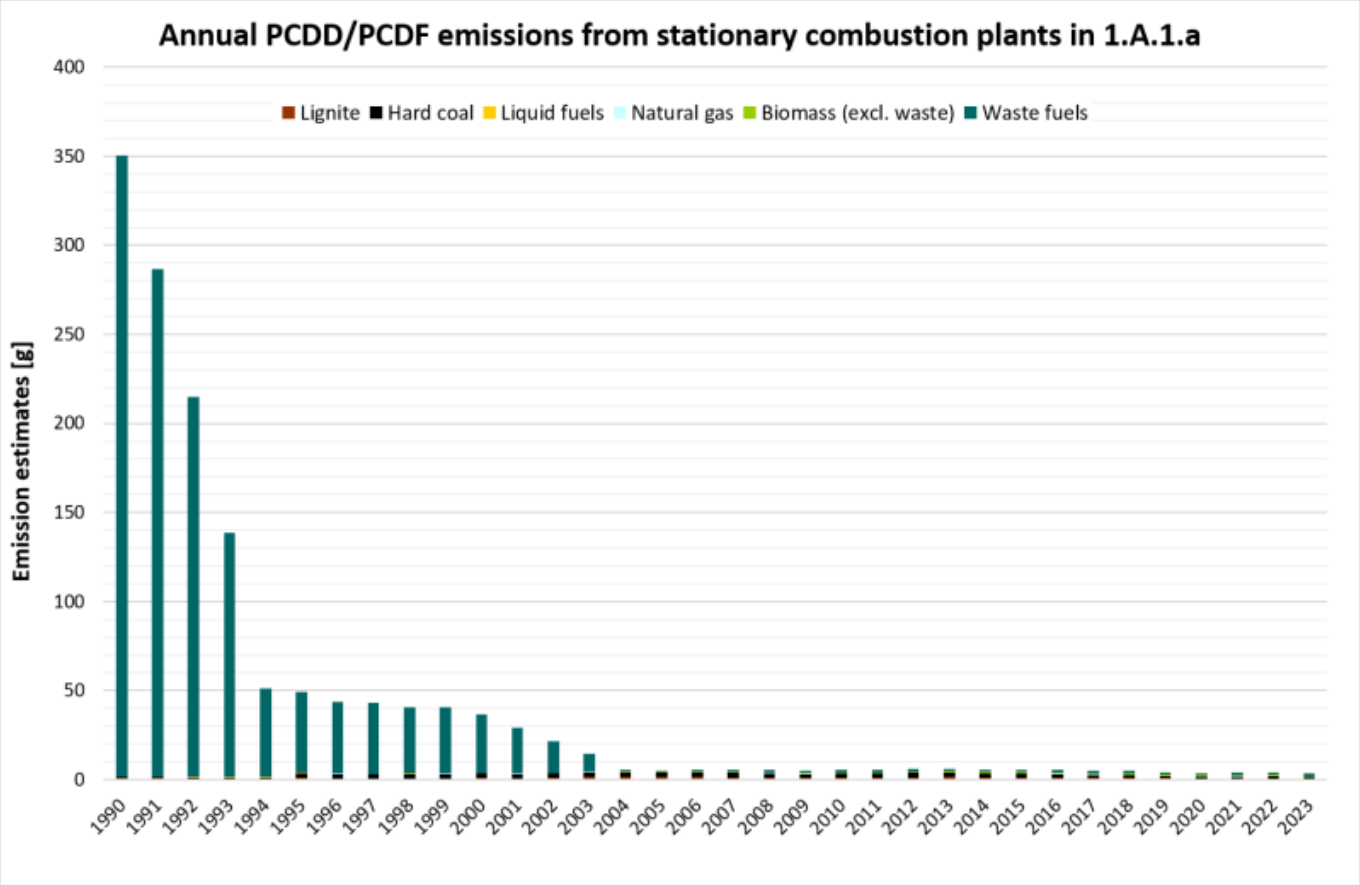






Persistent Organic Pollutants

Main driver of the dioxin emission trend is by far waste incineration with high specific emissions in the early 90s and considerably decreasing emissions due to stricter regulations in Germany. In recent years emissions remain stable at a very low level.



Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the energy balance for 2022 led to recalculations. Additionally, due to the updates in data source for biomass fuels, recalculations took place between 2003-2022.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

New POPs emission factors are available for waste incineration plants for 2015. Before the implementation of these values, a trend discussion with the experts is necessary.

The new PCB emission factors cannot be used at the moment since it would destroy the current inventory structure and impede a thorough and correct key source analyses. The new PCB emission factors are measured according to the WHO TEQ. The values which are currently used in the inventory are based on measurements according to German standards (Ballschmiter, LAGA) with a factor of 100,000 between both EF sources. The implementation of the new PCB emission factors will only be possible when new PCB emission factors are available for iron and steel production and cement industry, too.

[1)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen - AGEB), Berlin, 2024
[2)] Destatis (2024): Federal Statistical Office (Statistisches Bundesamt): Fachserie 19, Reihe 1: Abfallentsorgung - https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Wasserwirtschaft/_inhalt.html#sprg238684, Wiesbaden, 2024.
[3)] Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final

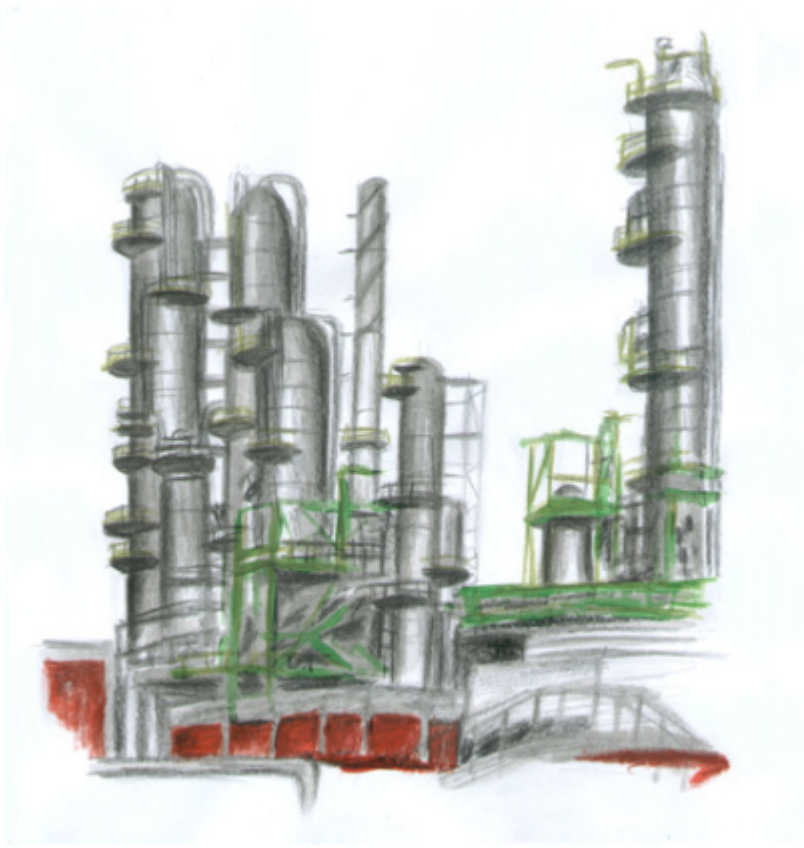
report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); https://publikationen.bibliothek.kit.edu/21412002; Karlsruhe / Dessau-Roßlau, 2002.

[4)] UBA2019]) For the reporting year 2016 a complete data set is available. In former times data were not complete. There was no reporting obligation of co-incineration plants. The large combustion data base was also the data basis of the research project (Fichtner et al. 2011)[(FICHTNER2011

[5)] Daschner et al. (2010): Daschner, R., Faulstich, Prof. Dr. M. , Quicker, Prof. Dr. P., Binder, S.: Waste incineration: “Überprüfung der Emissionsfaktoren für die Abfallverbrennung”; UFOPlan FKZ 3708 49 1075, ATZ Entwicklungszentrum, on behalf of the Umweltbundesamt, Dessau-Roßlau, not published

1.A.1.b - Petroleum Refining

Short description



Source catagory *Petroleum Refining (1.A.1.b)* comprises both refinery heating plants and electricity and heat production of refinery power plants.

NFR Code	Method	AD	EF
1.A.1.b	T2	NS	CS

NFR Code	Method	AD	EF
Method(s) applied			
D	Default		
T1	Tier 1 / Simple Methodology *		
T2	Tier 2*		
T3	Tier 3 / Detailed Methodology *		
C	CORINAIR		
CS	Country Specific		
M	Model		
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.			
(source for) Activity Data			
NS	National Statistics		
RS	Regional Statistics		
IS	International Statistics		
PS	Plant Specific		
As	Associations, business organisations		
Q	specific Questionnaires (or surveys)		
M	Model / Modelled		
C	Confidential		
(source for) Emission Factors			
D	Default (EMEP Guidebook)		
CS	Country Specific		
PS	Plant Specific		
M	Model / Modelled		
C	Confidential		

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	**L/-**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	**L/-**	-/-	**L/-**	-/-	-/-	**L/-**	**L/T**	-/-	-/-	-/-	IE	IE	IE	-/-	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Refinery processes are very complex. Therefore the development of an adequate calculation method is demanding. Since plant specific data are not complete and partly contradictory, a plant specific reporting is not possible. Data is used to determine fuel specific emission factors as general basis of the calculation model. However, in reality, a large number of fuels and waste fuels with different fuel characteristics is used for combustion processes. Insofar the calculation model is limited. Only some refinery power plants use wet desulfurisation in order to decrease sulfur emissions. Usually the fuels mix ensures the compliance with the limit values.

Activity data

Fuel inputs for electricity production in refinery power stations are included in Energy Balance line 12 (“Industrial power stations (only for electricity)”). Energy Balance line 38 (“Refineries”) shows the energy consumption (for heat production) of refineries. [1)]

Fuel inputs for heat production in refinery power plants and for bottom heating in refinery processes, are derived from these figures. Activity rates for refineries for fuel inputs for electricity and heat production in petroleum refining are determined by combining the national statistics of the Federal statistical Office (DESTATIS) and the Federal Office of Economics and Export Control (BAFA) [2)].

Energy inputs in facilities for used-oil processing are reported under *1.A.1.c - Manufacture Of Solid Fuels And Other Energy Industries* sector.

Emission factors

The emission factors for refinery power plants have been taken from the research project “Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010” (Rentz et al., 2002)[3)].

A detailed description of the procedure is presented in Chapter: *1.A.1.a - Public Electricity And Heat Production*.

Emission factors are available for different fuel types and combustion technologies. The distinction between refinery power plants and bottom heating in refinery processes is necessary since bottom heating systems have considerably higher specific emissions.

Results of a research project which has to evaluate data from emission declarations for the years 2004, 2008, 2012 and 2016 for all refineries will provide refinery gas emission factor data. The first results show the following range:

Table 1: Range of emission factors, in kg/TJ

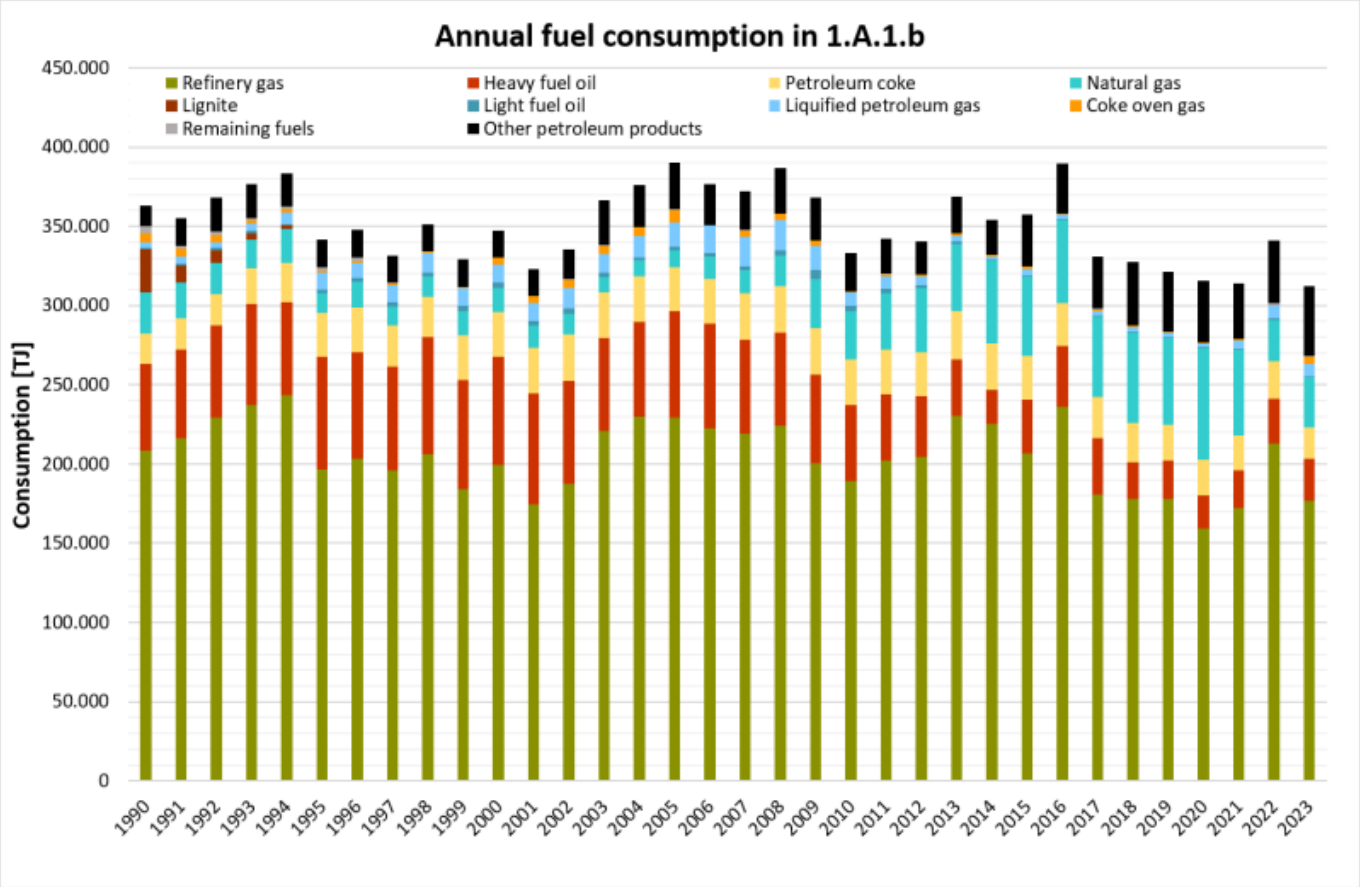
	Range
SO_2	4.79 - 16.09
CO	1.02 - 1.85
NO_x	36.71 - 45.60
NMVOC	0.843 - 1.170
TSP	0.24 - 0.37

Before the new emission factors can be used, it has to be checked which data are representative. Further quality checks are necessary in order to reproduce the trend correctly.

Trend discussion for Key Sources

Since 1990, fuel consumption has shown a slightly increasing trend overall. While some relevant installations have been decommissioned since 1990 - especially in the territory of the former GDR - production increased nevertheless. And while installation efficiencies were improved, increased production of lighter petroleum products and intensified hydrosulphurisation, which led to increases in specific fuel consumptions. Annual fluctuations of all fuel types can be explained as the result of differences in production quantities. The maximum production of petroleum products to date occurred in 2005, as a result of a shortfall in capacity in the USA, which led to an increase in imports. Thereafter, production decreased by reducing excess capacities like everywhere in Europe. The increasing use of natural gas in recent years led to decreasing emissions of all emissions (except NO_x).

The following diagram gives an overview of the fuel consumption in the refinery sector.



Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the Energy Balance for 2022 led to recalculations. In addition, to ensure that consumption of refinery fuels in the official mineral oil statistics is consistently included in the inventory reallocation of fuel data between 1.A.1.b and 1.A.2.g viii took place for the years 2003-2022.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

It is planned to revise emission factors for all pollutants on the basis of the above-mentioned project.

[1)] AGEB, 2024: National energy balance and Satellite balance for renewable energy: https://ag-energiebilanzen.de/en/data-and-facts/energy-balance-2000-to-2030/

[2)] BAFA, 2024: Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.

[3)] Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); https://publikationen.bibliothek.kit.edu/21412002; Karlsruhe / Dessau-Roßlau, 2002.

1.A.1.c - Manufacture Of Solid Fuels And Other Energy Industries

Short description



Source category *1.A.1.c - Manufacture Of Solid Fuels And Other Energy Industries* includes hard-coal and lignite mining, coking and briquetting plants and extraction of crude oil and natural gas. Used-oil processing plants are also included. Here, CO emissions from coking plants are reported in NFR sub-category 1.B.1.b.

NFR Code	Method	AD	EF
1.A.1.c	T2	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	**SO_2**	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	CO	Pb	**Cd**	**Hg**	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs

L/T	-/-	**L/T**	-/-	**-/T**	**-/T**	**L/T**	-/-	-/-	-/-	**L/T**	**L/T**	**L/T**	**L/T**	**L/T**	**L/T**	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

Activity data

Fuel inputs for electricity production in power plants of the hard-coal and lignite mining sector are listed in Energy Balance line 12 “Industrial power stations”. Fuel inputs for heat production in the transformation sector are listed in Energy Balance lines 33-39 [1)].

Fuel inputs for electricity production in power stations of the hard-coal mining sector are determined with the help of figures of the Federal Statistical Office (DESTATIS). The activity rates for heat production in power stations of the hard-coal mining sector correspond to Energy Balance line 34 “Energy input in pit and briquette plants of the hard-coal mining sector”. The listed fuel input for electricity and heat production in pit power plants is based on association information from DEBRIV (the federal German association of all lignite producing companies and their affiliated organisations). Inputs for heat production, especially for lignite drying for production of lignite products, are not shown in the Energy Balance. Those are calculated from figures for production of lignite products (STATISTIK DER KOHLENWIRTSCHAFT)[2)] and from the specific fuel inputs required for dying from DEBRIV.

Energy consumption data for hard-coal coke production are provided by the Energy Balance line 33.

The fuel input for heat production in the remaining transformation sector is obtained by combining the energy consumption figures in Energy Balance lines 33 to 39 (total energy consumption in the transformation sector). These figures include the pits' own consumption, facilities for petroleum and natural gas production and for processing of old oil; plants that produce coal products; plants for production and processing of fissile and fertile materials; and wastewater-treatment facilities.

Emission factors

The emission factors for power stations and other boiler combustion for production of steam and hot water, in source category 1.A.1.c, have been taken from the research project “Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010” (Rentz et al., 2002)[3)]. A detailed description of the procedure is presented in Chapter: *1.A.1.a - Public Electricity And Heat Production*. In 2018 all emission factors for large combustion plants were revised (UBA, 2019)[4)].

Table 1: Implied emission factors for manufacture of solid fuels and other energy industry

	SO_x	NO_x	TSP	CO	Pb	Hg	Cd
	[kg/TJ]				[g/TJ]		
Hard Coal	83.2	72.0	2.4	7.7	1.53	2.10	0.50
Lignite	104.1	78.6	3.1	25.1	1.49	3.19	0.16
Pit gas	2.0	118.0	0.3	72.0	NE	NE	NE
Coke oven gas	89.0	78.0	0.3	2.6	NE	NE	NE
Sewage sludge	2.0	29.0	0.5	2.2	3.20	2.40	0.34

The table gives an overview of the implied emission factors. In reality the German inventory compiling process is very complex and includes the use of a considerable number of emission factors, which cannot be published completely in the IIR. Actually there are different emission factors available for diverse fuel types, various techniques and licensing requirements. However, the implied emission factor may give an impression about the order of magnitude. PM_{10} and $PM_{2.5}$ emission factors are calculated as a fraction of TSP. The share of PM_{10} is 90 % and the share of $PM_{2.5}$ is 80 %. This is a simple but also conservative approach, knowing that, in reality, PM emissions depend on fuel, combustion and abatement technologies. PM

emission reporting starts in 1995, since no sufficient information about the dust composition of the early 1990th is available. Emission factors of sewage sludge refer to mono-incineration, using fluidized-bed combustion. Emission factors of coke oven gas does not include underfiring systems of coking plants. The determination of emission factors of coking plants is described in the study: “Emissionsfaktoren zur Eisen und Stahlindustrie für die Emissionsberichterstattung” carried out by Hensmann et al.(2011)[5]. Emission factors refer to the produced amount of coke, distinction is drawn between diffuse and channelled sources. The following graph gives an overview of the methodology:

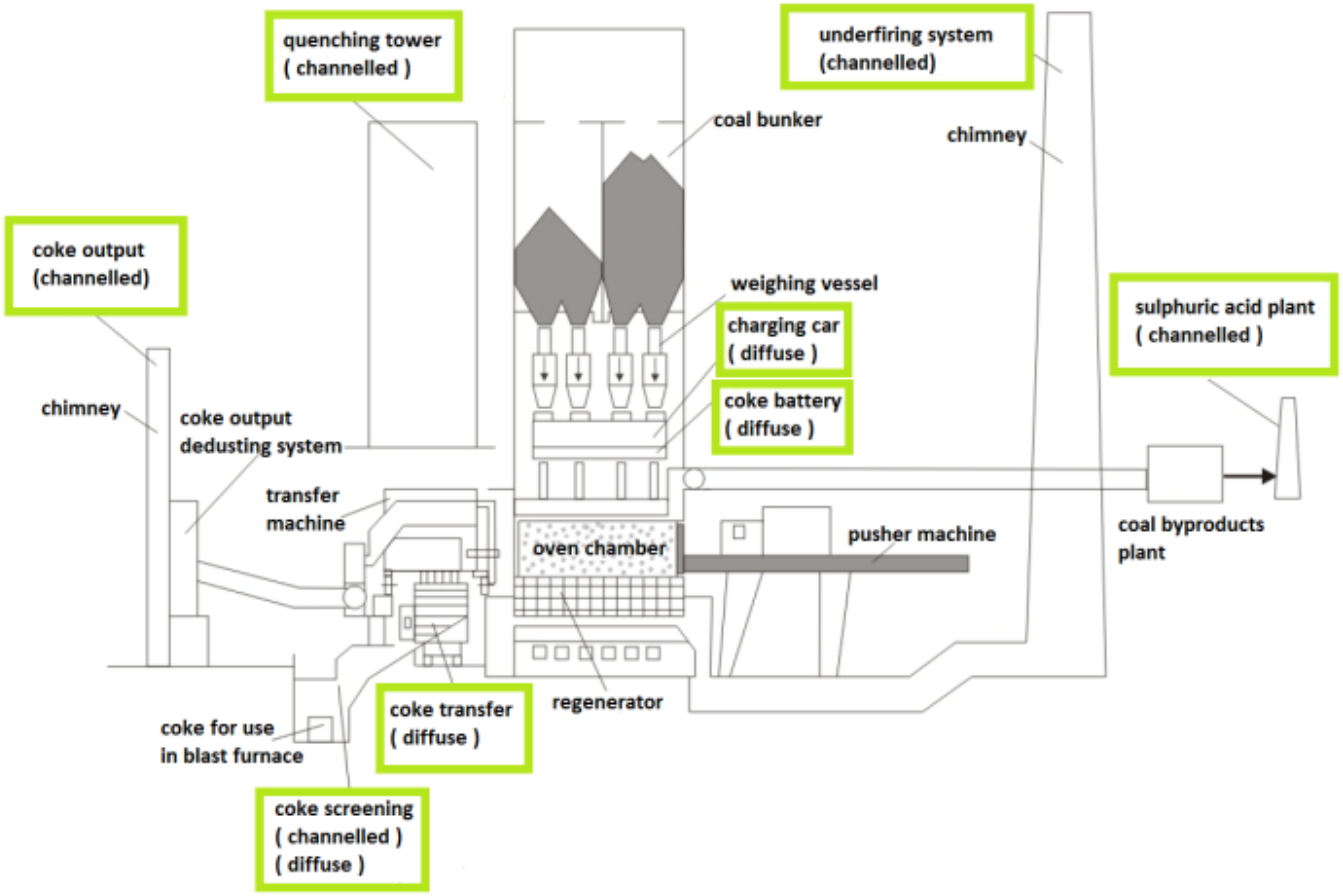


Table 2: emission factors for coking plants (solely channelled sources)

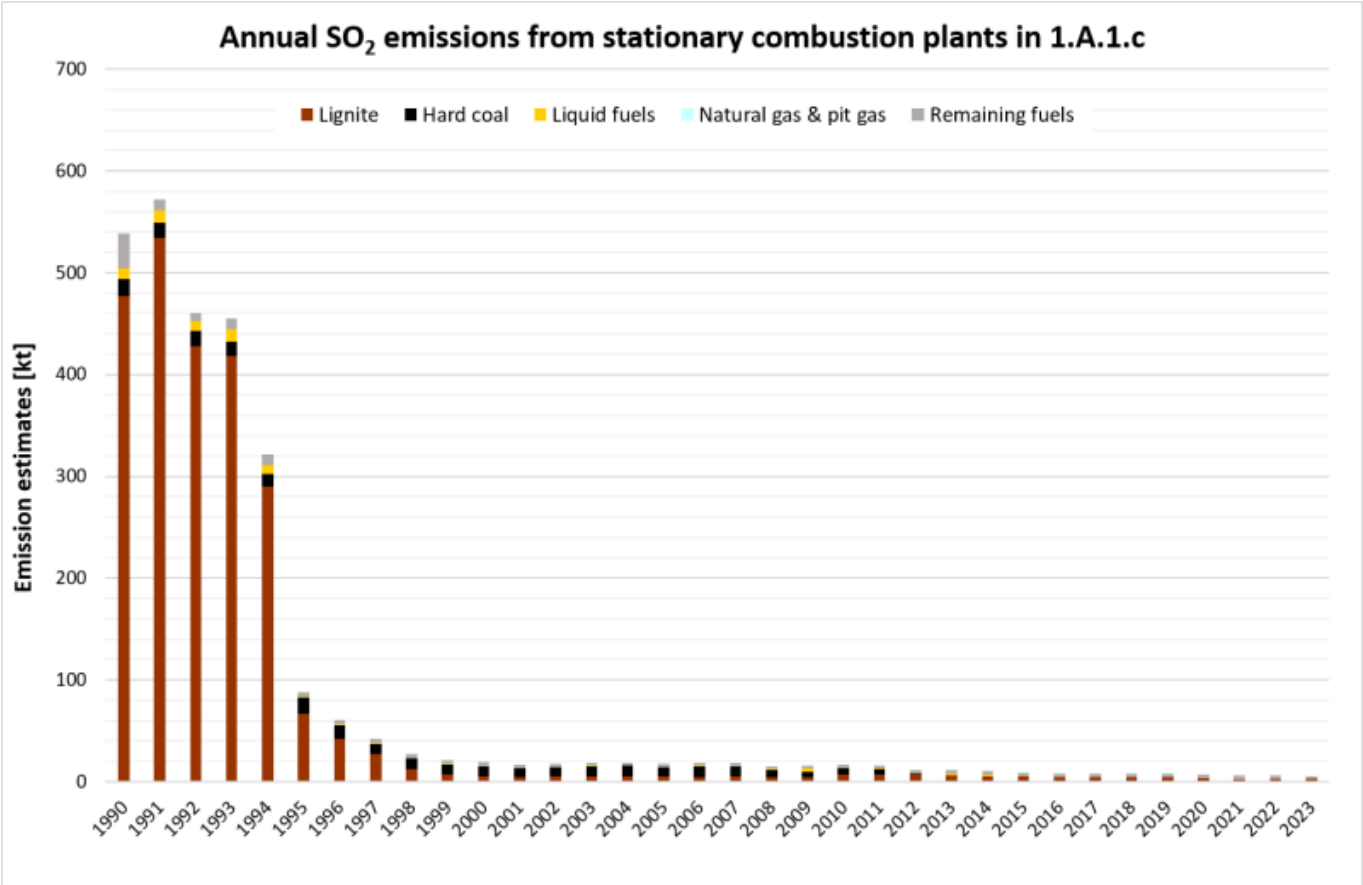
SO_x	NO_x	CO	TSP	PM_{10}	NH_3	B[a]P	Benzene
[g/t product]						[mg/t product]	Unit
220.5	529.9	828.2	25.9	12.1	1.9	7.2	36.2

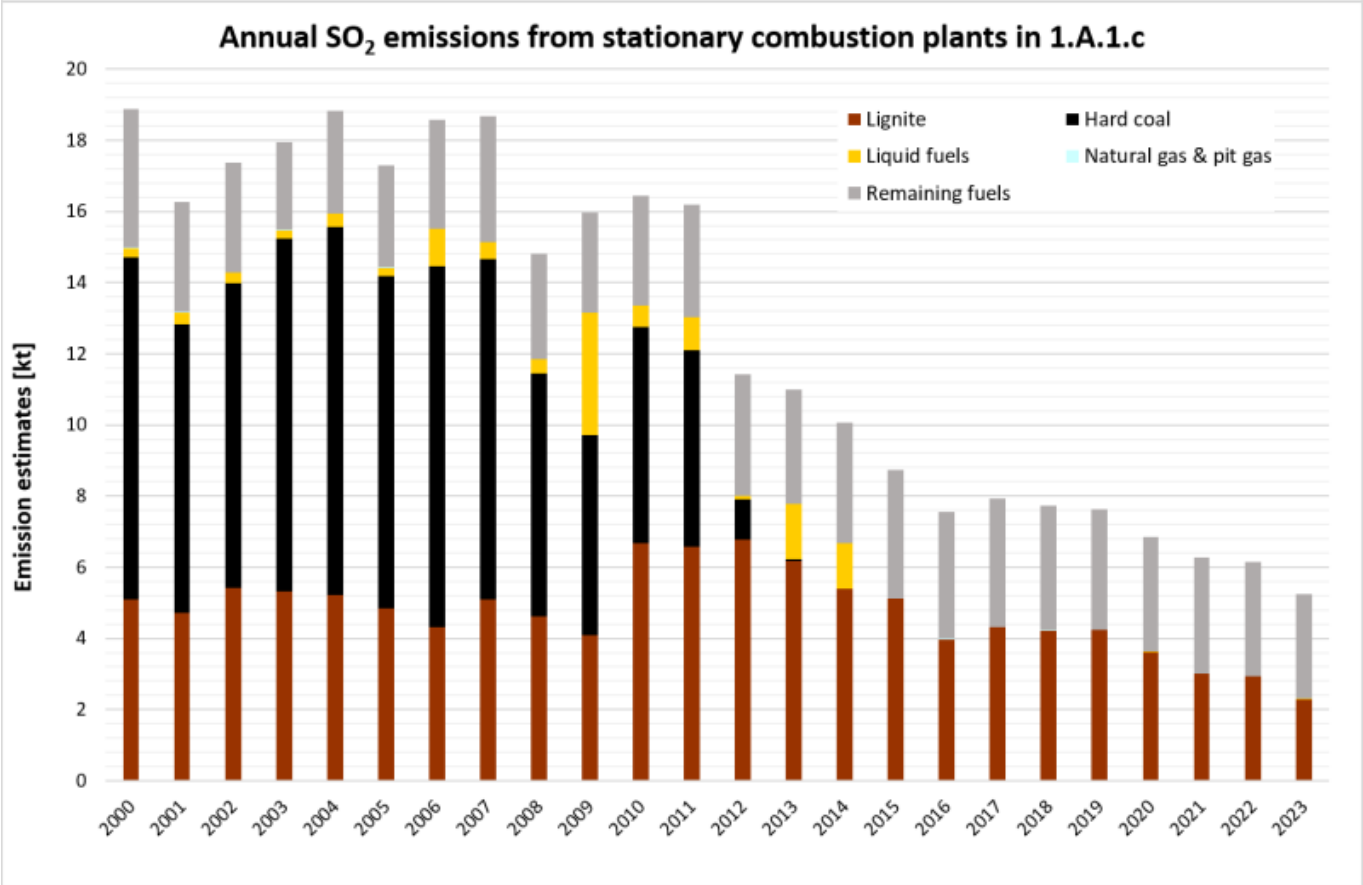
Trend Discussion for Key Sources

The following diagrams give an overview and assistance for explaining the dominant emission trends of selected pollutants.

Sulfur Oxides - SOx

The graph shows sharp declining SO_x emissions between 1990 and 1995 due to decreasing lignite consumption as well as the implementation of stricter regulations in eastern Germany. In the former GDR lignite industry was of prime importance for the economy. After the reunification, lignite briquette production in eastern Germany collapsed. The remaining factories had to install flue gas desulphurisation plants. The strong decline of SO_2 emissions in 2012 can be explained by the change of some power plants from the industrial to the public sector as a result of the closure of hard coal mines. A further reduction of SO_2 emission factors followed in 2016 when the reduction efficiency of desulfurization plants increased from 95 to 96%. However, this effect is counterbalanced by the increased use of lignite.

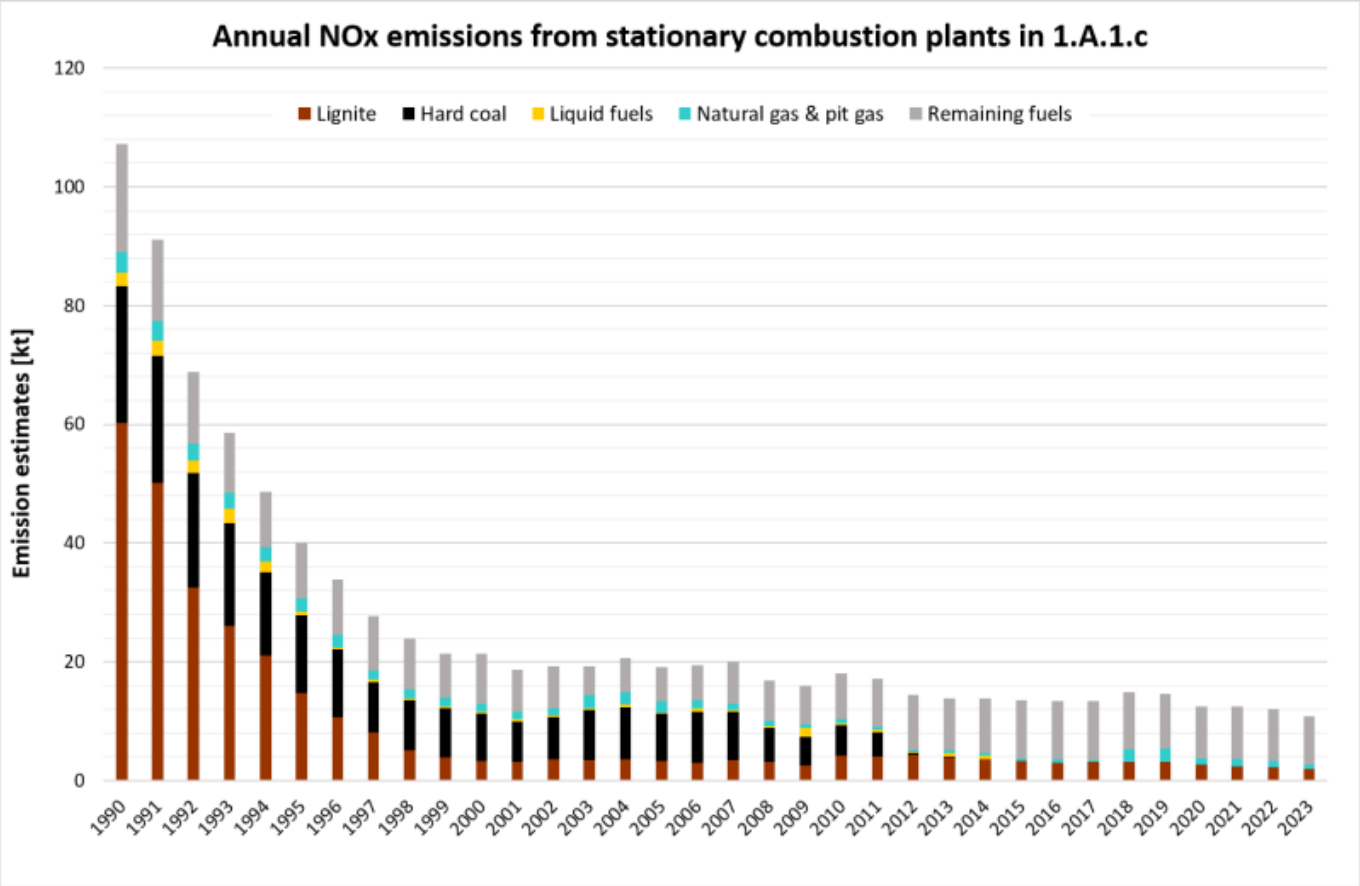




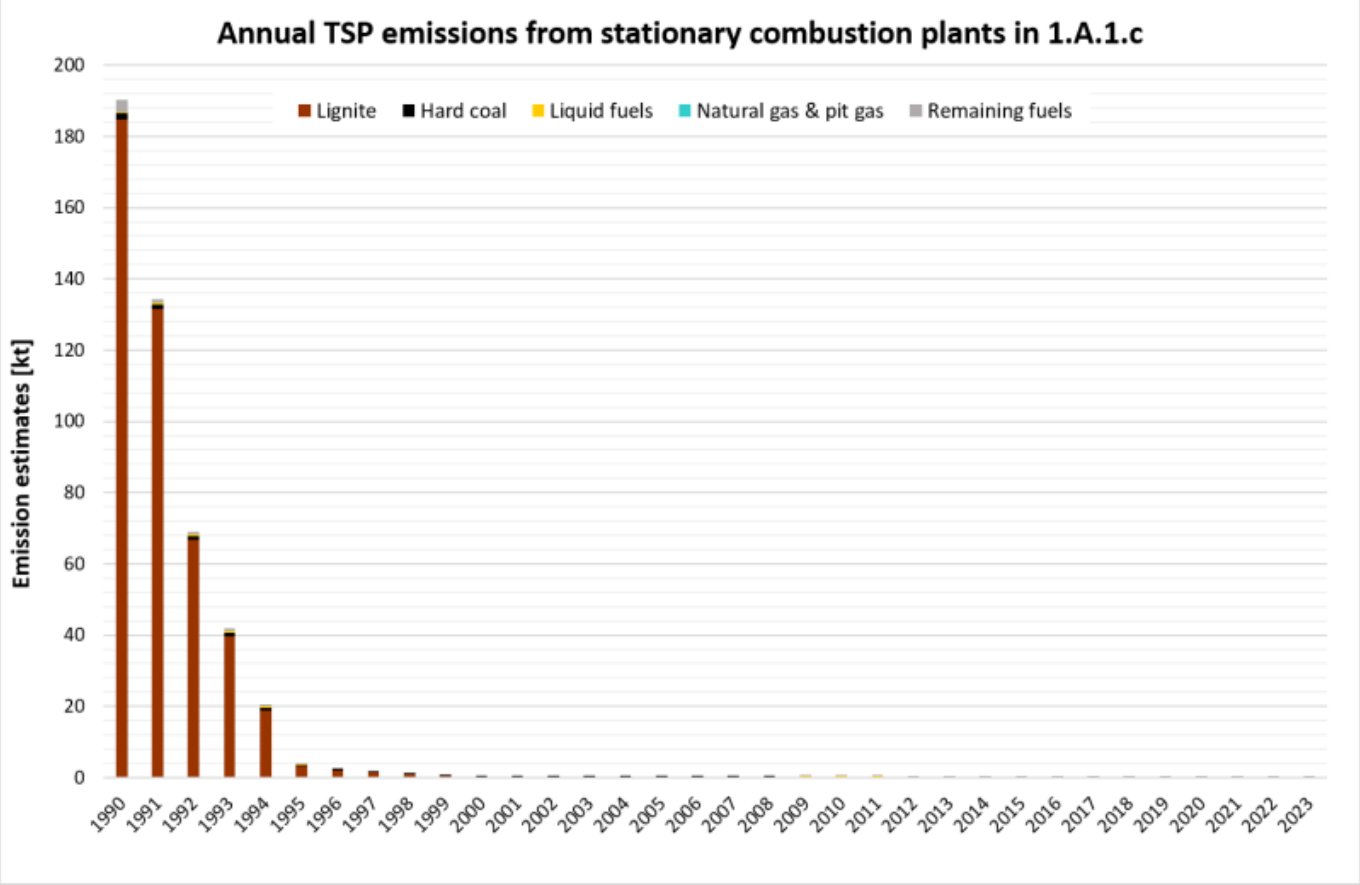
Nitrogen Oxides - NOx

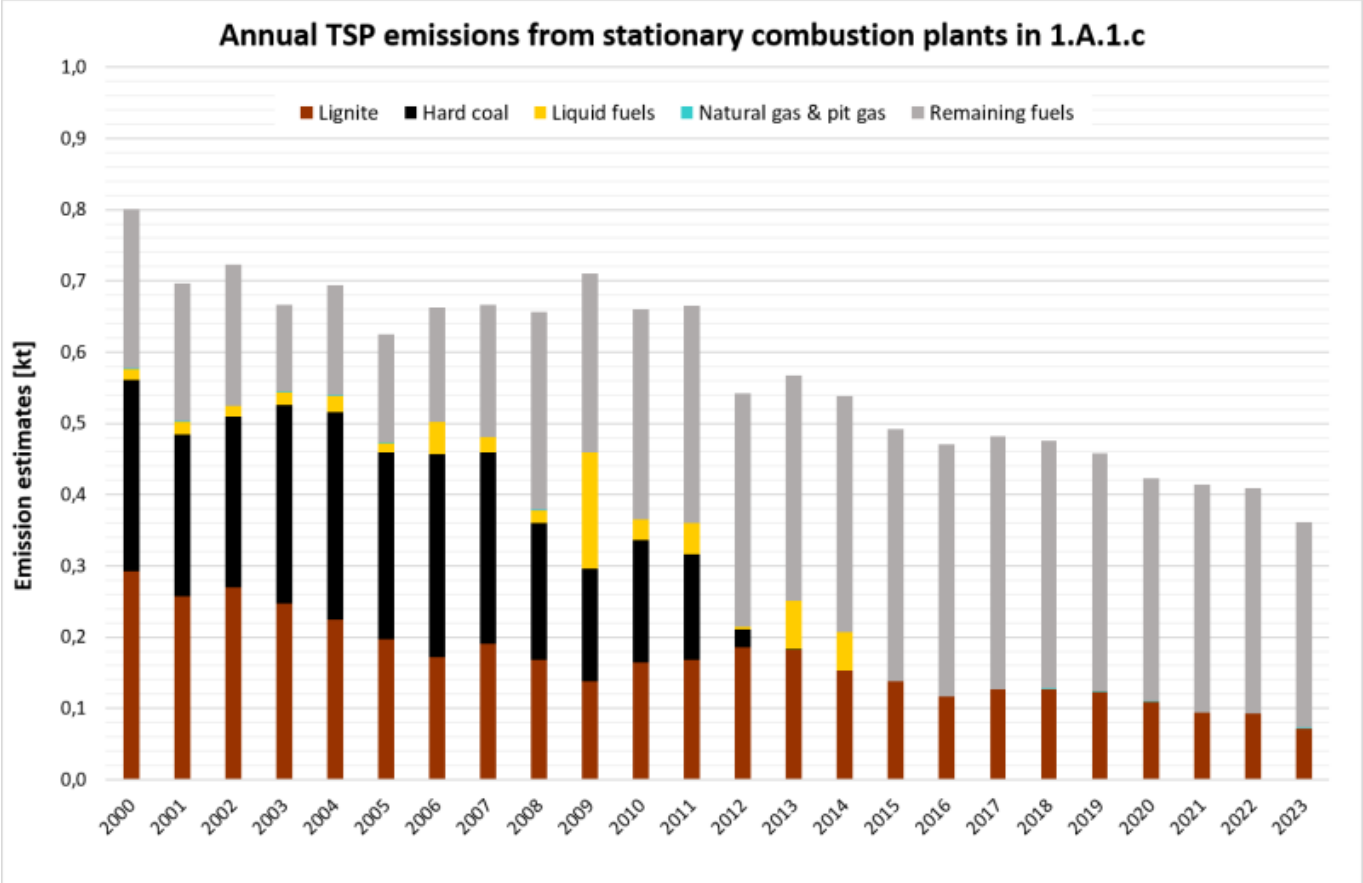
NO_x emissions decrease gradually from 1990 to 2001. The main reasons are the minor fuel use of lignite and of hard coal in this sector and the adaptation of regulations in eastern Germany to the western standard. Besides German hard coal production decreased considerably since 1990. Therefore some hard coal fired industrial power plants changed from sector

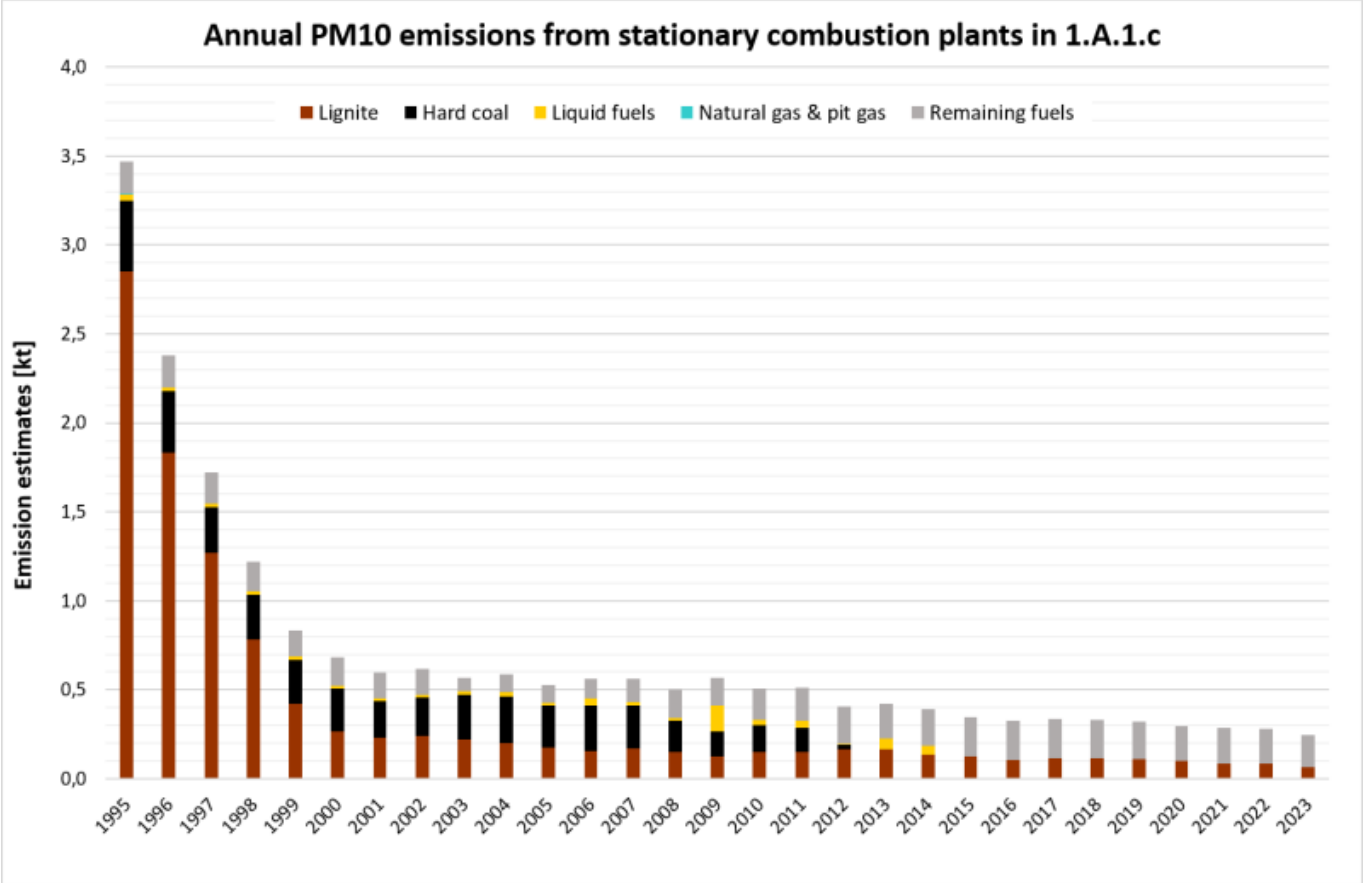
1.A.1.c to the public sector. This is also the reason for the significant emission reduction in 2012.

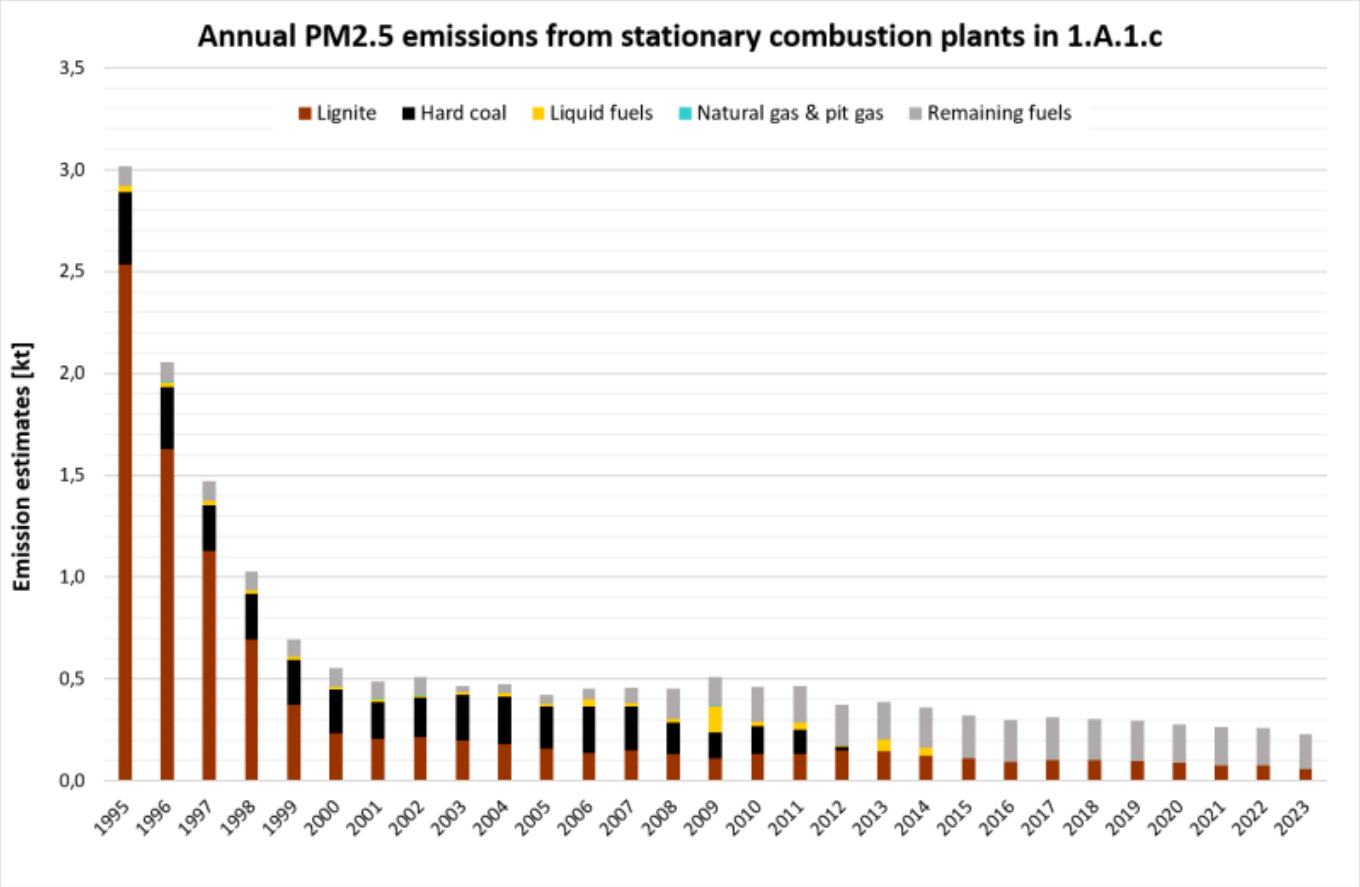


Total Suspended Matter - TSP, PM10 & PM2.5



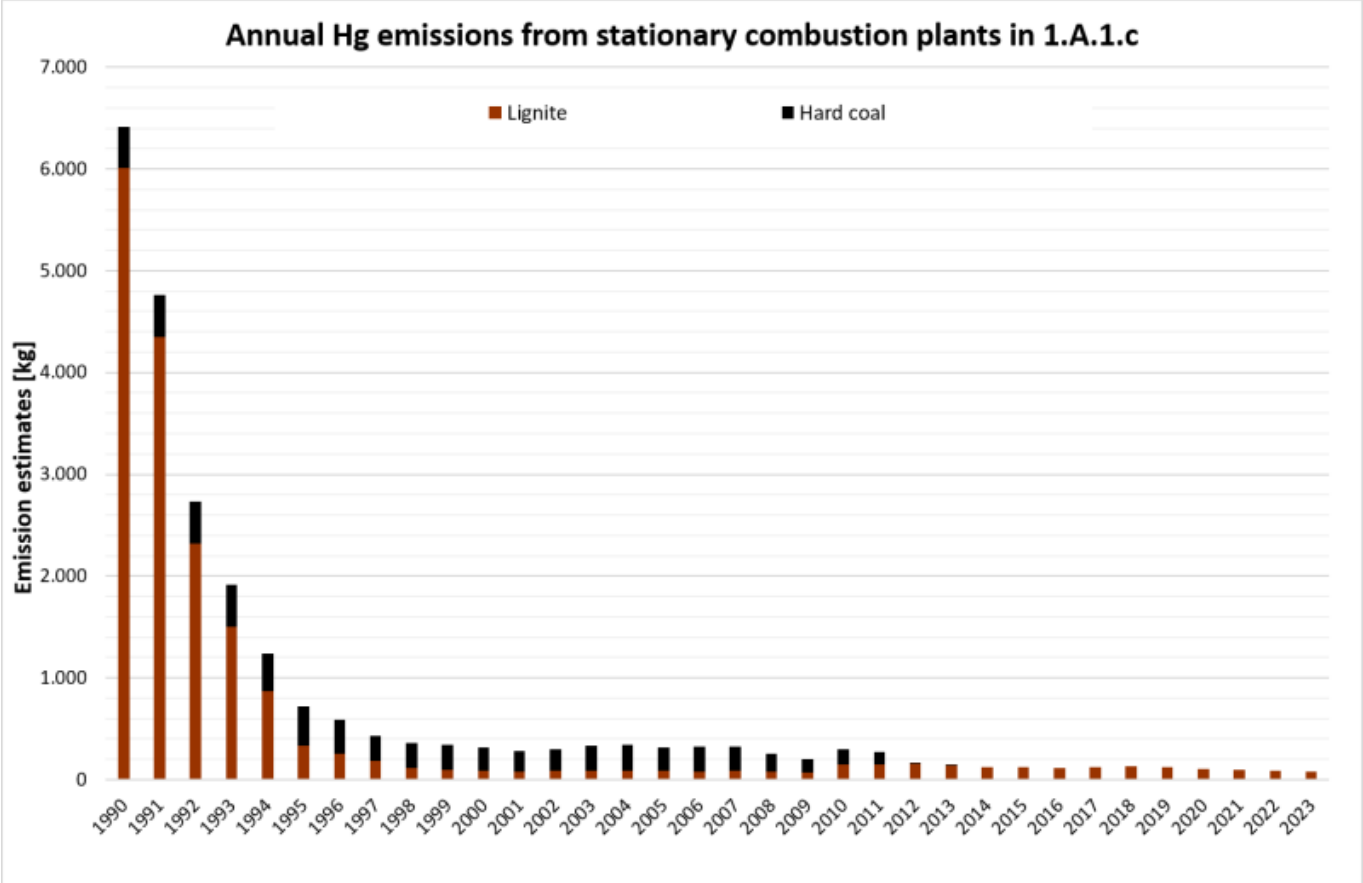

Annual TSP emissions from stationary combustion plants in 1.A.1.c
Emission estimates [kt]
Lignite
Hard coal
Liquid fuels
Natural gas & pit gas
Remaining fuels
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

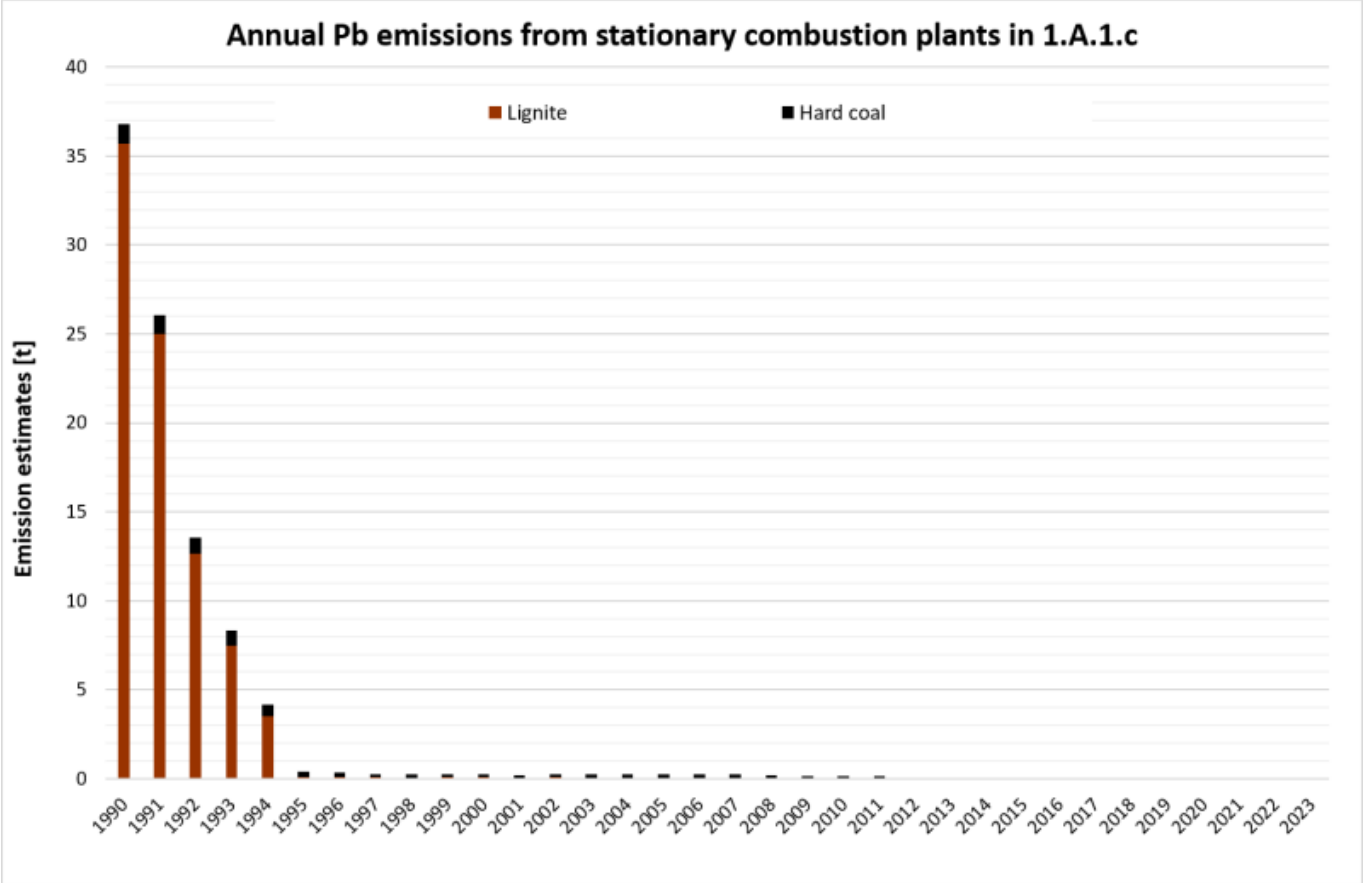

Annual PM10 emissions from stationary combustion plants in 1.A.1.c
Emission estimates [kt]
Lignite
Hard coal
Liquid fuels
Natural gas & pit gas
Remaining fuels
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

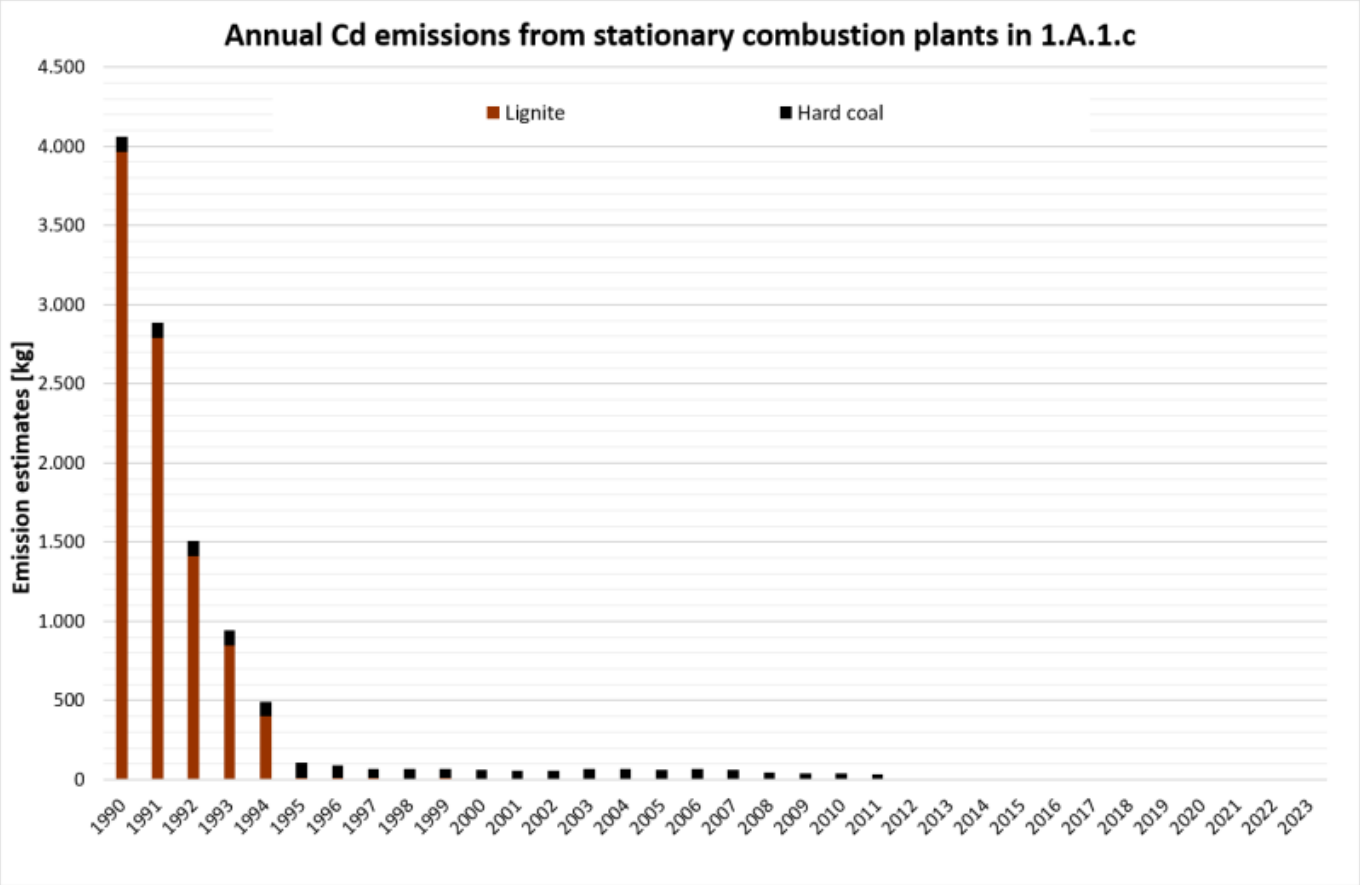


Priority Heavy Metal - Hg, Pb & Cd

Similar to SO_x emissions, TSP and Priority Heavy Metal emission trends show a high dominance of emissions from lignite combustion. Like already discussed for other pollutants, the main reason for sharp declining emissions in this sector is the complete restructuring of the east German lignite industry. The low standard of dust abatement in eastern Germany in the early 1990s involved high heavy metal emissions too. The closing of briquette factories and the implementation of stricter regulations resulted in a considerable improvement of the air quality especially in the New German Länder.


Annual Hg emissions from stationary combustion plants in 1.A.1.c
Lignite
Hard coal
Emission estimates [kg]
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023


Annual Pb emissions from stationary combustion plants in 1.A.1.c
Lignite
Hard coal
Emission estimates [t]
40
35
30
25
20
15
10
5
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023



Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the Energy Balance for 2022 led to recalculations. In addition, to ensure that consumption of fuels in the official data sources is consistently included in the inventory, reallocation of fuel data between 1.A.1.b, 1.A.1.c and 1.A.2.g viii took place for the years 2003-2022.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen - AGEB): National energy balance and Satellite balance for renewable energy: https://ag-energiebilanzen.de/en/data-and-facts/energy-balance-2000-to-2030/; Berlin, 2024

[2)] Statistik der Kohlenwirtschaft, 2021 - URL: https://www.kohlenstatistik.de

[3)] Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); https://publikationen.bibliothek.kit.edu/21412002; Karlsruhe / Dessau-Roßlau, 2002.

[4)] UBA (2019): Juhrich, K. and Beckers, R.: “Updating the Emission Factors for Large Combustion Plants”, https://www.umweltbundesamt.de/publikationen/updating-emission-factors-large-combustion-plants, Dessau-Roßlau, 2019
[5)] Hensmann et al. (2011): Hensmann, M., Haardt, S., Ebert, D.: Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichterstattung (FKZ 3707 42 301); https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/4362.pdf, on behalf of the Umweltbundesamt, Dessau-Roßlau, October 2012

1.A.2 - Fuel Combustion Activities in Industries and Construction (OVERVIEW)

Short description

In sub-sector **1.A.2 - Fuel Combustion Activities in Industries and Construction** emissions from both stationary and mobile fuel combustion activities in industries and construction are reported within the following sub-categories:

NFR-Code	Name of Category
Stationary Combustion in Manufacturing Industries and Construction	
1.A.2.a	Iron and Steel
1.A.2.b	Non-ferrous Metals
1.A.2.c	Chemicals
1.A.2.d	Pulp, Paper and Print
1.A.2.e	Food Processing, Beverages and Tobacco
1.A.2.f	Non-Metallic Minerals
1.A.2.g viii	Other
Mobile Combustion in Manufacturing Industries and Construction	
1.A.2.g vii	Mobile Combustion in Manufacturing Industries & Construction

The German emission inventory is generally based on the emission behaviour of the plants. Therefore it's necessary to distinguish between process-combustion on the one hand and industrial power plants and boiler systems on the other hand. The emission behaviour of power plants and boiler systems of the various industrial sectors is similar. That's why all the emissions from these type of plants were reported under source category 1.A.2.f.i other. Whereas the emission behaviour of the different process-combustion systems is individual. A distinction between fuel and process related emissions is usually not possible. Therefore all emissions emissions from process-combustion systems are reported in the corresponding source category of the industry sector NFR 2.

1.A.2.a - Stationary Combustion in Manufacturing Industries and Construction: Iron and Steel



Short description

Category Code	Method	AD	EF
1.A.2.a	T2	NS	?

Category Code	Method	AD	EF
Method(s) applied			
D	Default		
T1	Tier 1 / Simple Methodology *		
T2	Tier 2*		
T3	Tier 3 / Detailed Methodology *		
C	CORINAIR		
CS	Country Specific		
M	Model		
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.			
(source for) Activity Data			
NS	National Statistics		
RS	Regional Statistics		
IS	International Statistics		
PS	Plant Specific		
As	Associations, business organisations		
Q	specific Questionnaires (or surveys)		
M	Model / Modelled		
C	Confidential		
(source for) Emission Factors			
D	Default (EMEP Guidebook)		
CS	Country Specific		
PS	Plant Specific		
M	Model / Modelled		
C	Confidential		

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	$BC_{(since\ 2000)}$	**CO**	Pb	Cd	**Hg**	As	Cr	Cu	Ni	Se	Zn	**PAHs**	HCB	PCBs
-/T	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	IE	IE	-/-	NE	NE	NE	NE	NE	NE	-/-	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

In 2023, a total of 25.6 million tonnes of raw steel were produced in six integrated steelworks. Electrical steel production amounted to another 9.8 million tonnes.

The structural elements of this category are the production of pig iron (blast furnaces), sponge iron (direct reduction), sinter, rolled steel, iron and steel casting, Siemens-Martin steel (in the new German Länder only until shortly after 1990), electric steel and the power stations and boilers of the entire steel production.

In category 1.A.2.a Iron and Steel only emissions of

- CO (for all years exept 2008-2010, where only CO emissions from ferrous metal foundries are reported),
- NH_3 (until 1999 and then for the years 2010 and later; from 2000 to 2009 only NH_3 emissions from use of coal and coke in electric steelworks are reported),
- NMVOC and NO_x (until 1999),
- $PM_{2.5}$, PM_{10} and TSP (until 2007 and then for the years 2010 and later; for 2008 and 2009 only emissions from the use of fuel gases sinter plants (ignition hoods) are reported) and
- SO_2 (untiil 1999; SO_2 emissions from the use of coal and coke in electric steelworks until 2000 and in 2004)

are reported. The emissions of these pollutants in other years as well as emissions of other pollutants are reported under Category 2.C.1 (see explanation below).

Methods

Activity data

Data source of the fuel consumption for iron and steel casting is the statistic for the manufacturing sector; Statistik 060 - Energieverwendung des produzierenden Gewerbes (Energy use in the manufacturing sector; DESTATIS), reporting-numbers 27.21, 27.51 and 27.52. Fuel consumption data for the hot metal production as well as the production of sinter and hot rolling are collected by the steel trade association (WV Stahl) in continuation of the former National Statistic: Fachserie 4, Reihe 8.1.

Emission factors

The emission factors used for the years 1990 - 1994 were taken from the report on the research project “Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010” (Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010“; RENTZ et al, 2002)[1)]. Starting from 1995 new emission factors for iron and steel were determined, based on real emission data from the installations concerned. (1995-2001: own calculations by UBA; EF for 2008 by a research project by the steel industry´s research institut BSI.

In category 1.A.2.a - Iron and Steel only emissions from power plants and steam boiler of the steel industry are reported. Basically, all industrial power plants and steam boiler are reported in source category 1.A.2.gviii - Other since the emission behaviour is comparable. The reason for the different structure of 1.A.2.a are the requirements of the UNFCCC Guidelines and the resulting review proceedings. Insofar it is more sensible to report all emissions from blast furnace fired power plants and steam boiler in Source category 1.A.2.a to avoid notes regarding CO_2 IEFs.

Whereever emission factors were determined from real emission data of the installations concerned, both process and energy related emissions from the production of sinter, pig iron (blast furnace including the cowpers), steel (both BOF and EAF steel production), rolled steel as well as from cast iron and steel are reported under Category 2.C.1, since it is not possible to separate combustion from process emissions within the same stack. Insofar in later years the emissions of the most pollutants are reported under 2.C.1.

Trend discussion for Key Sources

Category 1.A.2.a Iron and Steel is a trend key category for NO_x (mainly because the NO_x emissions reported here until 1999 are then reported under Category 2.C.1).

Recalculations

Recalculations were necessary for 2022 due to the implementation of the now finalised National Energy Balance.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); https://publikationen.bibliothek.kit.edu/21412002; Karlsruhe / Dessau-Roßlau, 2002.

1.A.2.b - Stationary Combustion in Manufacturing Industries and Construction: Non-Ferrous Metals

Short description

Sub-category *1.A.2.b - Stationary Combustion in Manufacturing Industries and Construction: Non-Ferrous Metals* includes aluminium production (sub-divided into primary and resmelted aluminium) as well as lead production, thermal galvanisation, copper and zinc production.

In Germany, aluminium is produced at four foundries, in electrolytic furnaces with pre-burnt anodes. The principal emission sources are resulting from fuel provided in the energy related processes.

NFR Code	Method	AD	EF
1.A.2.b	T2	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Heavy Metals**	**PCDD/F**	**PAHs**	**HCB**	**PCBs**
-/-	-/-	-/-	-/-	IE	IE	IE	IE	-/-	IE	IE	IE	IE	IE

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

Activity data

The source of the fuel inputs consists of the statistics for the manufacturing sector (Statistik 060 - Energieverwendung des produzierenden Gewerbes / energy use in the manufacturing sector), DESTATIS, reporting number 27.43 and 27.44, production and initial processing of lead, zinc and tin, production and initial processing of copper - and, for differentiations relative to heat and electricity production, Statistik 067 (DESTATIS).

Data for fuel consumption for production and initial processing of precious metals are also provided by these statistics.

Emission factors

Reported pollutants are NOx, NMVOC, SO_2, NH_3 and CO. Instead, all particulate matter emissions are reported as process emissions in the associated categories in 2.C. Germany carefully checked all possible aditional sources for HCB in this sector. This includes the BREF documents as well as other literature. There was no indication for any missing emission found. The emission factors for HCB in the Guidebook are only applicable to processes not occuring in Germany.

The underlying data for the emission factors used is provided by the report on the research project “Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010” (Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010“; RENTZ et al, 2002)[1)]. The values for the intermediate years 1996 - 1999 and 2001 - 2010 are obtained via linear interpolation; adjusted values for the following years.

Recalculations

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); https://publikationen.bibliothek.kit.edu/21412002; Karlsruhe / Dessau-Roßlau, 2002.

1.A.2.c - Fuel Combustion Activities in Industries and Construction: Chemicals

Energy related emissions from power plants and boiler systems are reported in NFR 1.A.2.g viii: Other whereas process related emissions are reported in NFR 2.B - Chemical Industry.

1.A.2.d - Pulp, Paper and Print

All emissions from fossil fired power plants and boiler systems are reported in NFR 1.A.2.g viii: Other whereas all process related emissions as well as emissions from black liquor incineration are reported in NFR 2.H.1 - Pulp and Paper .

It is not possible to report combustion related emissions under the category 1.A.2.d for purposes of comparison as the emission estimates are based on a complete report of branches with EF for all occurring emissions in sum.

1.A.2.e - Stationary Combustion in Manufacturing Industries and Construction: Food Processing, Beverages and Tobacco

Short description

Source category *1.A.2.e - Stationary Combustion in Manufacturing Industries and Construction: Food Processing, Beverages and Tobacco* includes emissions from process-combustion systems of the sugar industry. Emissions from CHP plants and steam boiler are reported under 1.A.2.g viii - Stationary Combustion in Manufacturing Industries and Construction: Other.

NFR Code	Method	AD	EF
1.A.2.e	T2	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	$PM_{2.5}$	PM_{10}	TSP	BC	**CO**	Heavy Metals	PCDD/F	PAHs	HCB	PCBs
-/-	-/-	-/-	-/-	IE	IE	IE	IE	-/-	NE	NE	NE	NA	NA

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

Method

Activity data

The source of the fuel inputs consists of the statistics for the manufacturing sector (Statistik 060 - Energieverwendung des produzierenden Gewerbes / energy use in the manufacturing sector), DESTATIS, reporting number 10.81, sugar production - and, for differentiations relative to heat and electricity production, Statistik 067 (DESTATIS).

Emission factors

Reported pollutants are NOx, NMVOC, SO_2, NH_3 and CO.

All particulate matter emissions are reported as process emissions under 2.H.2. But the allocable part of BC emissions is included in 1.A.2.g viii (emissions from CHP plants and steam boilers).

The underlying data used for the emission factors is provided by the report on the research project “Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010” (Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010“; RENTZ et al, 2002)[1)].

The values for the intermediate years 1996-1999 and 2001-2010 are obtained via linear interpolation; adjusted values for the following years.

Recalculations

Recalculations were necessary for most recently year due to the implementation of the now finalised National Energy Balance.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); https://publikationen.bibliothek.kit.edu/21412002; Karlsruhe / Dessau-Roßlau, 2002.

1.A.2.f - Stationary Combustion in Manufacturing Industries and Construction: Non-Metallic Minerals

Short Description

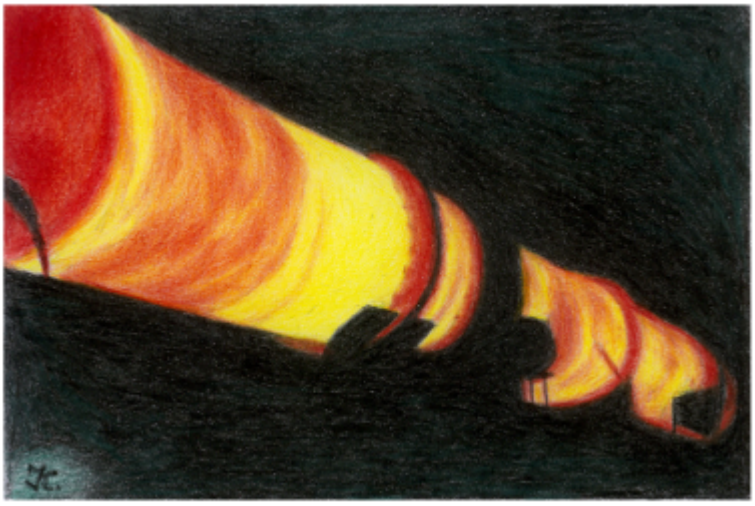
Sub-category *1.A.2.f - Non Ferrous Metals* refers to emissions from fuel consumption for burning processes in energy-intensive mineral industries.

Category Code	Method	AD	EF
1.A.2.f	T1	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
-/-	-/-	-/-	-/-	IE	IE	IE	IE	-/-	NA	NA

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential



In order of significance relating energy use and emissions, the covered industries are:

- burning of cement clinker,
- burning of quicklime,
- melting of glass,
- burning of ceramics.

Method

Regarding the burning processes emissions can allocated to the use of fuels or to the production process. Current allocation is regarding the main importance of the production process.

Activity data

The key source of all conventional fuel data is the national energy balance. Moreover the use of additional statistical data is necessary in order to disaggregate data. Data source for fuel inputs for energy-related process combustion in cement industry are manufacturing-sector statistics (Statistik des produzierenden Gewerbes); reporting number (Melde-Nr.) 23.51, Cement production. Furthermore the cement industry uses significant amounts of substitute fuels that do not appear in national statistics and in the Energy Balance. Relevant production figures and fuel-use amounts have been taken from statistics of the VDZ cement-industry association. The fuel-input data for ceramics production has also been taken from manufacturing industry statistics (Statistik des produzierenden Gewerbes); reporting no. (Melde-Nr.) 23.32, brickworks (Ziegelei), production of other construction ceramics. The same statistic is also used as source for fuel input of glass (reporting number: 23.1, Production of glass and glassware) and lime production (reporting number: 23.52, Lime).

Emissions

Due to allocating emissions to process part we have removed most of time series inconsistencies. The current situation is the following:

Table 1: relevance of emission sources regarding the fuel use due to burning processes in 1.A.2.f

	SO_x	**NO_x**	**CO**	**NMVOC**	**NH_3**	**TSP**	**BC**
cement	IE[1]	IE[1]	medium	IE[1]	IE[1]	IE[2]	NE
lime	IE[1]	IE[1]	IE[1]	IE[1]	low	IE[2]	NE
glass	IE[2]	IE[1]	IE[1]	IE[1]	IE[1]	IE[2]	NE
ceramics	IE[3]	IE[3]	low	IE[1]	IE[1]	IE[1]	NE
[1] Included in process related emissions, in all cases it is the link to complementary source category.							
[2] Some artifacts occur for 1990 emissions that cannot be shifted.							
[3] Inclusion in process related emissions occurs from different time points onwards.							

The entire appraisal of the emissions situation succeeds only in connection with the process related emissions. Especially further relevant pollutants as heavy metals or persistent organics are shown as process related generally.

Recalculations

Recalculations were necessary for most recently year due to the implementation of the now finalised National Energy Balance.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements



At the moment, no category-specific improvements are planned.

1.A.2.g viii - Stationary Combustion in Manufacturing Industries and Construction: Other

Short description

Source category *1.A.2.g viii - Stationary Combustion in Manufacturing Industries and Construction: Other* comprises stationary combustion systems for heat and power production of industrial power plants and industrial boiler systems.

NFR Code	Method	AD	EF
1.A.2.g viii	T2	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
L/T	-/-	**L/T**	-/-	**L/-**	-/-	**L/T**	-/-	-/-	-/-	**L/-**	**L/T**	**L/T**	**L/T**	**-/T**	**L/T**	-/-	**L/T**	**L/T**	**-/T**	IE	IE	IE	**-/T**	-/-	-/-

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential



Method

Generally, the calculation method is based on a Tier2 approach. This means the use of country-specific data at a more detailed level.

Emission factors and activity data are available for different fuel types, different technologies, plant size, etc. The use of

plant-specific data for a bottom-up approach is not possible. Emissions from industrial power plants cannot be allocated clearly to source category 1.A.2, since reality does not follow the definition of the Guidebook. In real life an industrial power plant generates electricity and heat for the industry but also electricity for the public network. Therefore the borderline between these two categories is not fixed.

The market is not static. Frequent changes in the cooperate structure of industrial enterprises including the separation of the energy supply via spin-off from the parent company lead to frequent changes between sector 1.A.1.a, 1.A.1.c and 1.A.2. Therefore it was necessary to develop a flexible calculation system, based on robust emission factors, which can be used for all sectors. Source category 1.A.2.g.viii does only include emissions from industrial power plants and boiler systems.

Activity data

Conventional fuels

The key source of all conventional fuel data are the national energy balances published by the Working Group on Energy Balances (AGEB, (2024))[1)].

Moreover, the use of additional statistical data is necessary in order to disaggregate data. Data source for fuel inputs for electricity generation in industrial power stations are shown in Energy Balance line 12. The difference resulting after deduction of the fuel inputs for refinery power stations, pit power stations, power stations in the hard-coal-mining sector and, for the period until 1999, for the power stations of German Railways (Deutsche Bahn) consists of the activity data for other industrial power stations. These data cannot be further differentiated. Additional data from the Federal Statistical Office are needed for allocation of fuel inputs to heat production in industrial power stations and boiler systems. For both electricity production and heat production, gas turbines, gas and steam systems and gas engines are differentiated. These detailed information is provided by the national statistic 067 (industrial power stations). The definition of industrial and public power plants follows the National statistics.

Biomass

Along with the main Energy Balance, a Satellite Balance of renewable Energies (Satellitenbilanz Erneuerbarer Energieträger) is also published. This balance describes the growth and use of renewable energies in detail. This is the database for all biomass fuels excluding waste.

Waste

With regard to determination of activity data from waste incineration and co-combustion of waste in combustion system in source category 1.A.2 Energy Balance and energy statistics show smaller waste quantities than the waste statistics of the Federal Statistical Office (Statistisches Bundesamt, Fachserie 19, Reihe 1)[2)]. For that reason activity data were taken from waste statistics.

Emission factors

The emission factors for power stations and other boiler combustion for production of steam and hot water, in source category 1.A.2.g.viii, have been taken from the research project “Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010” (RENTZ et al., 2002)[3)].

In 2018 and 2019 SO_2, NOx, TSP, PM, CO, NH_3 and Hg emission factors were revised for all large combustion plants by using data from the large combustion plant reporting (UBA 2019)[4)]. A detailed description of the procedure is presented in Chapter: 1.A.1.a - Public Electricity And Heat Production. This chapter contains also information about emission factors of engines and waste incineration plants. In terms of black carbon default emission factors for the EMEP EEA Guidebook 2019 are used.

Table 1: Implied emission factors for industrial electricity and heat generation for 2023

	SO_x	NO_x	TSP	CO	Pb	Hg	Cd
	[kg/TJ]				[g/TJ]		
Hard Coal	142.9	101.2	3.3	25.9	4.98	2.34	0.36

	SO_x	NO_x	TSP	CO	Pb	Hg	Cd
Lignite	190.0	90.0	4.9	45.7	1.53	2.46	0.20
Natural gas	0.1	41.3	0.2	10.5	NA	0.01	NA
Liquid fuels	33.3	53.4	1.4	5.6	0.75	0.24	0.06
Biomass	9.5	131.9	16.7	50.7	0.39	0.17	0.49
Hazardous waste	0.5	69.2	0.2	7.8	4.90	0.34	1.10

The table gives an overview of the implied emission factors. In reality the German inventory compiling process is very complex and includes the use of a considerable number of emission factors, which cannot be published completely in the IIR.

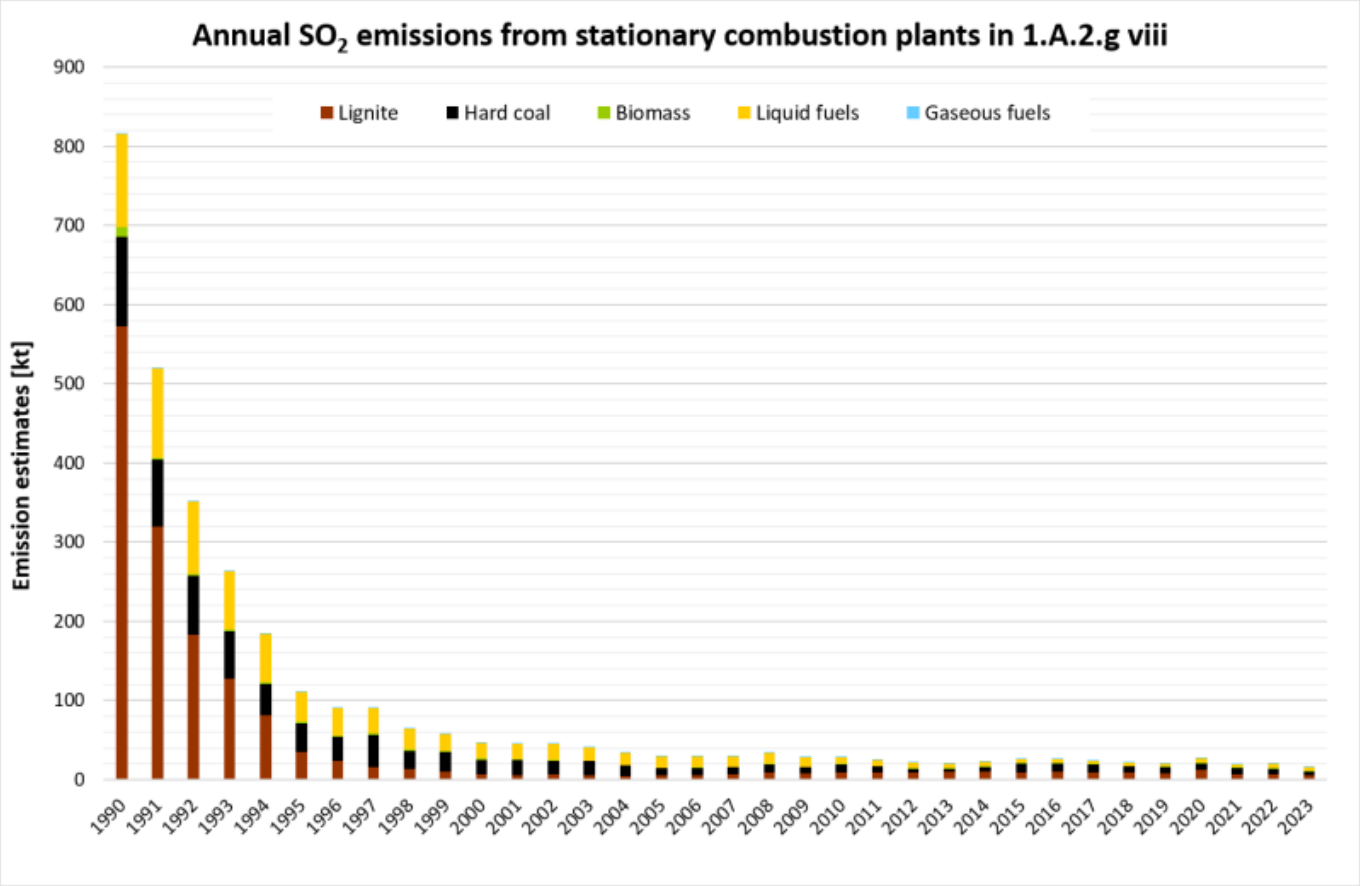
Actually there are different emission factors available for diverse fuel types, various techniques and due to permissions. However, the implied emission factor may give an impression about the order of magnitude. PM_{10} and $PM_{2.5}$ emission factors are calculated as a fraction of TSP. The share of PM_{10} is 90 % and the share of $PM_{2.5}$ is 80 % for solid fuels. This is a simple but also conservative approach, knowing that, in reality, PM emissions depend on fuel, combustion and abatement technologies. In terms of natural gas and biogas PM_{10} and $PM_{2.5}$ fractions are considered as 100 % of TSP. Regarding wood a share of 100% PM_{10} and 90% $PM_{2.5}$ is used. For liquid fuels the default share of 100% PM_{10} and $PM_{2.5}$ is used. In the cases of co-incineration, where liquid fuels are only used for ignition in coal fired plants, the share of coal fired plants is used. PM emission reporting starts in 1995, since no sufficient information about the dust composition of the early 1990s is available.

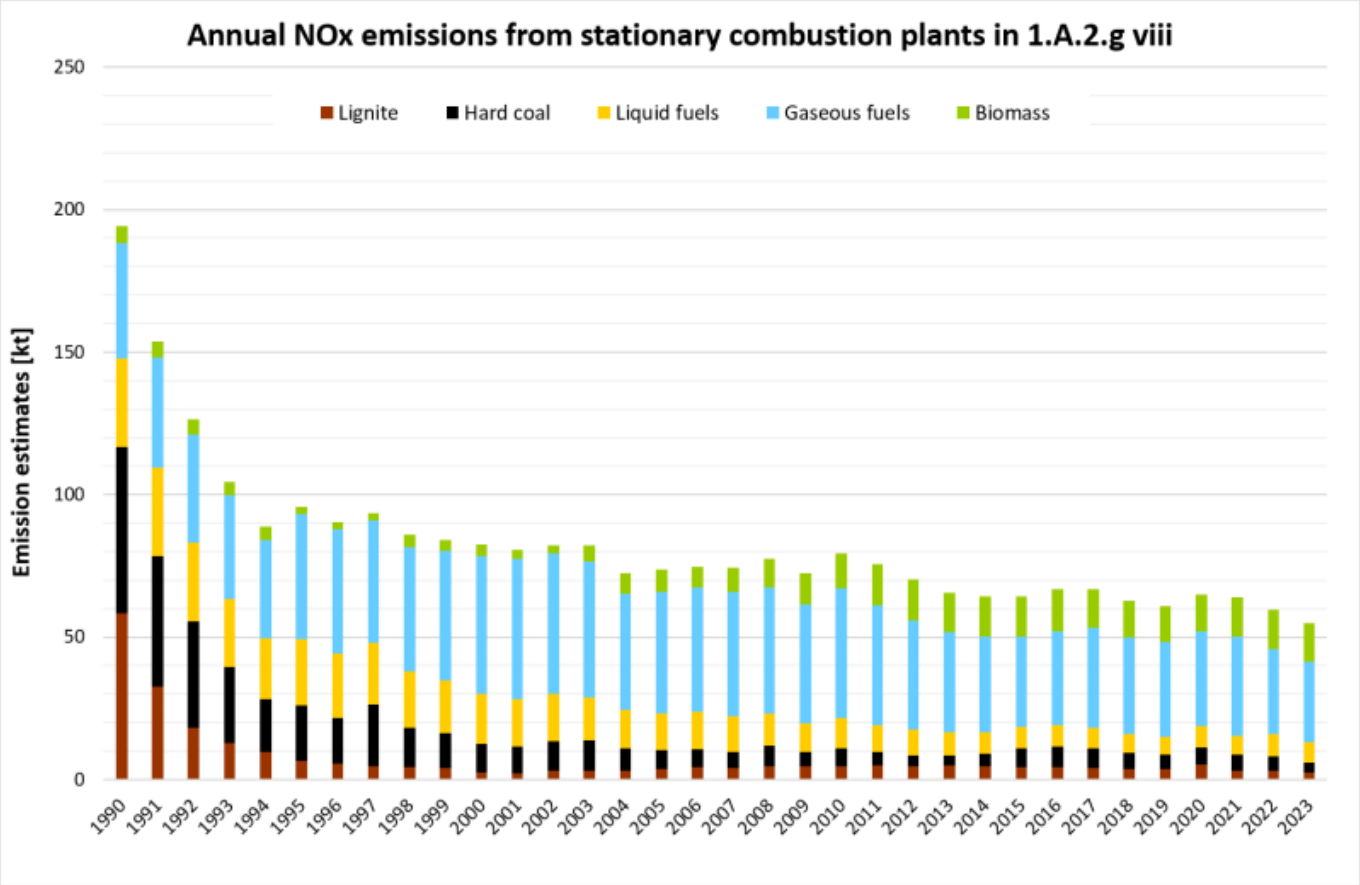
Trend Discussion for Key Sources

The following diagrams give an overview and assistance for explaining dominant emission trends of selected pollutant.

Sulfur Oxides & Nitrogen Oxides - SOx & NOx

As already discussed in source category 1.A.1.c, SO_x emission trend is very much influenced by emissions from lignite fired plants. The strong decline of lignite use in the East German industry and the installation of flue gas desulfurisation plants in the remaining heat and power stations are the main reasons for decreasing SO_x emissions.

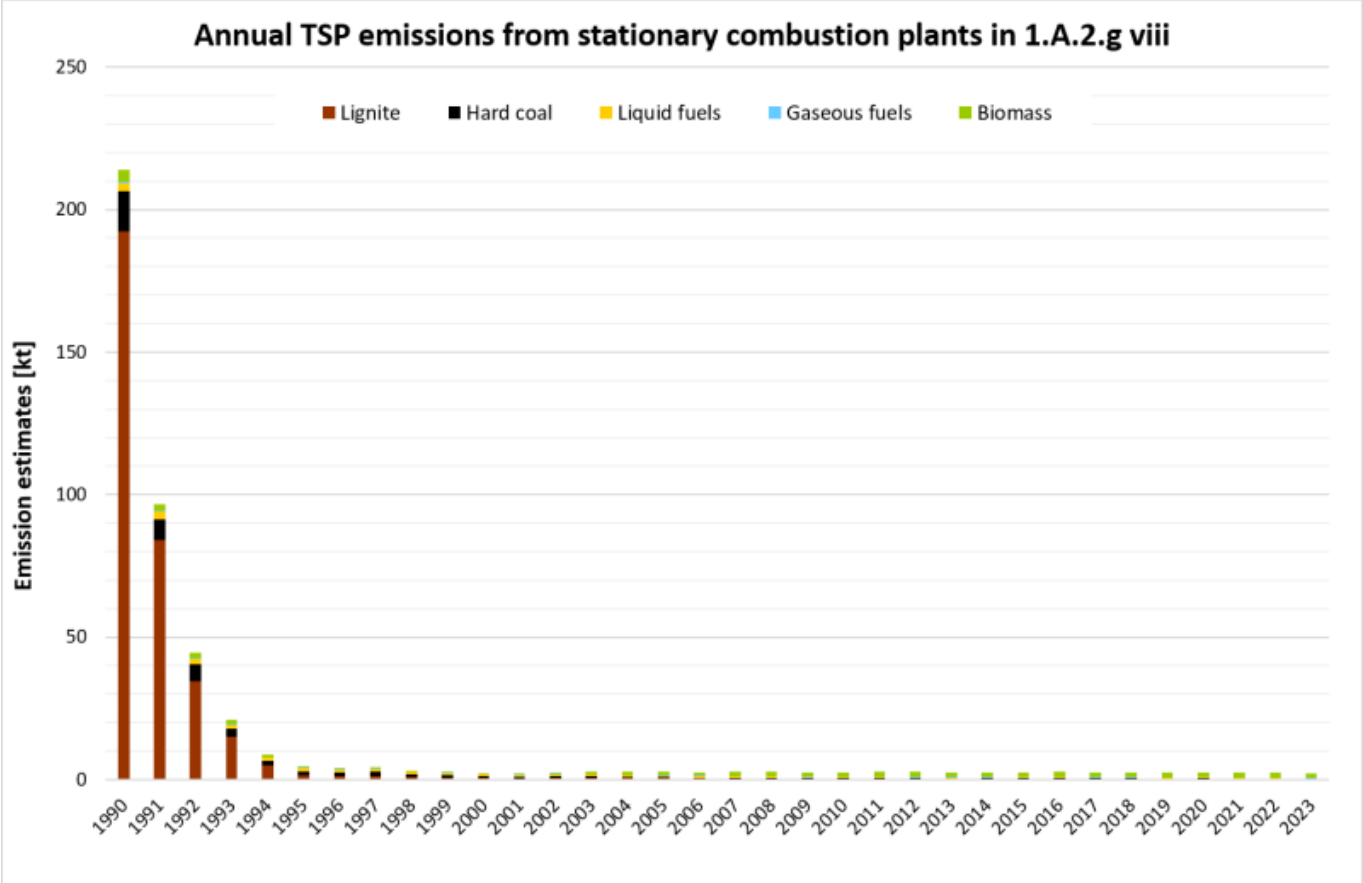


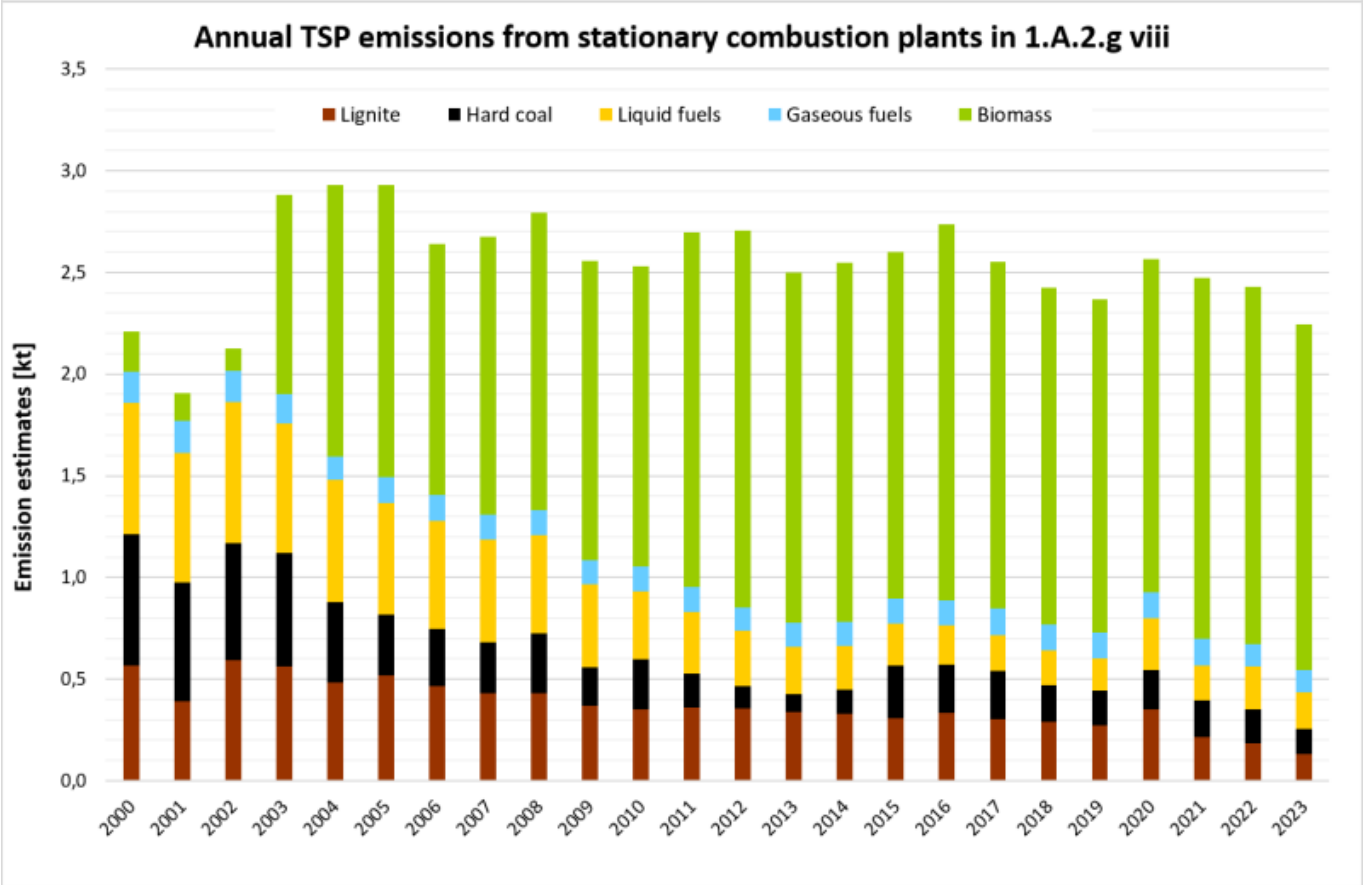


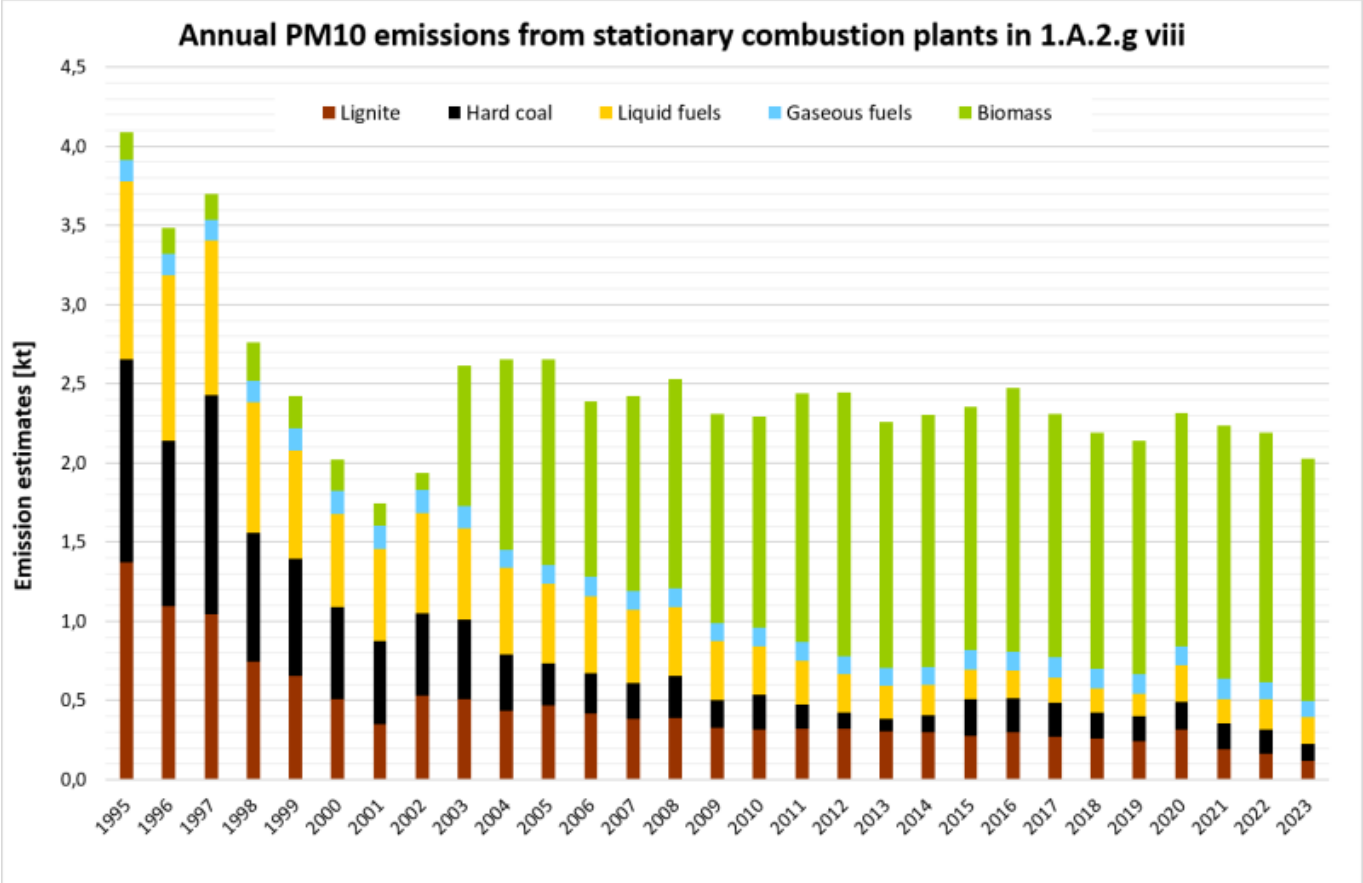
Particulate Matter (TSP, PM10) and Priority Heavy Metals (Hg & Cd)

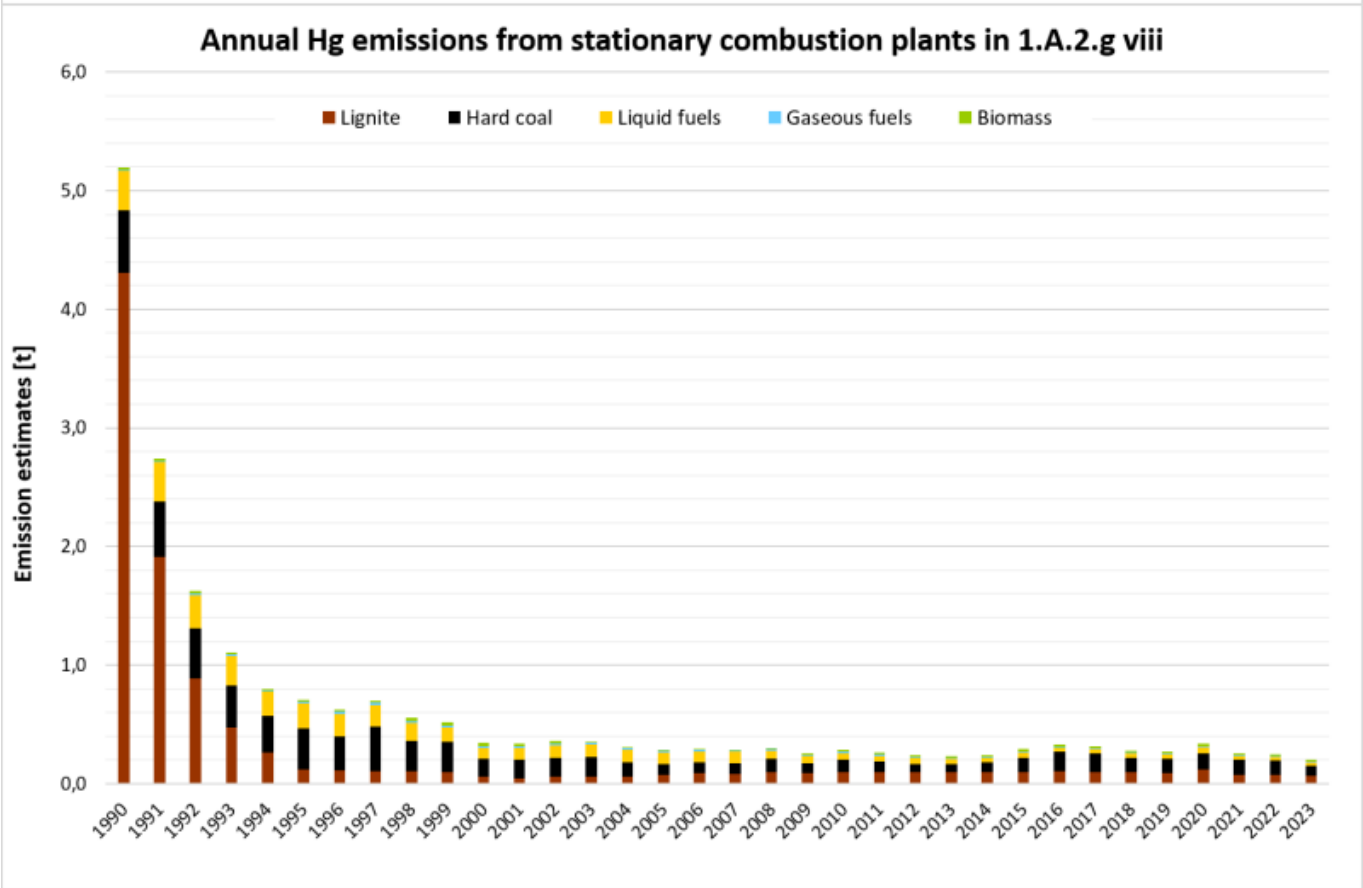
The main driver of TSP and heavy metal emission trends is the declining lignite combustion due to the closure of industrial plants in the East German industry especially from 1990 to 1994. Furthermore, the noticeable improvement of dust extraction installations and the optimisation of the combustion process resulted in considerably decreasing TSP and heavy metal emissions.

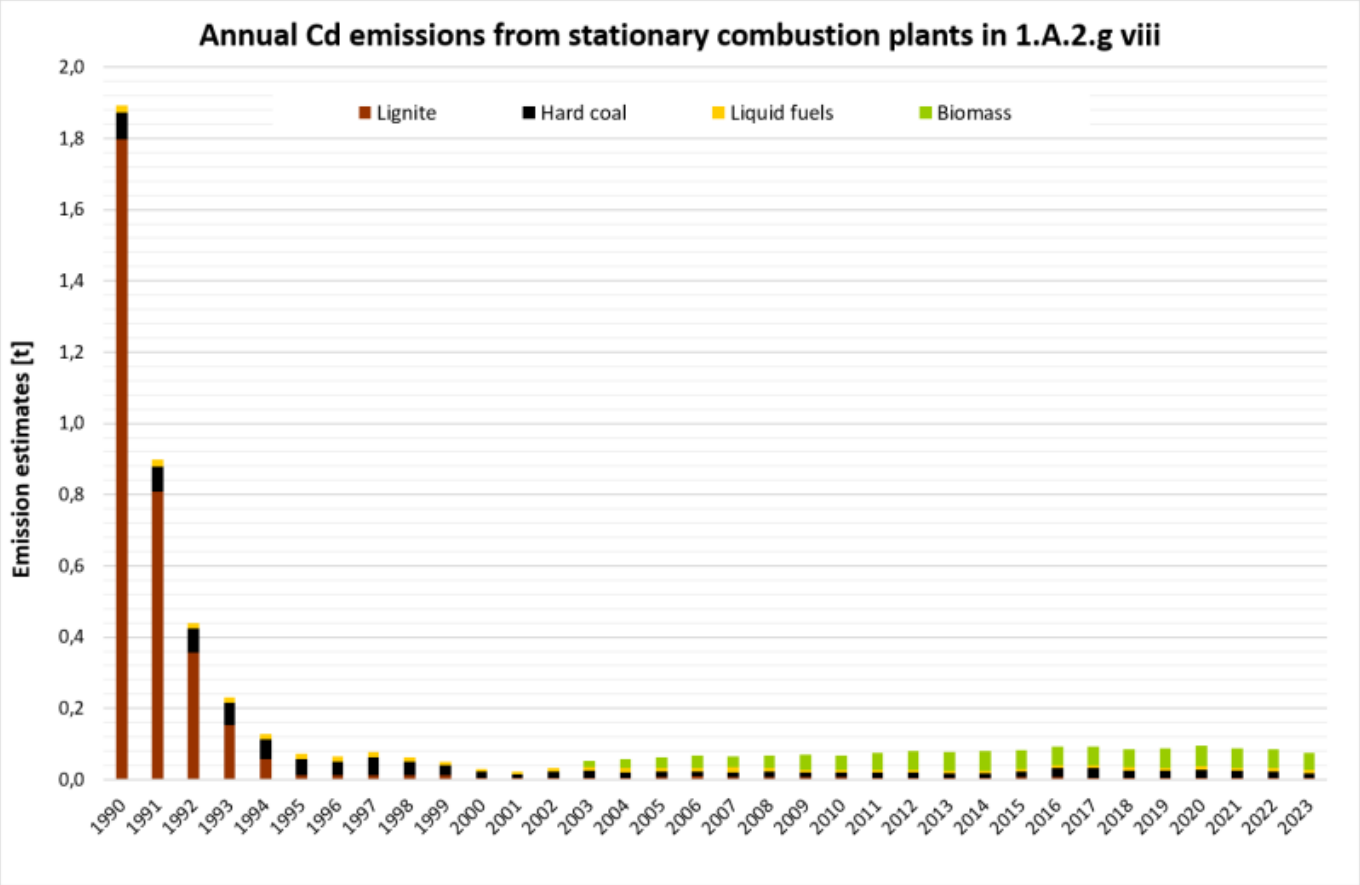
In recent years the use of biomass gains influence.


Annual TSP emissions from stationary combustion plants in 1.A.2.g viii
Lignite
Hard coal
Liquid fuels
Gaseous fuels
Biomass
Emission estimates [kt]
250
200
150
100
50
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023


Annual TSP emissions from stationary combustion plants in 1.A.2.g viii
Lignite
Hard coal
Liquid fuels
Gaseous fuels
Biomass
Emission estimates [kt]
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

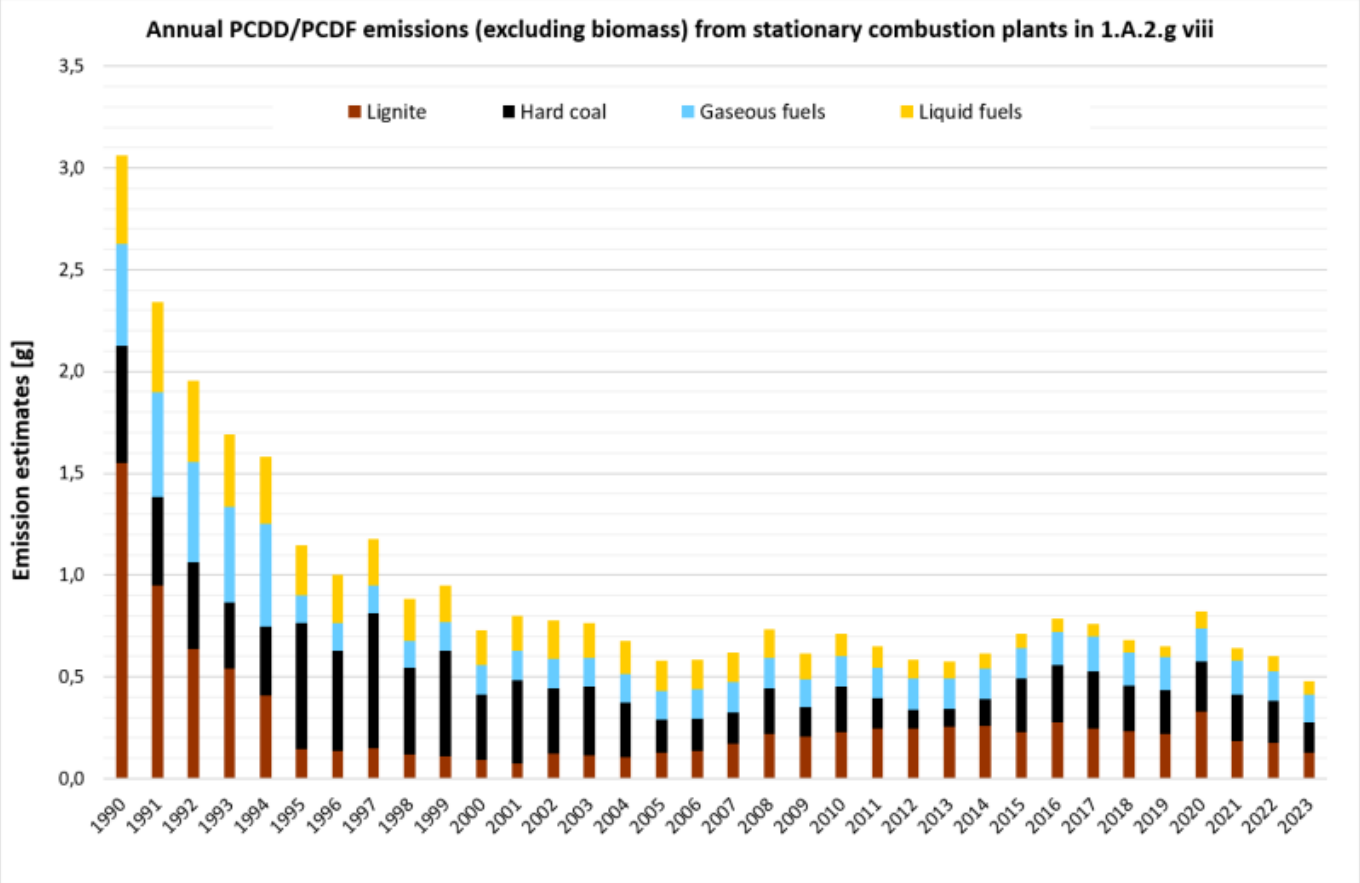

Annual PM10 emissions from stationary combustion plants in 1.A.2.g viii
Emission estimates [kt]
Lignite
Hard coal
Liquid fuels
Gaseous fuels
Biomass
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023


Annual Hg emissions from stationary combustion plants in 1.A.2.g viii
Emission estimates [t]
Lignite
Hard coal
Liquid fuels
Gaseous fuels
Biomass
6,0
5,0
4,0
3,0
2,0
1,0
0,0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023



Persistent Organic Pollutants

PCDD and PCDF emissions show a decreasing trend over the whole timeseries due to decreasing fuel consumption in the industry sector.



Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the Energy Balance for 2022 led to recalculations. In addition, to ensure that consumption of fuels in the official data sources is consistently included in the inventory, reallocation of fuel data between 1.A.1.b, 1.A.1.c and 1.A.2.g viii took place for the years 2003-2022.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 9.1 - Recalculations.

Planned improvements



At the moment, no category-specific improvements are planned.

[1)] AGEB (2024): Workin Group on Energy Balances: National energy balance and Satellite balance for renewable energy: https://ag-energiebilanzen.de/en/data-and-facts/energy-balance-2000-to-2030/, Berlin, 2024.
[2)] Destatis (2024a): Federal Statistical Office (Statistisches Bundesamt - Destatis): Fachserie 19, Reihe 1: Abfallentsorgung (now data on waste management are available from the GENESIS-Online database) - URL: http://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Abfallwirtschaft/_inhalt.html#sprg238672, Wiesbaden, 2024.
[4)] Umweltbundesamt (2019): Juhrich, K., Beckers, R.: “Updating the Emission Factors for Large Combustion Plants”: https://www.umweltbundesamt.de/publikationen/updating-emission-factors-large-combustion-plants; Dessau-Roßlau, 2002.

1.A.2.g vii - Mobile Combustion in Manufacturing Industries and Construction

Short description

Under NFR *1.A.2.g vii - Mobile Combustion in Manufacturing Industries and Construction*, emissions from Off-Road Construction Vehicles and Construction Machinery are reported in the German inventory.

NFR Code	Method	AD	EF
1.A.2.g vii	T1,T2	NS, M	CS, D, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/F**	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAH1-4**	HCB	PCBs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	**L/-**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

Sector-specific consumption data is included in the primary fuel-delivery data are available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2024) [1)]

Table 1: Sources for primary fuel-delivery data

through 1994	**AGEB** - National Energy Balance, line 79: 'Haushalte und Kleinverbraucher insgesamt'
as of 1995	**AGEB** - National Energy Balance, line 67: 'Gewerbe, Handel, Dienstleistungen u. übrige Verbraucher'

Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2024) [2)], the remaining amounts of gasoline and diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and off-road vehicles in commercial/institutional use (1.A.4. ii) as well as agriculture and forestry (NFR 1.A.4.c ii) based upon annual shares derived from TREMOD-MM (Knörr et al. (2024b)) [3)] (cf. NFR 1.A.4 - mobile).

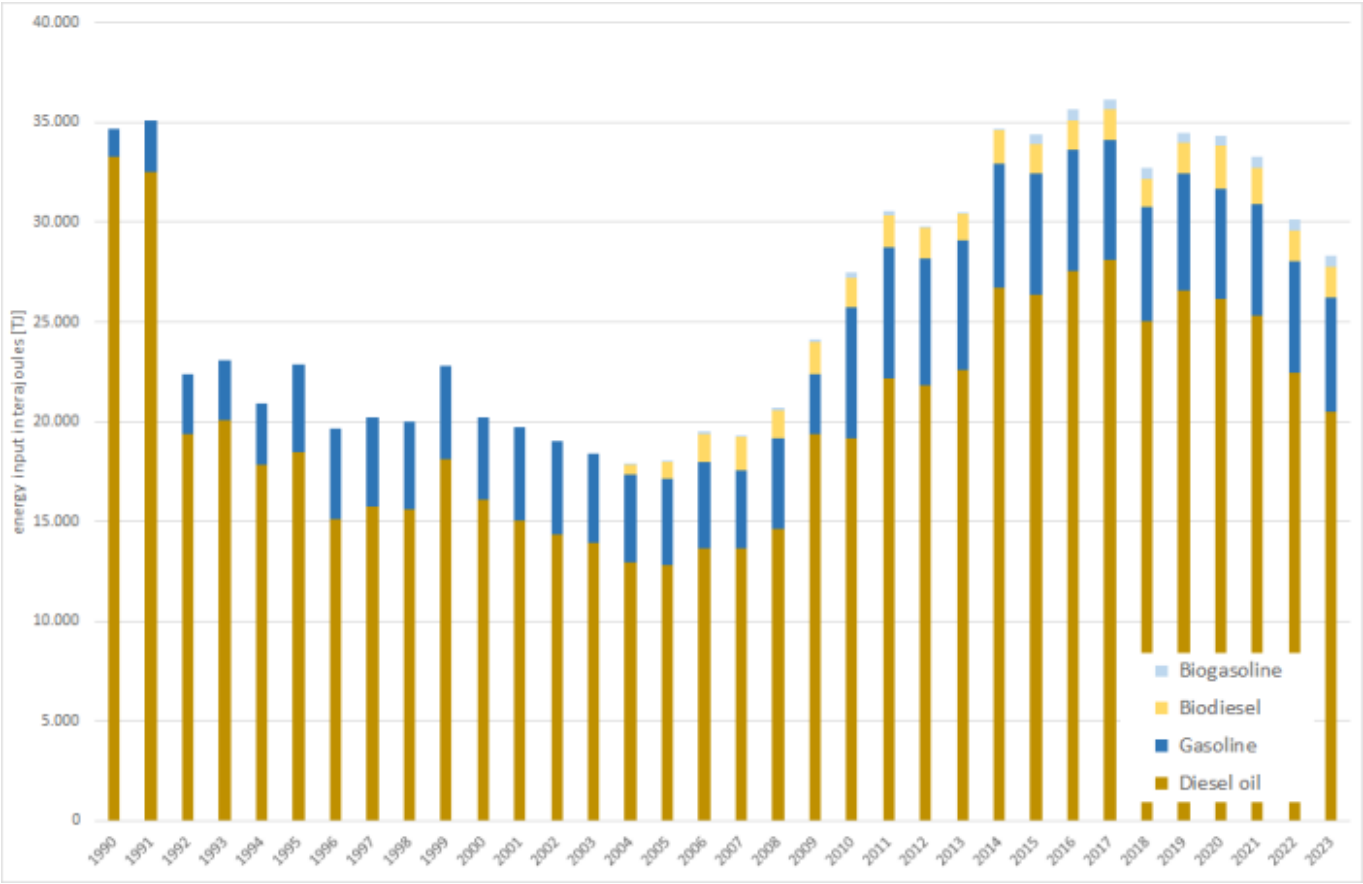
Table 2: Percental annual contribution of 1.A.2.g vii to fuel-specific over-all delivery data provided in NEB line 67

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel Fuels	29.7%	18.9%	17.0%	15.6%	21.6%	25.5%	26.2%	26.4%	24.2%	25.1%	25.1%	23.8%	21.9%	20.3%
Gasoline Fuels	31.5%	59.7%	55.1%	58.6%	64.5%	68.0%	70.9%	71.1%	67.9%	67.1%	63.5%	63.4%	63.8%	66.2%

Table 3: Annual fuel consumption in construction vehicles and mobile machinery, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel Oil	33,262	18,447	16,122	12,831	19,188	26,360	27,518	28,105	25,008	26,566	26,159	25,287	22,417	20,495
Gasoline	1,420	4,453	4,079	4,284	6,532	6,071	6,112	5,992	5,769	5,881	5,537	5,645	5,607	5,756
Biodiesel	0	0	0	853	1,501	1,464	1,491	1,532	1,411	1,507	2,140	1,773	1,555	1,519
Biogasoline	0	0	0	59.4	221	492	499	485	499	485	497	532	520	544
Σ 1.A.2.g vii	**34,682**	**22,900**	**20,201**	**18,028**	**27,442**	**34,387**	**35,621**	**36,113**	**32,687**	**34,439**	**34,332**	**33,238**	**30,099**	**28,314**

> NOTE: The remarkable increase in gasoline consumption after 2014 relates to the strongly increased inland deliveries reported in NEB line 67.



Emission factors

The emission factors used here are of rather different quality: Basically, for all **main pollutants**, **carbon monoxide** and **particulate matter**, annual IEF modelled within TREMOD MM (Knörr et al. (2023b)) [4)] are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

Table 4: Annual country-specific emission factors[1], in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Gasoline fuels														
NH_3	0.089	0.092	0.093	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
NMVOC[2]	678	623	571	562	561	561	561	561	561	559	550	538	526	514
NMVOC[3]	77.8	74.8	82.3	100.8	105.8	99.7	93.8	92.1	89.9	88.4	89.8	88.8	93.5	95.7
NO_x	54.1	68.3	75.9	76.8	76.9	76.9	76.9	76.9	76.9	75.1	70.4	64.9	60.2	56.2
SO_x	10.1	8.27	3.22	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[5]	0.30	0.27	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
PM[4]	6.03	5.43	4.82	4.72	4.71	4.71	4.71	4.71	4.71	4.71	4.71	4.71	4.71	4.71
TSP[6]	2.35	0.82	leaded gasoline out of use since 1997											
CO	38,510	35,310	32,415	32,095	34,666	36,825	36,903	36,958	36,994	36,685	35,450	33,555	31,563	29,552
Pb	1.47	0.52	leaded gasoline out of use since 1997											
Diesel fuels														
NH_3	0.162	0.165	0.168	0.169	0.170	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169
NMVOC	183	154	129	85.8	56.0	38.9	35.4	31.9	28.8	25.9	23.0	20.2	17.5	15.1
NO_x	1,040	1,012	971	755	518	384	362	340	321	303	283	262	240	219
SO_x	79.6	60.5	14.0	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[5]	78.2	63.6	50.3	35.6	26.7	20.3	18.8	17.4	16.0	14.6	13.0	11.3	9.58	7.93
PM[4]	148	120	92.8	58.9	37.7	26.7	24.7	22.7	20.9	19.1	17.1	15.1	13.0	11.1
CO	580	570	536	405	310	251	233	214	195	177	159	142	125	109

[1] due to lack of better information: similar EF are applied for fossil and biofuels
[2] from fuel combustion
[3] from gasoline evaporation
[4] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP consists of $PM_{2.5}$)
[5] estimated via a f-BCs as provided in [5)], Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery
[6] from leaded gasoline (until 1997)

With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [1)]

For lead (Pb) from leaded gasoline and corresponding TSP emissions, additional emissions are calculated from 1990 to 1997 based upon country-specific emission factors from [6)].

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

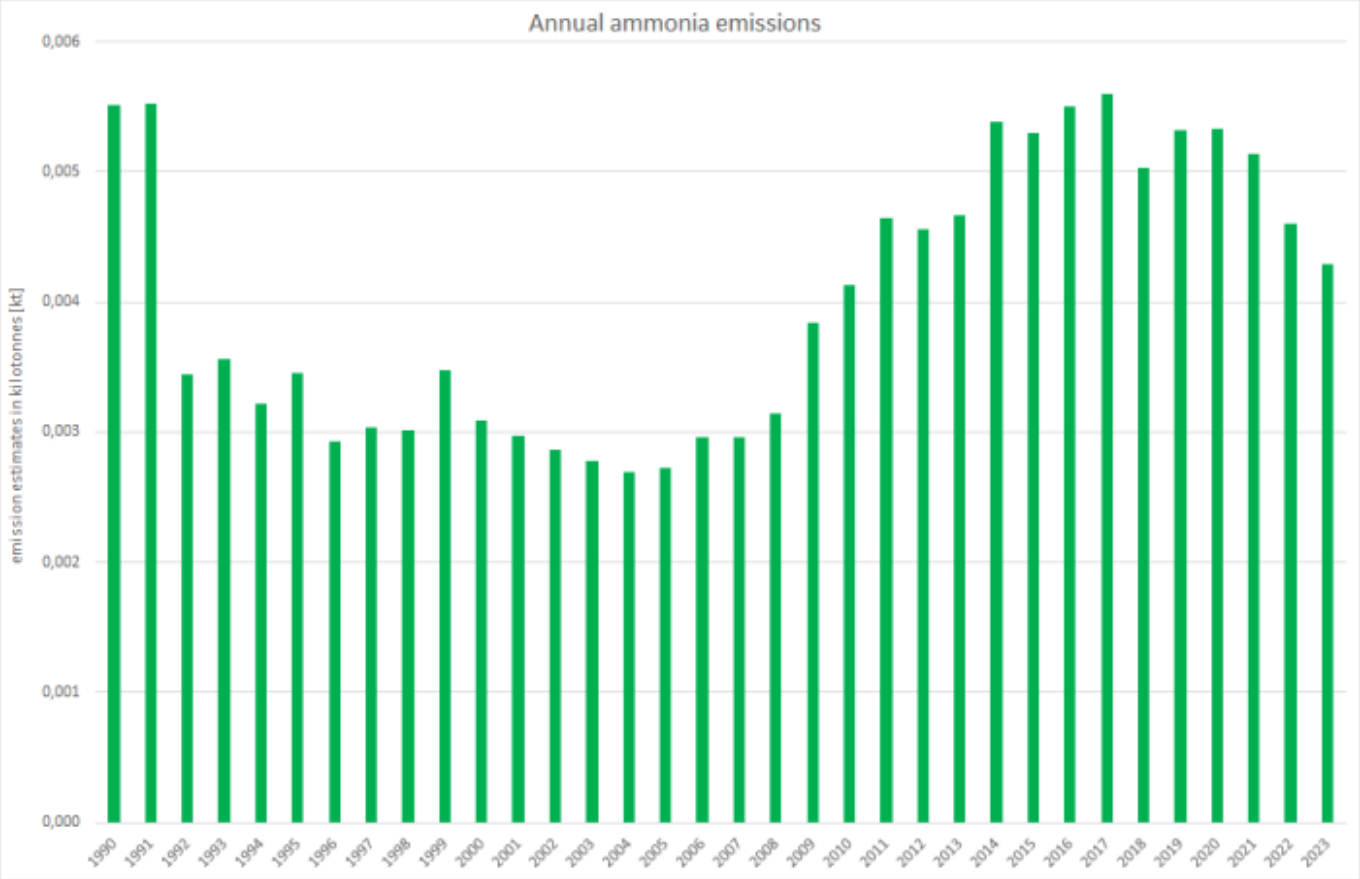
Discussion of emission trends

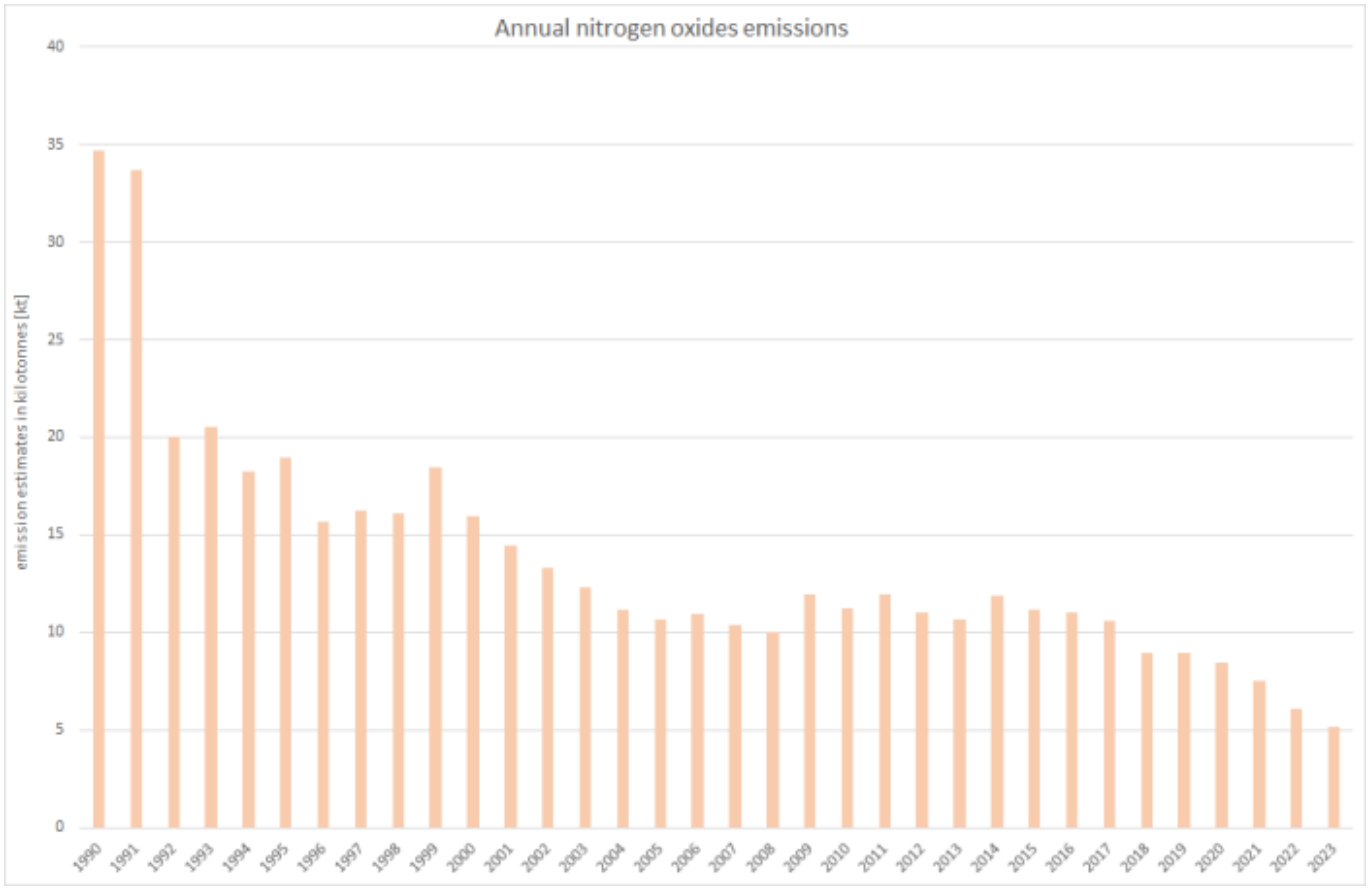
Table: Outcome of Key Category Analysis

for:	NOx	**CO**	**BC**	**PM_{10}**	**$PM_{2.5}$**
by:	Trend	Level	L	Trend	L & T

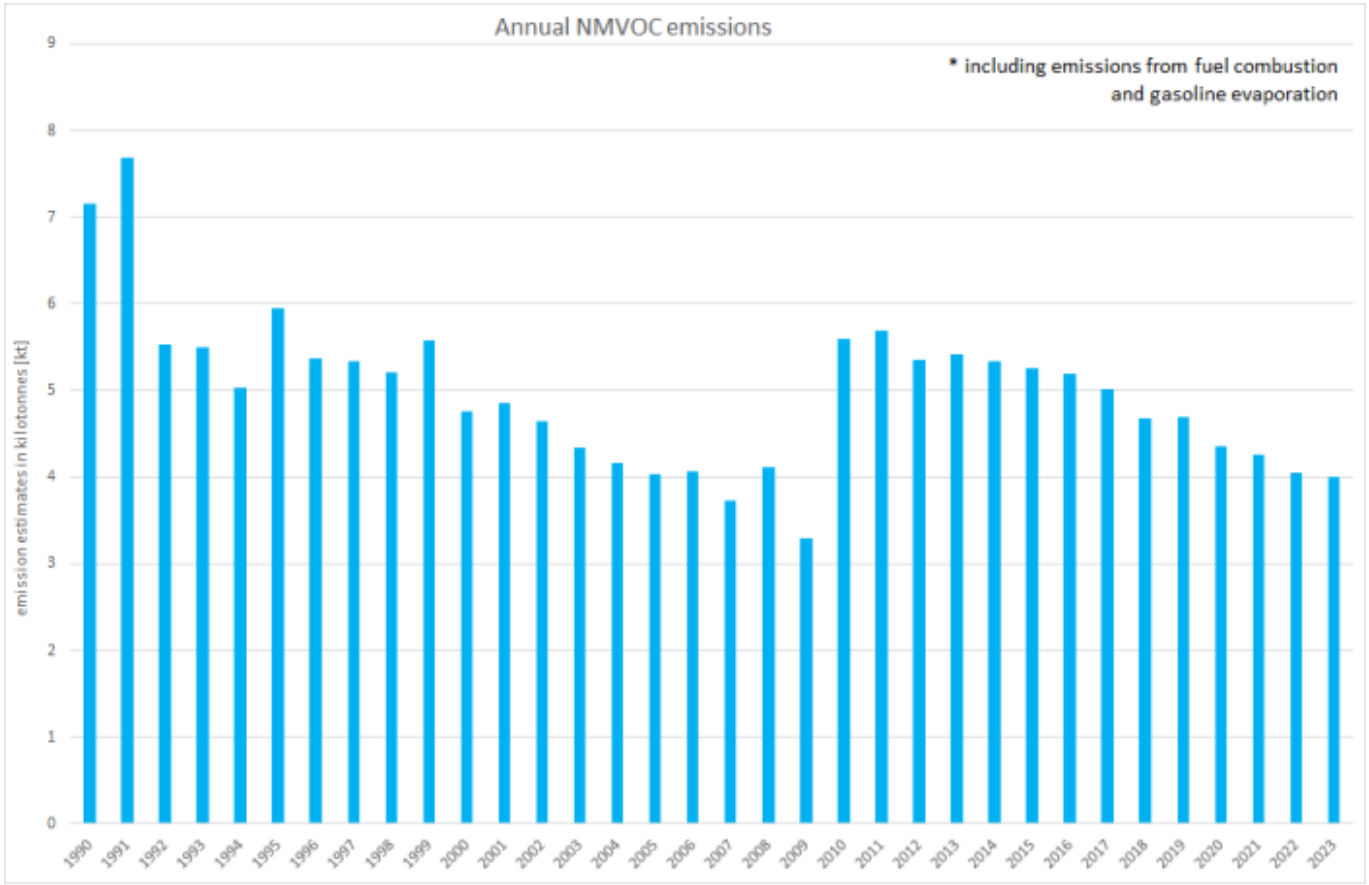
For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.

In contrast, for all regulated pollutants (such as NO_x, SO_x, NMVOC and particles), emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation.

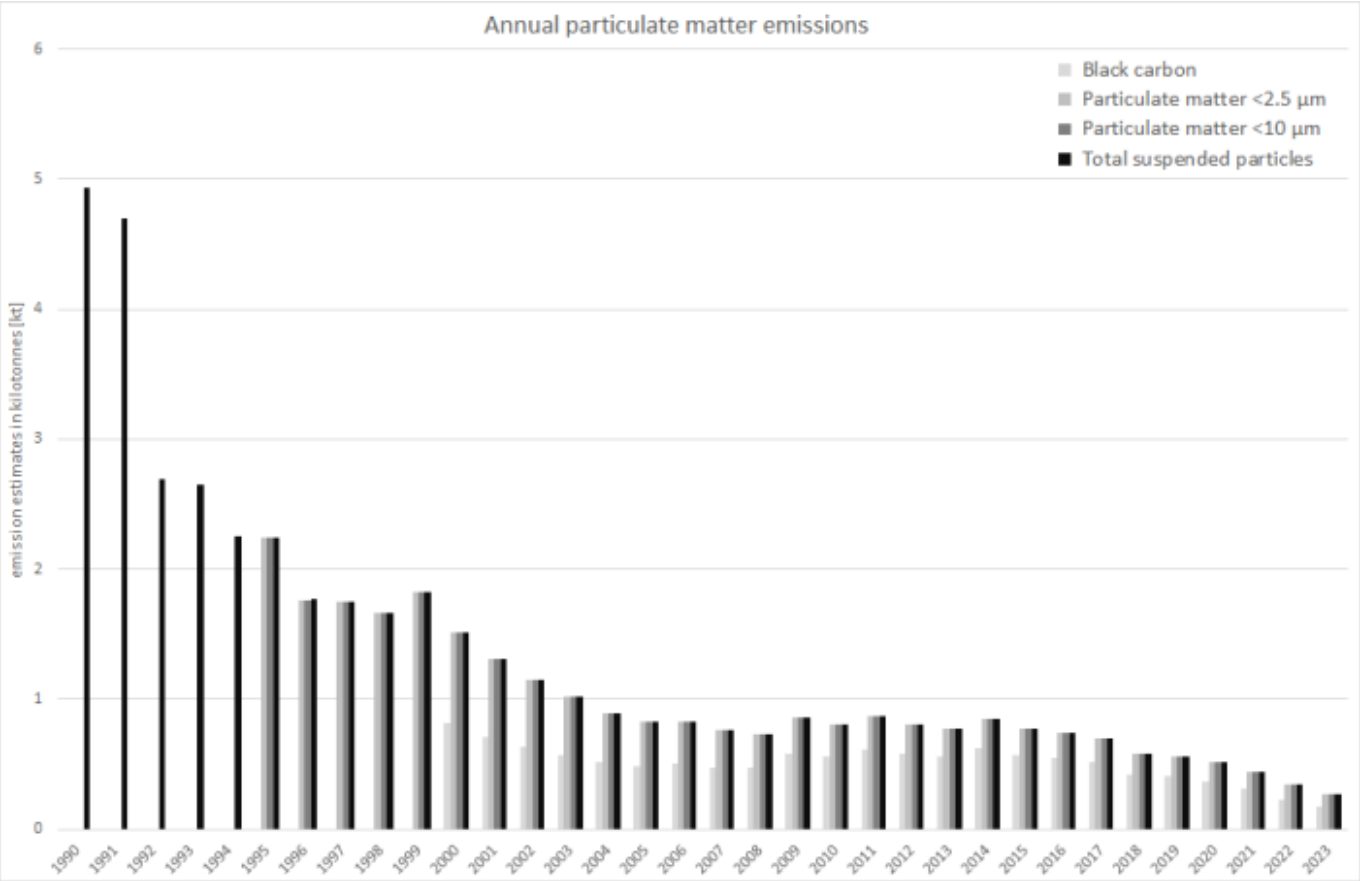




Here, as NMVOC emissions are dominated by gasoline fuels, the trend shows the same strong decline after 2011 as the underlying activity data (see above and NFR 1.A.4 - mobile, Table 1.) The remarkable increase after 2014 relates to the strongly increased gasoline inland deliveries reported in NEB line 67. (see table 3 above). This noticeable increase will be checked by the compiler of the National Energy Balance.



Over-all PM emissions are by far dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption between 2000 and 2005. Nonetheless, the decrease of the over-all emission trend was and still is amplified by the expanding use of particle filters especially to eliminate soot emissions.



Additional contributors such as the impact of TSP emissions from the use of leaded gasoline (until 1997) have no significant effect onto over-all emission estimates.

Recalculations

Revisions in activity data result from (i) a revision of the underlying National Energy Balances 2003 to 2021 as well as (ii) strongly revised consumption data for agricultural mobile sources: Here, as the over-all amounts of fuels to be distributed onto the different non-road mobile machinery (NRMM) is provided in NEB line 67, the strongly increased AD applied for agricultural mobile sources results in decreased amounts of diesel oil allocated to both mobile sources in forestry and construction/demolition (see also: chapter on NFR 1.A.4.c ii (ii)).

Table 6: Revised annual shares of NEB line 67, in %

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL FUELS													
current submission	0.297	0.189	0.170	0.156	0.216	0.255	0.262	0.264	0.242	0.251	0.251	0.238	0.219
previous submission	0.304	0.190	0.170	0.156	0.215	0.262	0.270	0.274	0.254	0.264	0.264	0.263	0.236
absolute change	-0.007	-0.001	0.000	0.000	0.001	-0.007	-0.008	-0.010	-0.012	-0.012	-0.013	-0.025	-0.017
relative change	-2.16%	-0.70%	0.00%	0.00%	0.35%	-2.73%	-3.06%	-3.53%	-4.59%	-4.69%	-5.03%	-9.55%	-7.34%
GASOLINE FUELS													
current submission	0.315	0.597	0.551	0.586	0.645	0.680	0.709	0.711	0.679	0.671	0.635	0.634	0.638
previous submission	0.315	0.597	0.551	0.586	0.645	0.667	0.684	0.681	0.642	0.632	0.597	0.592	0.596
absolute change	0.000	0.000	0.000	0.000	0.000	0.013	0.025	0.029	0.037	0.038	0.039	0.041	0.042
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	1.95%	3.72%	4.31%	5.69%	6.07%	6.48%	7.00%	6.98%

Table 7: Revised activity data, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL FUELS													
current submission	33,262	18,447	16,122	13,685	20,689	27,824	29,009	29,637	26,419	28,073	28,299	27,061	23,972
previous submission	33,997	18,577	16,122	13,685	20,616	28,605	29,926	30,721	27,689	29,454	29,799	29,919	25,927
absolute change	-735	-130	0.00	0.00	72.6	-781	-917	-1,084	-1,270	-1,381	-1,500	-2,858	-1,954
relative change	-2.16%	-0.70%	0.00%	0.00%	0.35%	-2.73%	-3.06%	-3.53%	-4.59%	-4.69%	-5.03%	-9.55%	-7.54%
GASOLINE FUELS													
current submission	1,420	4,453	4,079	4,343	6,753	6,564	6,612	6,476	6,268	6,366	6,034	6,177	6,126
previous submission	1,420	4,453	4,079	4,343	6,753	6,438	6,375	6,209	5,931	6,002	5,667	5,774	5,752
absolute change	0.00	0.00	0.00	0.00	0.00	126	237	267	337	364	367	404	374
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	1.95%	3.72%	4.31%	5.69%	6.07%	6.48%	7.00%	6.50%
OVER-ALL FUEL CONSUMPTION													
current submission	36,101	27,353	24,281	22,312	33,974	40,459	41,733	42,105	38,456	40,320	39,870	38,884	35,705
previous submission	36,837	27,483	24,281	22,312	33,902	40,998	42,194	42,674	39,079	41,000	40,666	40,969	36,944
absolute change	-736	-130	0.00	0.00	72.6	-539	-461	-570	-623	-681	-796	-2,085	-1,238
relative change	-2.00%	-0.47%	0.00%	0.00%	0.21%	-1.32%	-1.09%	-1.33%	-1.59%	-1.66%	-1.96%	-5.09%	-3.35%

As, in contrast, all **emission factors** remain unrevised compared to last year's submission, emission estimates change in accordance with the underlying activity data.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 9.1 - Recalculations.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by (Knörr et al. (2009)) [7)].

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

Planned improvements

Besides a **routine revision** of the **TREMOD MM** model, no specific improvements are planned.

FAQs

Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?

The EF provided in [8)] represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained in the biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to diesel and biodiesel.

[1)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf:

04.12.2024), Köln & Berlin, 2024
[2)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.
[3), 6)] Knörr et al. (2024b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2024, Heidelberg, 2024.
[5)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook – 2023, https://www.eea.europa.eu//publications/emep-eea-guidebook-2023, Copenhagen, 2023.
[7)] Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

[1)]
During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.A.3 - Transport (OVERVIEW)

Short description

Sub-sector **1.A.3 - Transport** includes emissions from fuel combustion activities as well as abrasive emission and fugitive emissions within the following sub-categories:

NFR-Code	Name of Category
1.A.3.a	Civil Aviation
1.A.3.b	Road Transport
1.A.3.c	Railways
1.A.3.d	Navigation
1.A.3.e	Other Transport

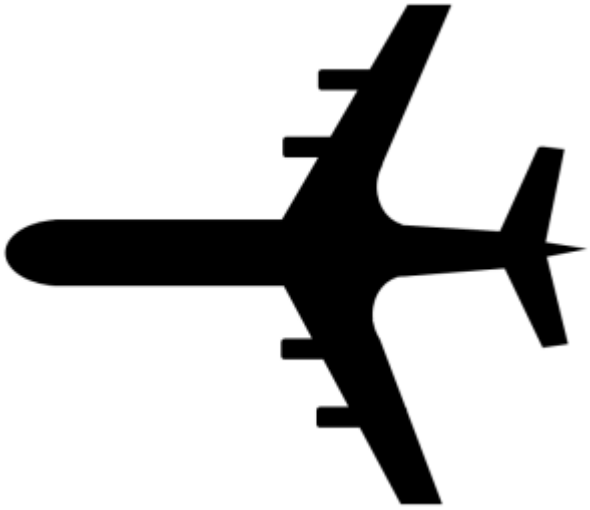
1.A.3.a - Transport: Civil Aviation

NFR-specific inventory data

Short description

NFR-Code	Name of Category	Method	AD	EF	Key Category Analysis
1.A.3.a	Civil Aviation	*see sub-category details*			
consisting of / including source categories					
LTO-range: Included in National Totals					
1.A.3.a i (i)	International Civil Aviation - LTO	*see sub-category details*			
1.A.3.a ii (i)	Domestic Civil Aviation - LTO	*see sub-category details*			
Cruise phase: Not included in National Totals					
1.A.3.a i (ii)	International Civil Aviation - Cruise	*see sub-category details*			
1.A.3.a ii (ii)	Domestic Civil Aviation - Cruise	*see sub-category details*			

Air transports differ significantly from land and water transports with respect to emissions production. In air transports, fuels are burned under atmospheric conditions that a) differ markedly from those prevailing at ground level and b) can vary widely.



The main factors that influence the combustion process in this sector include atmospheric pressure, environmental temperature and humidity – all of which are factors that vary considerably with altitude.

In category 1.A.3.a - Civil Aviation the emissions from both national (domestic) and international civil aviation are reported with separate acquisition of flight phases LTO (Landing/Take-off: 0-3,000 feet) and Cruise (above 3,000 feet) where only emissions from LTO from both national and international flights have to be included in the national totals.

Emissions from military aircraft are not included in this category but are reported under military airborne combustion in NFR sub-category 1.A.5.b ii.

Country specifics: The use of aviation gasoline is assumed to take place within the LTO-range of domestic flights only (below 3,000 feet). This assumption is a compromise due to a lack of further information and data.

Methodology

NOTE: Data available from Eurocontrol via the European Environment Agency (EEA) is not being used for inventory compilation. Nonetheless, depending on its timeliness, it is taken into account for verification purposes.

Estimation of aircraft emissions has been carried out using a tier 3a approach, i.e. under consideration of the annual distances flown by different types of aircraft, deviated into domestic and international flights, also considering the different flight stages LTO cycle (Landing/Take-off cycle, i.e. aircraft movements below 3,000 feet or about 915 meters of altitude) and cruise.

Essential for emissions reporting is the separation of domestic and international air traffic. This happens using a so-called split factor representing the ratio of fuel consumption for national flights and the over-all consumption.

For determination of this ratio, results from TREMOD AV (TRansport Emissions MODel AViation) have been used, based on the great circle distances flown by the different types of aircraft (Allekotte et al. (2024) [1)] & Gores (2024) [2)]. Here, the ratio is calculated on the basis of statistics on numbers of national and international flights departing from German airports provided by the Federal Statistical Office (Statistisches Bundesamt).

For further dividing kerosene consumption onto flight stages LTO and cruise, again results calculated within the TREMOD AV data base based on data provided by the Federal Statistical Office have been used.

Emissions are being estimated by multiplying the kerosene consumption of the flight stage with specific emission factors (EF). Here, emissions of SO_2 and H_2O are independent from the method used, depending only on the quantity and qualities of the fuel used. In contrast, emissions of NO_x, NMVOC, and CO strongly depend on the types of engines, flight elevations, flight stage, etc. and can be estimated more precisely with higher tiers. The emission factors for NO_x, CO, and NMVOC are therefore computed within TREMOD AV.

The aviation gasoline (avgas) used is not added to the annual kerosene consumptions but reported separately. As proposed in (IPCC, 2006a) [3)], emissions caused by the incineration of avgas are calculated using adapted EF and calorific values following a tier1 approach. Here, a split into national and international shares is not necessary as avgas is supposed to only being used in smaller aircraft operating on domestic routes and within the LTO range. - This conservative assumption leads to a slight overestimation of national emissions.1

For further information on AD (entire time series), EF, key sources, and recalculations see sub-chapters linked above.

Activity Data

Emissions estimation is mainly based on consumption data for jet kerosene and aviation gasoline as provided in the national Energy Balances (AGEB, 2024) [4)]. For very recent years with no AGEB data available (Normally the last year of the period reported.) data provided by the Federal Office of Economics and Export Control (BAFA) [5)] is being used.

Table 1: Sources for 1.A.3.a activity data

through 1994	**AGEB** - National Energy Balance, line 76: 'Luftverkehr'
from 1995	**AGEB** - National Energy Balance, line 63: 'Luftverkehr'
recent years / comparison	**BAFA** - Official oil data, table 7j: 'An die Luftfahrt' + 'An Sonstige'*

* to achieve consistency with AGEB data, amounts given for deliveries 'to Aviation' ('An die Luftfahrt') and 'to Others' ('An Sonstige') have to be added (see FAQs for more information)

Table 2: Total inland fuel deliveries to civil aviation, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Kerosene	193,329	233,437	297,258	343,828	361,751	361,651	389,024	425,140	437,203	434,490	199,931	257,520	384,975	402,121
Avgas	2,438	1,142	1,120	698	568	570	419	415	401	328	214	159	175	130
1.A.3.a	195,767	234,579	298,378	344,526	362,319	362,221	389,443	425,555	437,604	434,818	200,145	257,679	385,151	402,251

source: Working Group on Energy Balances (AGEB): National Energy Balances (AGEB, 2024) [6)]

For the present purposes, kerosene-consumption figures from NEB and BAFA statistics have to be broken down by national (= domestic) and international flights: Here, the split has been calculated on the basis of statistics on numbers of national and international flights departing from German airports provided by the Federal Statistical Office (Statistisches Bundesamt) within TREMOD AV [7)].

Table 3: Ratios for calculating the shares of fuels used in 1.A.3.a ii - Domestic and 1.A.3.a i - International Civil Aviation, in %

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
1.A.3.a ii - Civil domestic aviation														
Kerosene	15.3	12.8	11.0	8.80	8.35	7.63	7.14	6.34	6.14	6.38	6.18	3.70	3.61	3.65
Avgas	86.0	85.9	86.1	86.2	86.3	86.2	97.3	97.0	96.5	96.2	97.5	92.8	92.8	79.2
1.A.3.a i - Civil international aviation														
Kerosene	84.7	87.2	89.0	91.2	91.6	92.4	92.9	93.7	93.9	93.6	93.8	96.3	96.4	96.4
Avgas	14.0	14.1	13.9	13.8	13.7	13.8	2.66	3.00	3.53	3.80	2.54	7.22	7.20	20.8

Table 4: Resulting annual shares of jet kerosene and avgas used in 1.A.3.a ii - Domestic and 1.A.3.a i - International Civil Aviation, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
1.A.3.a ii - Civil domestic aviation														
Kerosene	29,501	29,989	32,746	30,260	30,210	27,605	27,783	26,935	26,843	27,739	12,354	9,541	13,914	14,676
Avgas	2,098	981	964	601	490	491	407	403	386	316	209	147	163	103
1.A.3.a i - Civil international aviation														
Kerosene	163,828	203,448	264,512	313,568	331,542	334,046	361,241	398,205	410,360	406,750	187,577	247,979	371,062	387,445
Avgas	340	161	156	96.3	78.0	78.6	11.1	12.5	14.1	12.5	5.43	11.5	12.6	27.0
1.A.3.a - OVER-ALL														
Kerosene	193,329	233,437	297,258	343,828	361,751	361,651	389,024	425,140	437,203	434,490	199,931	257,520	384,975	402,121
Avgas	2,438	1,142	1,120	698	568	570	419	415	401	328	214	159	175	130

The deviation of the kerosene consumed onto the two flight stages LTO and cruise again has been carried based on TREMOD AV estimations allowing the export of kerosene consumption during LTO for both domestic and international flights.

Table 5: Annual shares of LTO phase in domestic and international civil aviation, in %

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
1.A.3.a i	7.55	8.25	7.42	7.13	7.59	8.37	8.01	7.44	7.43	7.71	7.25	6.08	6.14	6.53
1.A.3.a ii	30.0	29.3	27.8	27.5	27.5	27.6	28.0	28.1	28.3	28.1	27.5	32.9	31.8	28.5

source: number of domestic and international flights as provided by the Federal Statistical Office (Destatis, 2024) [8)], compiled and computed within [9)] and [10)] a assumption: all aircraft using aviation gasoline are operated within the LTO-range below 3,000 feet and only for domestic flights

Cruise consumption is then calculated as the difference between Total Consumption minus LTO Consumption.

Emission factors

Kerosene

Emissions have been calculated for each flight phase, based on the respective emission factors. Therefore, the EF used have been taken from a wide range of different sources. In contrast to earlier submissions, the emissions of NO_x, CO und HC are based on aircraft-specific EF deposited within TREMOD AV. With this very detailed estimations average EF are being formed which are than used for emissions reporting.

The EF provided with the current submission represent annual average EF for the entire fleet, calculated as implied EF from the emissions computed within TREMOD AV and therefore differ from the values used in the past.

Sulphur dioxide (SO_2) emissions depend directly on the kerosene's sulphur content which varies regionally as well as seasonally. The EF used by Eurocontrol of 0.84 kg SO_2/t kerosene lies between the values used for German inventory for 1990 to 1994 (1.08 to 1.03 kg SO_2/t) and from 1995 (0.4 kg SO_2/t). In IPCC 2006b [11)] with 1 kg SO_2/t kerosene value comes very close to the old inventory values provided, based on a sulfur content of 0.05 % of weight. Following current information of the expert committee for the standardization of mineral oil and fuels (Fachausschuss für Mineralöl-und Brennstoffnormung, FAM), the common value for sulphur content of kerosene in Germany is about 0.01% of weight, i.e. one fifth of the IPCC data. In IIR 2009, a sulfur content of 0.021 weight% have been used, based on measurements from 1998 (Döpelheuer (2002)) [12)].

As an EF decreasing due to improved production procedures and stricter critical levels seems plausible, for this report a constant decline between the annual values of 1.08 g SO_2/kg for 1990, 0.4 g for 1998 and 0.2 g for 2009 has been assumed.

Thereby, an exhaustive conversion of the sulfur into suflur dioxide is expected. - Due to the EF depending directly on the S content of the kerosene, one annual EF is used for both flight stages.

Nitrogen oxide (NO_x), **carbon monoxide (CO)** and **hydrocarbons (HC)** emissions were estimated using IEF calculated within TREMOD AV, based upon more specific (depending on type of aircraft, flight stage) EF mostly taken from the EMEP-EEA data base. For 2009, 40 % of over-all starts (about 70 % of total kilometres flown) had to be linked with adapted EF as it was not possible to directly or even indirectly (via similar types of aircraft) allocate the aircraft used here. Therefore, regression analysis had to be carried out, estimating EF via emission functions that calculate an EF for the respective type of engine depending on the particular take-off weight.

As a basis for these functions the EF of types of aircraft with given EF have been used (see: Allekotte et al. (2024)) [13)]. From the trend of the emissions calculated within TREMOD AV, annual average EF for the entire fleet have been formed, which have then been used for reporting. Hence, the EF differ widely from those used in earlier submissions.

Ammonia (NH_3) emissions were estimated using an EF of 0.173 g/kg kerosene for both flight stages (UBA, 2009) [14)].

The EFs for **non-methane volatile organic compounds (NMVOC)** were calculated as the difference between the EF for over-all hydrocarbons (HC) and the EF for methane (CH_4).

Particulate Matter Within the IPCC EF data base, there are no default data provided for emissions of particulate matter (TSP, PM_{10}, and $PM_{2.5}$). Therefore, the EF for dust (**T**otal **S**uspended **P**articulate Matter – **TSP**) are taken over from Corinair (2006) [15)], giving specific values for an average fleet and for the two flight stages in table 8.2: For national flights 0.7 kg TSP/LTO and 0.2 kg TSP/t kerosene and 0.15 kg TSP/LTO and 0.2 kg TSP/t kerosene for international flights. Following this table, a kerosene consumption per LTO cycle of 825 kg for national and 1,617 kg for international flights have been assumed and the EF for the LTO stage have been estimated.

Regarding **Black Carbon**, f-BC fractions from EMEP/EEA guidebook 2023, Chapter 1.A.3.a, 1.A.5 - Aviation, Annex 3, Table A3.2 and Conclusion have been applied for both jet kerosene and aviation gasoline. (EMEP/EEA, 2023) [16)]

The EF for **water vapor (H_2O)** provided by Eurocontrol (2004) is about 1,230g H_2O / kg kerosene, whereas in Corinair (2006) [17)] 1,237g H_2O /kg is assumed. Based on the stoichiometric assumptions mentioned above a EF(CO_2) of 1.24 kg H_2O/kg can be derived. To reduce the number of sources for EF, here, the Corinair value has been used for both flight stages and for both national and international flights.

As for **polycyclic aromatic hydrocarbons** (PAH), tier1 EF from (EMEP/EEA, 2019) [18)] have been apllied here. As the EMEP guidebook does not provide original EF for jet kerosene, values provided for gasoline in road transport have been used here as a proxy and will be replaced by more appropriate data as soon as this is available.

The conversion of EF representing emissions per kilo fuel combusted [kg pollutant/kg kerosene] into energy related EF [kg pollutant/TJ energy] has been carried out using a net calorific value of 43,000 kJ/kg.

Aviation gasoline

For aviation gasoline (avgas) a deviation onto LTO and cruise is assumed to be unnecessary. Therefore, there are no such specific EF used here. As for kerosene, the EF for **NO_x**, **CO** and **HC** have been taken from the calculations carried out within TREMOD AV. Here, for calculating aircraft specific NO_x, CO, and HC emissions corresponding EF from the EMEP-EEA data base have been used that have than been divided by the annual avgas consumption to form annual average EF for emission reporting.

With respect to fuel characteristics, there are no big differences between avgas and gasoline used in passenger cars (PC). Therefore, specific **sulphur dioxide (SO_2)** emissions from PC gasoline can be carried forward to avgas. - Following the expert committee for the standardization of mineral oil and fuels (FAM), the critical value of sulfur content for gasoline sold at gas stations is 10 mg/kg, i.e. 0,001 % of weight - or one tenth of the kerosene value. Therefore, the EF used for avgas equals the EF used for kerosene reduced by 90 %.

There are different sorts of avgas sold with different **lead (Pb)** contents. As an exact annual ration of the sorts sold is not available, the most common type of avgas (AvGas 100 LL (Low Lead)) with a lead content of 0.56 g/l is set as an approximation. (see EMEP/EEA (2023), Chapter 1.A.3.a, 1.A.5.b Aviation, Annex 2, page 44, Table A2.1 [19)]

The **EF(TSP)** were calculated from the lead content of AvGas 100 LL by multiplication with a factor 1.6 as used for leaded gasoline in road transport in the TREMOD system.

For **NMVOC**, an EF from the Revised IPCC Guidelines 1996 (pages I 42 and 40) [20)], [21)], have been used.

All other EF are not available specifically for small aircraft and therefore have been equalized with the EF used for kerosene, national, cruise.

The conversion of the EF from [kg emission/kg avgas consumed] into [kg emission/TJ energy converted] has been carried out using a net calorific value of 44,300 kJ/kg.

> **NOTE:** For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.
>
> For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Recalculations

With the total kerosene inland deliveries remainig unchanged within the National Energy Balances, the domestic share of total kerosene consumption was revised only for 2022 and based on slightly revised background data for this specific year computed within the underlying model, TREMOD Aviation.

Table 7: Revised percental shares of kerosene used for domestic flights, in %

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
% of **JET KEROSENE** allocated to domestic flights													
current submission	15.3	12.8	11.0	8.80	8.35	7.63	7.14	6.34	6.14	6.38	6.18	3.70	3.614
previous submission	15.3	12.8	11.0	8.80	8.35	7.63	7.14	6.34	6.14	6.38	6.18	3.70	3.613
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%
% of **AVGAS** allocated to domestic flights													
current submission	86.0	85.9	86.1	86.2	86.3	86.2	97.3	97.0	96.5	96.2	97.5	92.8	92.8
previous submission	86.0	85.9	86.1	86.2	86.3	86.2	97.3	97.0	96.5	96.2	97.5	92.8	92.8
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

As a result, the amounts of jet kerosene allocated to NFR sub-categories *1.A.3.a i* and *1.A.3.a ii* and for 2022 had to be revised accordingly. Here, the activity data allocated to NFR *1.A.3.a i* was reduced by the same amount by which the activity data allocated to NFR *1.A.3.a ii* was increased:

Table 8: Revised amounts of fuel allocated to international (1.A.3.a i) and domestic (1.A.3.a ii) flights, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
1.A.3.a i - CIVIL INTERNATIONAL AVIATION													
JET KEROSENE													
current submission	163,828	203,448	264,512	313,568	331,542	334,046	361,241	398,205	410,360	406,750	187,577	247,979	371,062
previous submission	163,828	203,448	264,512	313,568	331,542	334,046	361,241	398,205	410,360	406,750	187,577	247,979	371,066
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-4.64
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.001%
AVGAS													
current submission	340	161	156	96.3	78.0	78.6	11.1	12.5	14.1	12.5	5.43	11.5	12.6
previous submission	340	161	156	96.3	78.0	78.6	11.1	12.5	14.1	12.5	5.43	11.5	12.6
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
1.A.3.a ii - CIVIL DOMESTIC AVIATION													
JET KEROSENE													
current submission	29,501	29,989	32,746	30,260	30,210	27,605	27,783	26,935	26,843	27,739	12,354	9,541	13,914
previous submission	29,501	29,989	32,746	30,260	30,210	27,605	27,783	26,935	26,843	27,739	12,354	9,541	13,909
absolute change	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	-0.01	0.00	0.00	-0.01	-0.01	4.63
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%
AVGAS													
current submission	2,098	981	964	601	490	491	407	403	386	316	209	147	163
previous submission	2,098	981	964	601	490	491	407	403	386	316	209	147	163
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.01
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

Besides the routine revision of the underlying model, no specific improvements are planned.

Uncertainties

Information on uncertainties is provided here with most data representing expert judgement from the research project mentioned above.

For estimating uncertainties, the partial uncertainties (U_1 to U_n) of the components incorporated in emission calculations have to be quantified. By additive linking of the squared partial uncertainties the overall uncertainty (U_{total}) can then be estimated (IPCC, 2000) [22)].

The uncertainties given here have been evaluated for all time series and flight stages as average values. Estimating the overall uncertainty has been carried out as shown in the table below. In the very left column the components of the uncertainty estimations are listed with their partial uncertainties given in the next column. The next columns show the data linked to estimate the different overall uncertainties which themselves represent partial uncertainties for higher aggregated data and so on.

As an example, the uncertainty of the kerosene consumptions for domestic flights divided by flight stages (LTO and cruise) has been calculated from the partial uncertainty of the over-all kerosene consumption for domestic flights and the partial uncertainty of the LTO-cruise-split. Here, the split is based on the number of flights provided by the Federal Statistical Office and assumptions on the composition of the fleet. The overall uncertainties of both fuel consumption during LTO and cruise itself then represent a partial uncertainty within the estimation of the uncertainties of emissions.

Several partial uncertainties are based on assumptions. For example, the uncertainty given for the entire time series of the split factor domestic:international flights is an average value: For the years 1990 to 2002 data is based upon estimations carried out within TREMOD AV which themselves are based on data from the Federal Statistical Office and EF from the EMEP-EEA data base. For 2003 to 2011 data from Eurocontrol are being used, that are calculated within ANCAT. Comparing results from the ANCAT model with actual consumption data show aberrations of ±12 %. Here, data calculated with AEM 3 model would have an uncertainty of only 3 to 5 % (EUROCONTROL 2006) [23)].

As no uncertainty estimates were carried out for ammonia and particulate matter within the above-mentioned project, values from the PAREST research project mentioned for most over mobile sources were used. Here, the final report has not yet been published.

FAQs

Whereby does the party justify the adding-up of the two amounts provided by BAFA as deliveries 'An die Luftfahrt' and 'An Sonstige' ?

For mineral oils, German National Energy Balances (NEBs) - amongst other sources - are based on BAFA data on the amounts delivered to different sectors. A comparison with consumption data from AGEB and BAFA shows that data from NEB line 76 /63: 'Luftverkehr' equals to the amount added from both columns provided by BAFA [24)].

On which basis does the party estimate the reported lead emissions from aviation gasoline?

assumption by party: aviation gasoline = AvGas 100 LL (see EMEP/EEA (2023): Chapter 1.A.3.a, 1.A.5.b Aviation, Annex 2, page 44, Table A2.1) [25)] (AvGas 100 LL is the predominant sort of aviation gasoline in Western Europe) [26)] lead content of AvGas 100 LL: 0.56 g lead/liter (as tetra ethyl lead) [27)]

The applied procedure is similar to the one used for calculating lead emissions from leaded gasoline used in road transport. (There, in contrast to aviation gasoline, the lead content constantly declined resulting in a ban of leaded gasoline in 1997.)

On which basis does the party estimate the reported TSP emissions from aviation gasoline?

The TSP emissions calculated depend directly on the reported lead emissions: The emission factor for TSP is 1.6 times the emission factor used for lead: EF(TSP) = 1.6 x EF(Pb). The applied procedure is similar to the one used for calculating TSP emissions from leaded gasoline used in road transport.

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[4), 6)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024
[5), 24)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.
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[21)] Revised 1996 IPCC Guidelines, Volume 3: Reference Manual, Chapter I: Energy; http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref3.pdf, p. I.42
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[26)] https://en.wikipedia.org/wiki/Avgas

1.A.3.a i (i) - International Civil Aviation: LTO

NFR-specific inventory data

Short description

In NFR category *1.A.3.a i (i) - International Civil Aviation: LTO* emissions during LTO stage (Landing/Take-off: 0-3,000 feet) are reported. In the following, information on sub-category specific AD, (implied) emission factors and emission estimates are provided.

Category Code	Method	AD	EF
1.A.3.a i(i)	T1, T2, T3	NS, M	CS, D, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Actitvity Data

Specific jet kerosene consumption during LTO-stage is calculated within TREMOD AV [1)] as described in the main chapter on civil aviation.

Table 1: Percentual annual fuel consumption during LTO-stage of international flights

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jet Kerosene	7.55	8.25	7.42	7.13	7.59	8.37	8.01	7.44	7.43	7.71	7.25	6.08	6.14	6.53
Aviation Gasoline	1.89	1.84	1.82	1.89	1.87	1.74	6.80	6.63	7.44	7.59	9.09	20.9	19.9	1.58

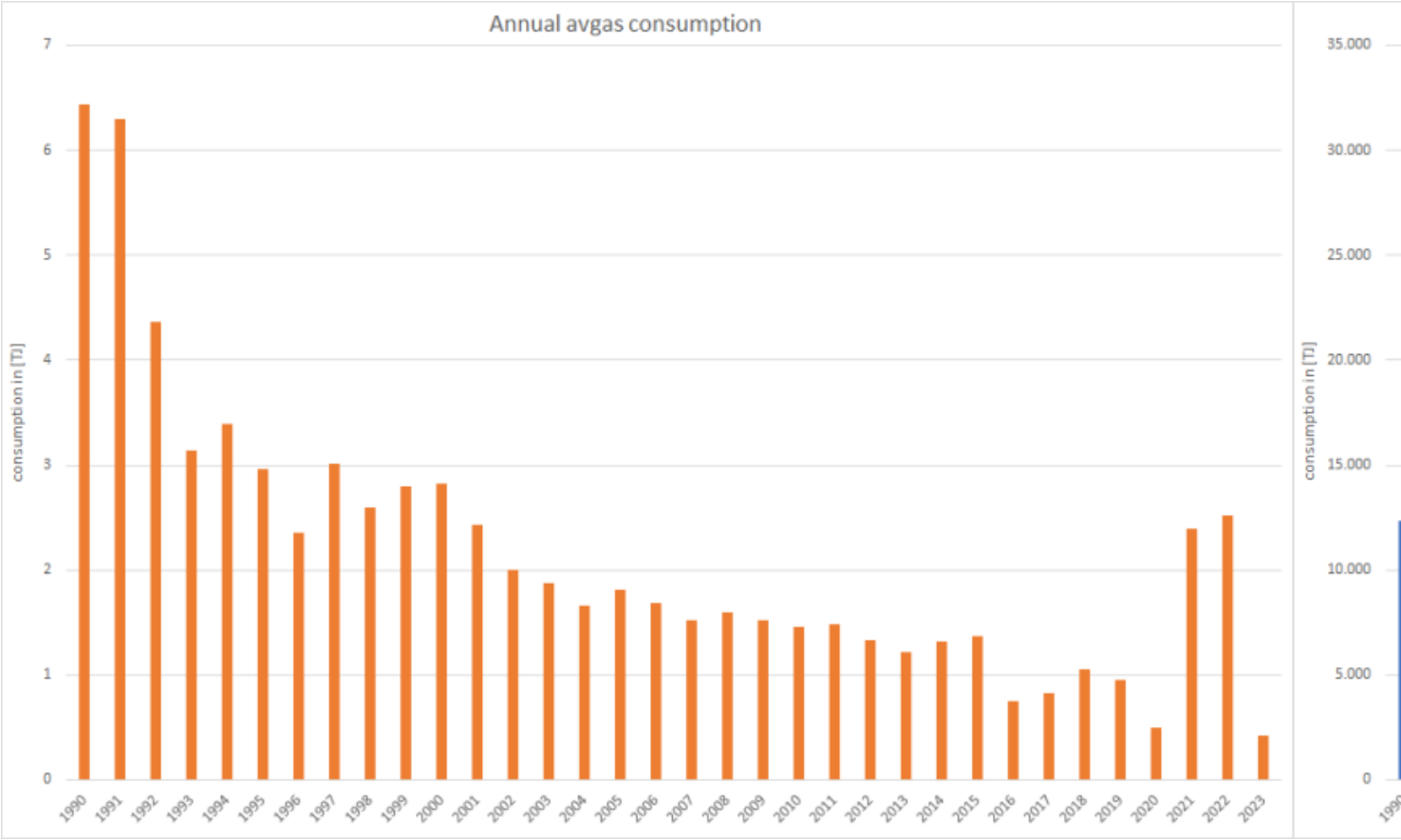
source: Allekotte et al. (2024) [2)] &: Gores (2024) [3)]

Table 2: annual LTO fuel consumption for international flights, in terajoule

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jet Kerosene	12,364	16,785	19,619	22,351	25,149	27,961	28,920	29,629	30,477	31,355	13,603	15,084	22,789	25,293
Aviation Gasoline	6.44	2.96	2.82	1.81	1.46	1.37	0.76	0.83	1.05	0.95	0.49	2.40	2.51	0.43
∑	**12,370**	**16,788**	**19,622**	**22,353**	**25,150**	**27,963**	**28,920**	**29,630**	**30,478**	**31,356**	**13,604**	**15,087**	**22,791**	**25,294**

source: Allekotte et al. (2024) [4)] &: Gores (2024) [5)]

After a strong but temporary decline during an right after the Covid-19 pandemic, kerosene consumption shows a steady upwards trend again especially after 2021, already reaching about 80% of its pre-pandemic levels. In contrast, domestic flights show no such strong “regeneration” yet (see related sub-chapters).



Emission factors

All country specific emission factors used for emission reporting were basically ascertained within UBA project FKZ 360 16 029 (Knörr, W., Schacht, A., & Gores, S. (2010)) [6)] and have since then been compiled, revised and maintained in TREMOD AV [7)].

For more information, please see superordinate chapter on civil aviation.

Table 2: Annual country-specific emission factors, in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
JET KEROSENE														
NH_3	3.98	3.95	3.95	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
NMVOC	61.7	37.5	27.0	23.7	21.9	21.3	20.9	21.4	22.2	20.0	20.7	19.1	18.9	17.8
NO_x	296	306	302	323	342	352	357	357	355	358	368	367	365	365
SO_x	19.7	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
BC[1]	1.75	1.61	1.44	1.36	1.20	1.13	1.11	1.10	1.10	1.06	1.05	1.06	1.08	1.09
PM[2]	3.65	3.35	2.99	2.82	2.49	2.35	2.32	2.29	2.29	2.22	2.19	2.21	2.24	2.28
CO	253	230	240	221	204	198	193	193	197	189	189	189	187	184
AVIATION GASOLINE														
NH_3	NE													
NMVOC	619	636	659	678	665	668	653	644	651	642	634	667	667	663
NO_x	101	96.1	92.7	91.9	91.3	96.7	97.4	98.2	80.4	75.8	72.8	95.7	97.9	94.2
SO_x	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
BC[1]	4.06	4.59	4.92	4.90	4.98	4.25	4.10	4.02	6.95	7.71	8.13	4.53	4.18	4.81
PM[2]	27.0	30.6	32.8	32.6	33.2	28.3	27.3	26.8	46.4	51.4	54.2	30.2	27.9	32.0
TSP[3]	42.2	45.8	48.0	47.8	48.4	43.5	42.5	42.0	61.5	66.6	69.3	45.4	43.0	47.2
CO	15,535	16,276	16,792	16,174	16,885	16,141	16,441	16,754	19,006	19,952	20,619	16,543	16,262	16,961

[1] estimated via a f-BCs (avgas: 0.15, jet kerosene: 0.48) as provided in EMEP/EEA (2023) [8)], Chapter: 1.A.3.a, 1.A.5.b Aviation, Annex 3, Table A3.2 and Conclusion

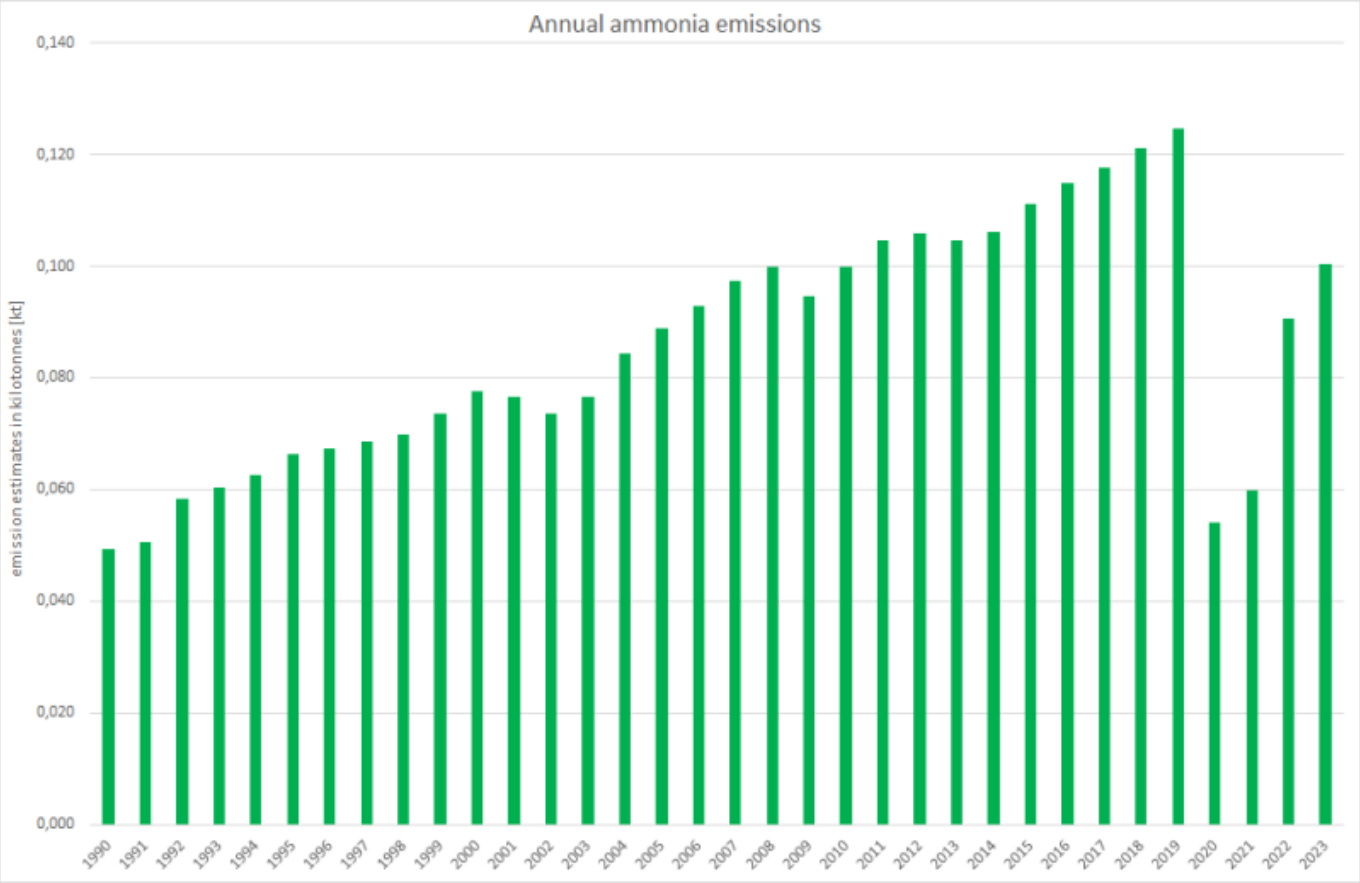
	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
[2] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP from diesel oil combustion consists of $PM_{2.5}$)														
[3] also including TSP from lead: EF(TSP) = 1.6 x EF(Pb) - see road transport														

For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

Discussion of emission trends

NFR sub-category 1.A.3.a i (i) is no key source for emissions.

Corresponding directly with fuel consumption, emission estimates show a steady upwards trend again especially as of 2022 for international flights, already reaching about 80% of its pre-pandemic levels. In contrast, emissions from domestic flights show no such strong “regeneration” yet (see related sub-chapters).



Recalculations

As mentioned in the superordinate chapter on 1.A.3.a, the LTO fuel consumptions applied in TREMOD AV have been adapted to Eurocontrol AEM model and the underlying fleet composition.

Hence, the percentual annual shares of kerosene consumed during L/TO for international flights have been re-estimated…

Table 3: Revised percentual share of kerosene and avgas consumed during L/TO for international flights, in %

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
JET KEROSENE													
current submission	7.55	8.25	7.42	7.13	7.59	8.37	8.01	7.44	7.43	7.71	7.25	6.08	6.14
previous submission	7.55	8.25	7.42	7.13	7.59	8.37	8.01	7.44	7.43	7.71	7.25	6.08	6.13
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.17%
AVGAS													
current submission	1.89	1.84	1.82	1.89	1.87	1.74	6.80	6.63	7.44	7.59	9.09	20.9	19.9
previous submission	1.89	1.84	1.82	1.89	1.87	1.74	6.80	6.63	7.44	7.59	9.09	20.9	19.9
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

... and the amounts of kerosene allocated to sub-category 1.A.3.a i (i) were revised accordingly:

Table 4: Revised fuel-use in 1.A.3.a i (i), in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
JET KEROSENE													
current submission	12,364	16,785	19,619	22,351	25,149	27,961	28,920	29,629	30,477	31,355	13,603	15,084	22,789
previous submission	12,364	16,785	19,619	22,351	25,149	27,961	28,920	29,629	30,477	31,355	13,603	15,084	22,751
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.5
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.16%
AVGAS													
current submission	6.44	2.96	2.82	1.81	1.46	1.37	0.76	0.83	1.05	0.95	0.49	2.40	2.51
previous submission	6.44	2.96	2.82	1.81	1.46	1.37	0.76	0.83	1.05	0.95	0.49	2.40	2.51
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

In addition, several rather small revisions occur for some country-specific **emission factors** derived from Allekotte et al. (2024) [9)] and for 2022.

Table 5: Revised annual country-specific emission factors for jet kerosene in 1.A.3.a i (i), in [kg/TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
AMMONIA													
current submission	3.98	3.95	3.95	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
previous submission	3.98	3.95	3.95	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NMVOC													
current submission	61.7	37.5	27.0	23.7	21.9	21.3	20.9	21.4	22.2	20.0	20.7	19.1	18.861
previous submission	61.7	37.5	27.0	23.7	21.9	21.3	20.9	21.4	22.2	20.0	20.7	19.1	18.863
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.002
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%
NITROGENE OXIDES													
current submission	296	306	302	323	342	352	357	357	355	358	368	367	364.58
previous submission	296	306	302	323	342	352	357	357	355	358	368	367	364.66
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.08
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.02%
SULPHUR OXIDES													
current submission	19.7	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
previous submission	19.7	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
BLACK CARBON													
current submission	1.75	1.61	1.44	1.36	1.20	1.13	1.11	1.10	1.10	1.06	1.05	1.06	1.0764
previous submission	1.75	1.61	1.44	1.36	1.20	1.13	1.11	1.10	1.10	1.06	1.05	1.06	1.0762
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0002

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
relative change	0.0%	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%
PARTICULATE MATTER													
current submission	3.65	3.35	2.99	2.82	2.49	2.35	2.32	2.29	2.29	2.22	2.19	2.21	2.2425
previous submission	3.65	3.35	2.99	2.82	2.49	2.35	2.32	2.29	2.29	2.22	2.19	2.21	2.2420
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0005
relative change	0.0%	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%
CARBON MONOXIDE													
current submission	253	230	240	221	204	198	193	193	197	189	189	189	186.81
previous submission	253	230	240	221	204	198	193	193	197	189	189	189	186.70
absolute change	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
relative change	0%	0.00%	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 8.1 - Recalculations.

Uncertainties

For information on uncertainties, please see the main chapter on civil aviation.

Planned improvements

For information on planned improvements, please see main chapter on civil aviation.

FAQs

[1), 2), 4), 7), 9)] Allekotte et al. (2024): TREMOD Aviation (TREMOD AV) - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Heidelberg, Berlin: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., Berlin & Heidelberg, 2024.
[3), 5)] Gores, S.(2024): Inventartool zum deutschen Flugverkehrsinventar 1990-2023, im Rahmen der Aktualisierung des Moduls TREMOD-AV im Transportemissionsmodell TREMOD, Berlin, 2024.
[8)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 1.A.3.a, 1.A.5.b Aviation, https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023/@@download/file; Copenhagen, 2023

1.A.3.a ii (i) - Domestic Civil Aviation: LTO



NFR-specific inventory data

Short description

In NFR category *1.A.3.a ii (i) - Domestic Civil Aviation: LTO* emissions from domestic flights between German airports occuring during LTO stage (Landing/Take-off: 0-3,000 feet) are reported.

Category Code	Method	AD	EF
1.A.3.a ii (i)	T1, T2, T3	NS, M	CS, D, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

In the following, information on sub-category specific AD, (implied) emission factors and emission estimates are provided.

Methodology

Actitvity Data

Specific jet kerosene consumption during LTO-stage is calculated within TREMOD AV as described in the superordinate chapter.

Table 1: Percentual annual fuel consumption during LTO-stage of domestic flights

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jet Kerosene	30.0	29.3	27.8	27.5	27.5	27.6	28.0	28.1	28.3	28.1	27.5	32.9	31.8	28.5
Aviation Gasoline	12.6	12.6	12.6	13.0	12.8	12.6	12.6	12.3	12.8	12.8	12.7	21.7	21.9	21.0

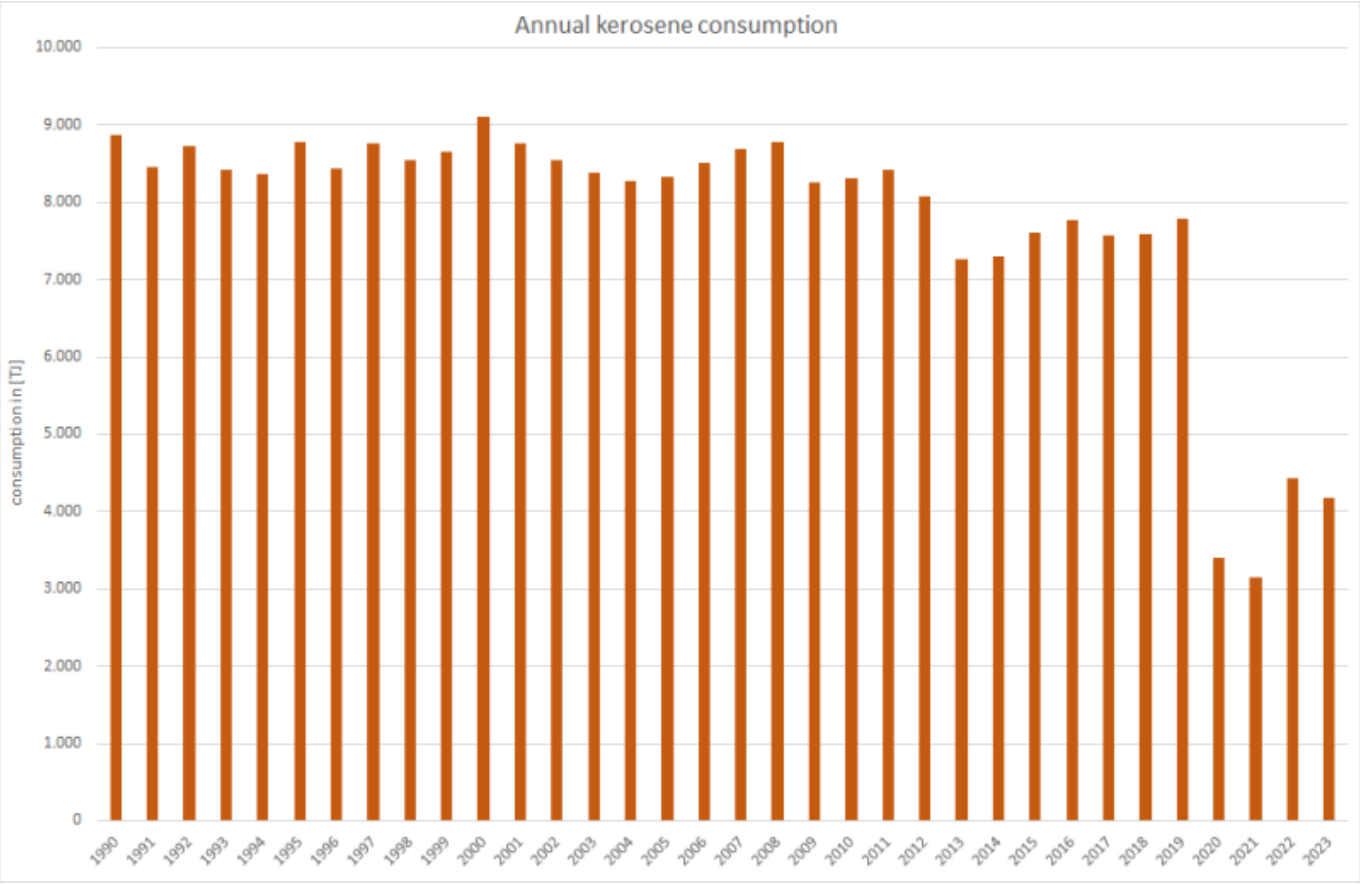
source: Allekotte et al. (2024) [1)] &: Gores (2024) [2)]

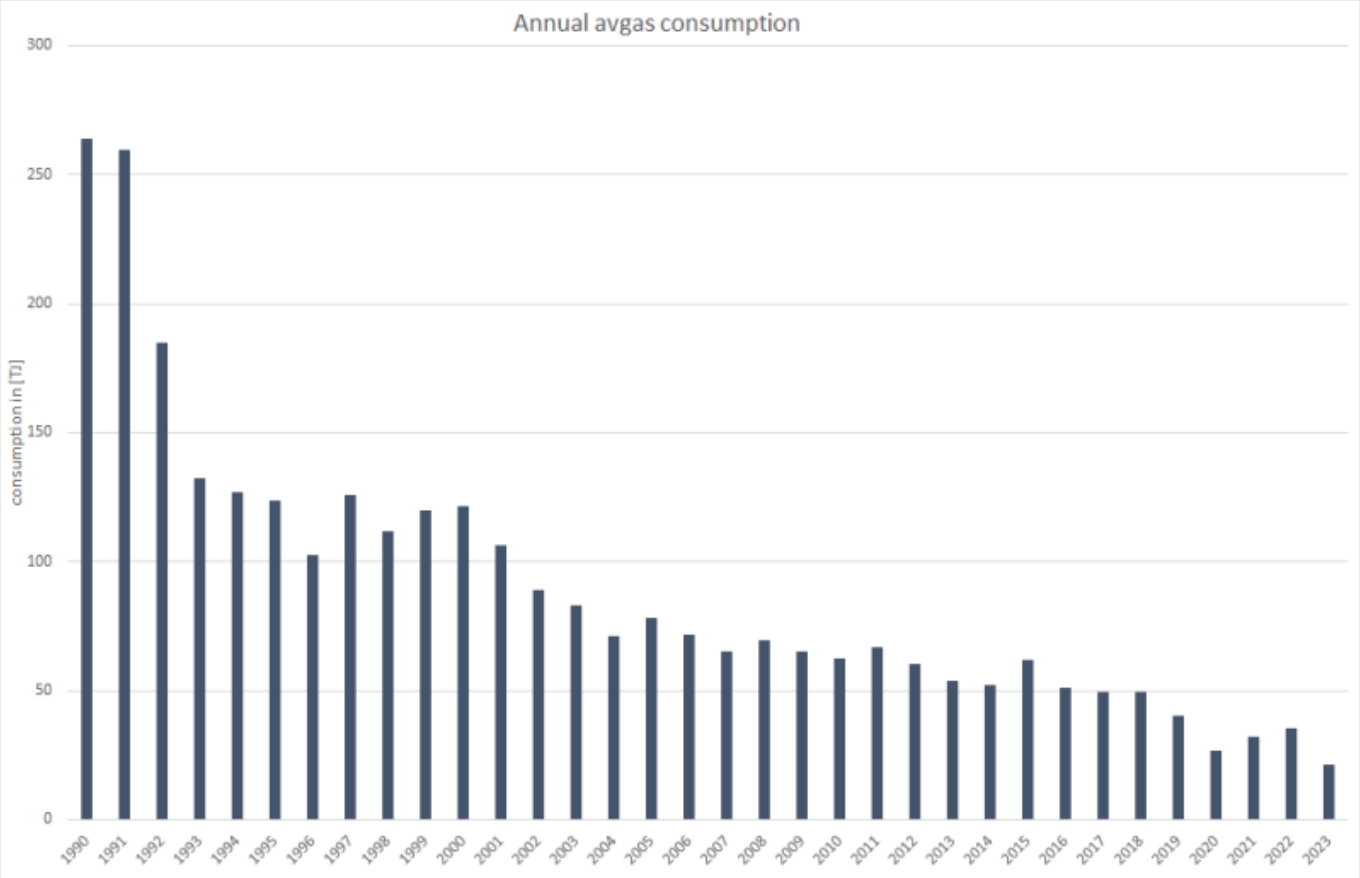
As explained above, the use of aviation gasoline is - due to a lack of further information - assumed to entirely take place within the LTO-range.

Table 2: annual LTO fuel consumption for domestic flights, in terajoule

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jet Kerosene	8,864	8,782	9,100	8,331	8,318	7,612	7,773	7,569	7,584	7,784	3,402	3,140	4,429	4,186
Aviation Gasoline	264	123	121	78.2	62.6	62.0	51.3	49.7	49.4	40.5	26.6	32.0	35.6	21.6
∑	**9,128**	**8,906**	**9,221**	**8,409**	**8,380**	**7,674**	**7,825**	**7,619**	**7,634**	**7,824**	**3,428**	**3,172**	**4,465**	**4,208**

source: Allekotte et al. (2024) &: Gores (2024)





Emission factors

All country-specific emission factors used for emission reporting were basically ascertained within UBA project FKZ 360 16 029 (Knörr, W., Schacht, A., & Gores, S. (2012)) [3)] and have since then been compiled, revised and maintained in TREMOD AV.

Furthermore, the **newly implemented EF(BC)** have been estimated via f-BCs as provided in the 2023 EMEP/EEA Guidebook [4)], Chapter 1.A.3.a, 1.A.5.b Aviation, page 49: “Conclusion”.

For more details, please see the superordinate chapter on civil aviation.

Table 3: Country-specific emission factors, in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
JET KEROSENE														
NH_3	3.98	3.95	3.95	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
NMVOC	36.1	36.2	38.8	39.5	38.6	44.8	42.3	44.6	48.0	50.2	80.4	92.2	72.8	48.7
NO_x	290	320	282	273	300	308	318	318	313	310	286	272	288	305
SO_x	19.7	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
BC[1]	1.37	1.51	1.49	1.55	1.45	1.44	1.39	1.37	1.46	1.32	1.38	1.44	1.39	1.25
PM[2]	2.86	3.15	3.10	3.23	3.02	3.01	2.89	2.85	3.04	2.75	2.87	2.99	2.91	2.61
CO	227	225	293	305	273	280	264	267	280	289	402	442	372	369
AVIATION GASOLINE														
NH_3	NE													
NMVOC	673	672	673	687	675	672	663	654	674	669	666	667	663	668
NO_x	97.2	96.7	96.7	94.7	95.4	96.9	97.8	98.8	95.5	94.2	94.6	93.5	91.6	98.2
SO_x	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
BC[1]	4.26	4.32	4.31	4.52	4.5	4.3	4.2	4.1	4.5	4.7	4.7	4.9	5.2	4.1
PM[2]	28.4	28.8	28.8	30.2	29.8	28.6	27.9	27.3	30.0	31.6	31.3	32.7	34.8	27.6
TSP[3]	43.5	44.0	43.9	45.3	45.0	43.8	43.1	42.5	45.2	46.8	46.4	47.8	50.0	42.8

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
CO	16,026	16,098	16,095	15,647	16,133	16,131	16,436	16,740	16,287	16,667	16,761	16,948	17,407	16,236

[1] estimated via a f-BCs (avgas: 0.15, jet kerosene: 0.48) as provided in EMEP/EEA (2023) [5)], Chapter: 1.A.3.a, 1.A.5.b Aviation, Annex 3, Table A3.2 and Conclusions
[2] EF($PM_{2.5}$,) also applied for PM_{10} and TSP (assumption: > 99% of TSP from diesel oil combustion consists of $PM_{2.5}$)
[3] also including TSP from lead: EF(TSP) = 1.6 x EF(Pb) - see road transport

For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

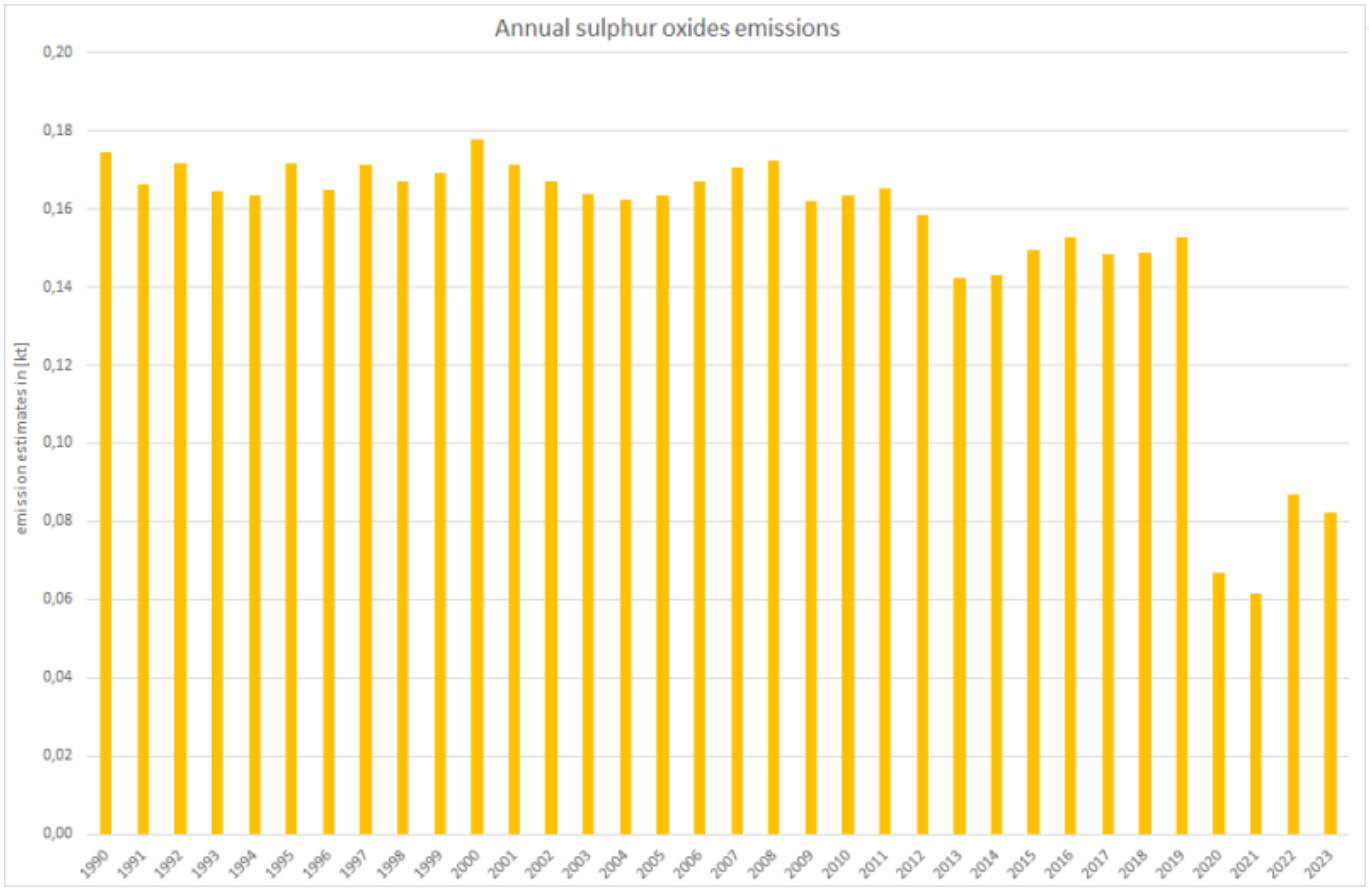
For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Trend discussion for Key Sources

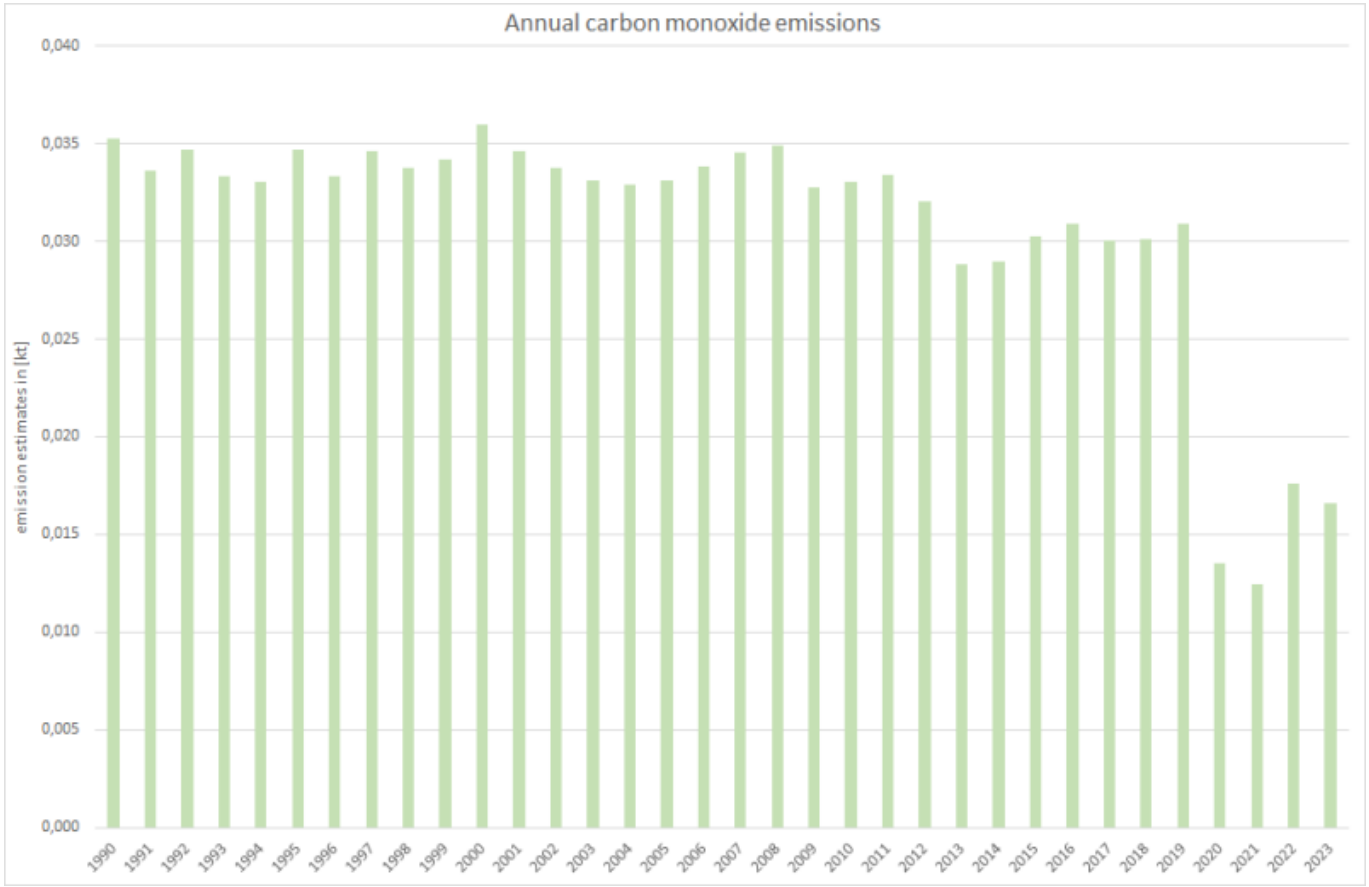
NFR sub-category 1.A.3.a ii (i) is no key source for emissions.

Basically, emission trends corespond directly with fuel consumption, resulting in a strong but temporary decline during an right after the Covid-19 pandemic. Here, with fuel consumption and emissions showing a steady upwards trend again in 2021 and 2022 for international flights, this “recovery” is much slower for domestic flights.

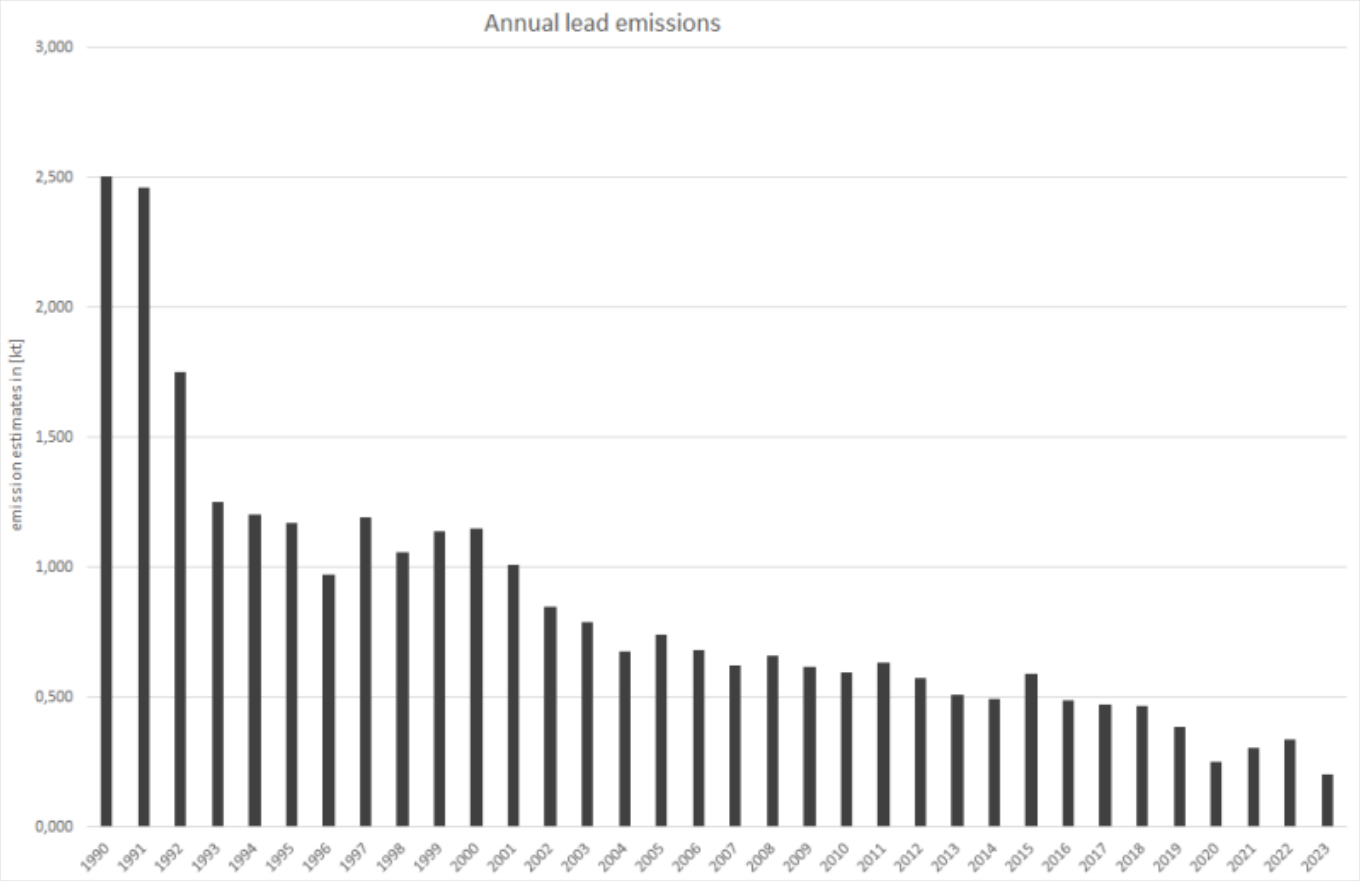
Where, for example, **nitrogen oxides** and **sulphur oxides** emissions are dominated by jet kerosene due to the amount of fuel used,...



... the majority of **carbon monoxide** stems from the consumption of avgas given the much higher emission factor applied to this fuel, with the emission trend following the trend in avgas consumption:



Lead emissions, on the other hand, with no emission factor available for jet kerosene, are only calculated for avgas. Based on a stable fuel lead-content, the emission trend follows the trend in avgas consumption:



Recalculations

Activity data

In contrast to previous submissions, the percentual shares of kerosene and avgas consumed during LTO remain almost unrevised with the only recalculation taking place for 2022.

Table 4: Revised percentual share of kerosene and avgas consumed during L/TO for domestic flights, in %

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
JET KEROSENE													
current submission	30.0	29.3	27.8	27.5	27.5	27.6	28.0	28.1	28.3	28.1	27.5	32.9	31.833
previous submission	30.0	29.3	27.8	27.5	27.5	27.6	28.0	28.1	28.3	28.1	27.5	32.9	31.834
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.001
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.003%
AVGAS													
current submission	12.6	12.6	12.6	13.0	12.8	12.6	12.6	12.3	12.8	12.8	12.7	21.7	21.9
previous submission	12.6	12.6	12.6	13.0	12.8	12.6	12.6	12.3	12.8	12.8	12.7	21.7	21.9
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

However, unrevised total inland deliveries in combination with a slightly increased percental share of kerosene allocated to domestic flights for 2022 result in slightly increased specific activity data for kerosene allocated to 1.A.3.a ii (i). The negligible revision visible for avgas in 2022 results, in contrast, from the application of rounded data in the previous submission.

Table 5: Revised fuel consumption data, in terajoule

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
JET KEROSENE													
current submission	8.864	8.782	9.100	8.331	8.318	7.612	7.773	7.569	7.584	7.784	3.402	3.140	4.429
previous submission	8.864	8.782	9.100	8.331	8.318	7.612	7.773	7.569	7.584	7.784	3.402	3.140	4.428

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%
AVGAS													
current submission	264	123	121	78.2	62.6	62.0	51.3	49.7	49.4	40.5	26.6	32.0	35.607
previous submission	264	123	121	78.2	62.6	62.0	51.3	49.7	49.4	40.5	26.6	32.0	35.610
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.003
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%

In addition, several rather small revisions occur for some country-specific **emission factors** derived from Allekotte et al. (2024) [6)] and for 2022.

Table 6: Revised annual country-specific emission factors for jet kerosene in 1.A.3.a ii (i), in [kg/TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
AMMONIA													
current submission	3.98	3.95	3.95	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
previous submission	3.98	3.95	3.95	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NMVOC													
current submission	36.1	36.2	38.8	39.5	38.6	44.8	42.3	44.6	48.0	50.2	80.4	92.2	72.81
previous submission	36.1	36.2	38.8	39.5	38.6	44.8	42.3	44.6	48.0	50.2	80.4	92.2	72.83
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.03%
NITROGENE OXIDES													
current submission	290	320	282	273	300	308	318	318	313	310	286	272	288.31
previous submission	290	320	282	273	300	308	318	318	313	310	286	272	288.27
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
SULPHUR OXIDES													
current submission	19.7	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
previous submission	19.7	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
BLACK CARBON													
current submission	1.37	1.51	1.49	1.55	1.45	1.44	1.39	1.37	1.46	1.32	1.38	1.44	1.3945
previous submission	1.37	1.51	1.49	1.55	1.45	1.44	1.39	1.37	1.46	1.32	1.38	1.44	1.3943
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0002
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
PARTICULATE MATTER													
current submission	2.86	3.15	3.10	3.23	3.02	3.01	2.89	2.85	3.04	2.75	2.87	2.99	2.9051
previous submission	2.86	3.15	3.10	3.23	3.02	3.01	2.89	2.85	3.04	2.75	2.87	2.99	2.9048
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0003
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
CARBON MONOXIDE													
current submission	227	225	293	305	273	280	264	267	280	289	402	442	371.79
previous submission	227	225	293	305	273	280	264	267	280	289	402	442	371.87
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.08
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.02%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 8.1 - Recalculations.

Uncertainties

For information on uncertainties, please see the main chapter on civil aviation.

Planned improvements

For information on planned improvements, please see main chapter on civil aviation.

[1), 6)] Allekotte et al. (2024): TREMOD Aviation (TREMOD AV) - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Heidelberg, Berlin: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., Berlin & Heidelberg, 2024.
[2)] Gores, S. (2024): Inventartool zum deutschen Flugverkehrsinventar 1990-2023, im Rahmen der Aktualisierung des Moduls TREMOD-AV im Transportemissionsmodell TREMOD, Berlin, 2024.
[3)] Knörr, W., Schacht, A., & Gores, S. (2012): Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV): Endbericht. Endbericht zum F+E-Vorhaben 360 16 029, https://www.umweltbundesamt.de/publikationen/entwicklung-eines-modells-zur-berechnung; Berlin & Heidelberg, 2012.
[4), 5)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 1.A.3.a, 1.A.5.b Aviation, https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023/@@download/file; Copenhagen, 2023

1.A.3.a i (ii) - Internatinal Civil Aviation: Cruise

NFR-specific inventory data

Short description

Category Code	Method	AD	EF
1.A.3.a i (ii)	T1, T2, T3	NS, M	CS, D, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

In NFR category *1.A.3.a i (ii) - Internatinal Civil Aviation: Cruise* emissions from international flights from German airports during cruise stage (above 3,000 feet of altitude) are reported.

In the following, information on sub-category specific activity data, (implied) emission factors and emission estimates are provided.

Methodology

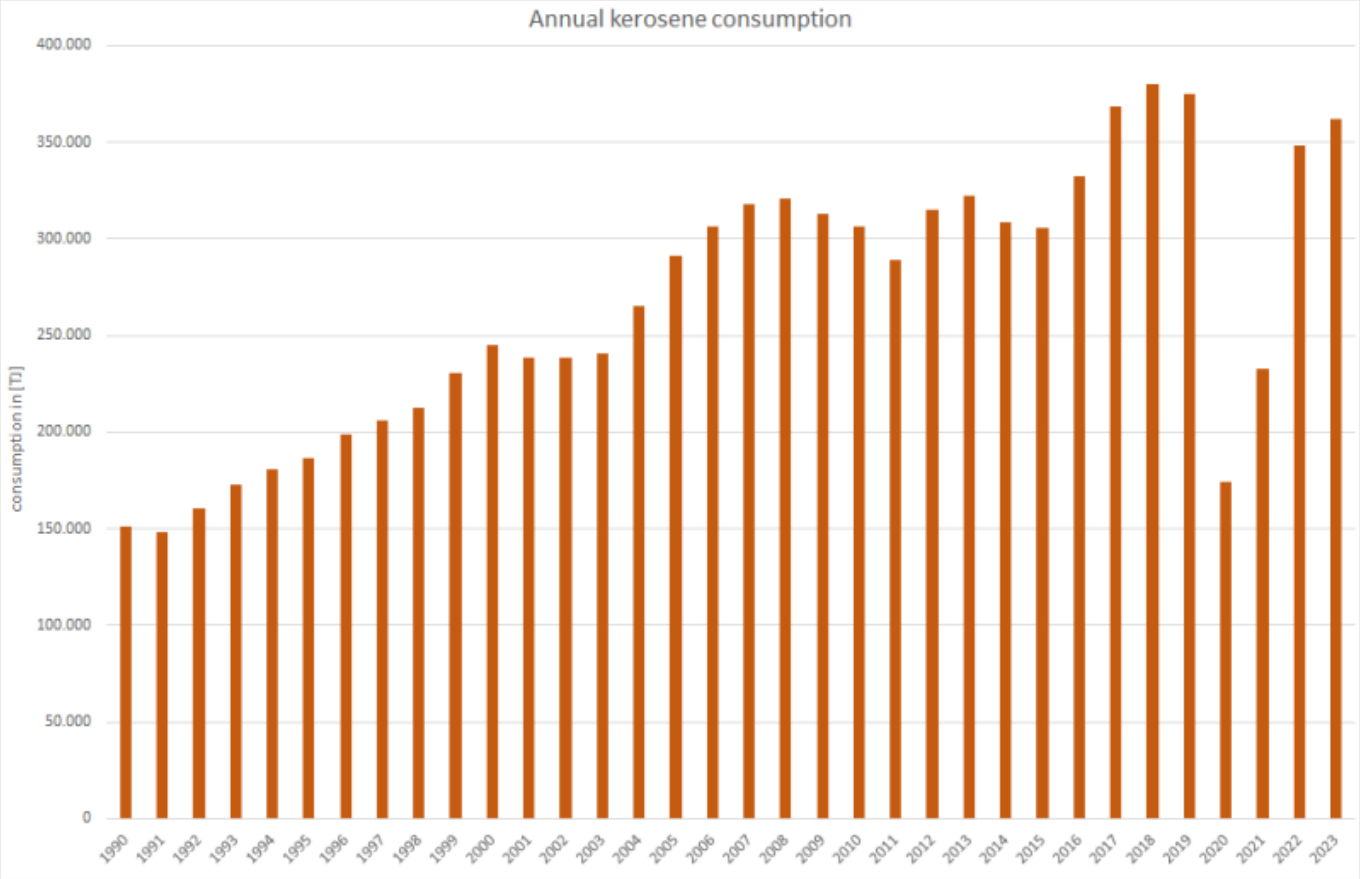
Actitvity Data

Specific jet kerosene consumption during cruise-stage is calculated within TREMOD AV as described in the superordinate chapter on civil aviation.

Table 1: annual jet kerosene consumption during cruise-stage, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jet kerosene	151,464	186,663	244,893	291,217	306,393	306,085	332,321	368,575	379,883	375,395	173,974	232,895	348,273	362,152
Avgas	334	158	153	94.5	76.5	77.3	10.4	11.7	13.1	11.5	4.94	9.07	10.1	26.6

source: Allekotte et al. (2024) [1)] and Gores (2024) [2)]



After a strong decrease during the Covid-19 pandemic, flight activity and, hence, fuel consumption show a ongoing “recovery” being close to pre-pandemic levels again in 2022.

Emission factors

All country specific emission factors used for emission reporting were basically ascertained within UBA project FKZ 360 16 029 [3)] and have since then been compiled, revised and maintained in TREMOD AV [4)].

For more information, please see the superordinate chapter on civil aviation.

Table 2: Annual country-specific emission factors, in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
JET KEROSENE														

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
NH_3	3.98	3.95	3.95	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
NMVOC	13.5	9.09	6.13	5.33	4.72	4.44	4.24	4.30	4.41	4.35	4.49	4.13	4.21	4.13
NO_x	313	316	328	337	351	365	370	372	373	375	379	378	378	375
SO_x	19.7	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
BC	1.87	1.94	2.02	1.92	1.80	1.71	1.72	1.72	1.73	1.71	1.68	1.76	1.77	1.79
PM	3.90	4.04	4.20	4.00	3.75	3.57	3.59	3.58	3.60	3.57	3.50	3.67	3.69	3.73
CO	74.4	62.1	48.5	42.6	38.1	36.5	34.5	34.5	35.0	34.4	35.1	34.8	34.6	37.4
AVGAS														
NH_3	NE													
NMVOC	593	592	599	601	600	602	594	593	572	563	543	589	591	601
NO_x	147	147	148	149	148	150	150	149	135	130	118	146	148	149
SO_x	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
BC	0.41	0.41	0.42	0.42	0.42	0.42	0.41	0.42	0.42	0.42	0.43	0.42	0.42	0.42
$PM_{2.5}$, PM_{10}	2.75	2.75	2.78	2.77	2.78	2.77	2.76	2.77	2.80	2.82	2.85	2.79	2.78	2.78
TSP	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	18.0	18.0	18.0	18.0	18.0	17.9
CO	19,837	20,022	20,502	20,378	20,563	20,217	20,287	20,390	22,290	22,963	24,691	20,738	20,533	20,374

[1] EF(TSP) also applied for PM_{10} and $PM_{2.5}$ (assumption: > 99% of TSP consists of $PM_{2.5}$)
[2] estimated via a f-BC of 0.48 as provided in EMEP/EEA (2023) [5)], Chapter: 1.A.3.a, 1.A.5.b Aviation, Annex 3, Table A3.2 and Conclusion.

For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Trend discussion for Key Sources

NFR 1.A.3.a i (ii) - International Civil Aviation - Cruise is **not included in the national emission totals** and hence **not included in the key category analysis**.

Recalculations

Activity data have been revised as a result of the slightly increased percental share of jet kerosene allocated to domestic flights (see description of re-calculations in super-ordinate chapter on 1.A.3.a). Here, as slightly more jet kerosene is allocated to NFR 1.A.3.a ii for 2022, the amounts allocated to NFR sub-categories 1.A.3.a i(i) and 1.A.3.a i(ii) have been decreased accordingly.

Table 3: Revised fuel-use in 1.A.3.a i (ii) 2022, in terajoules

	JET KEROSENE	AVGAS
current submission	348,273	10.1
previous submission	348,315	10.1
absolute change	-42.1	0.00
relative change	-0.01%	0.00%

In addition, rather small revisions occur for several country-specific **emission factors** derived from Allekotte et al. (2024) [6] and for 2022.

Table 4: Revised annual country-specific emission factors for jet kerosene in 1.A.3.a i (ii) and for 2022, in [kg/TJ]

	AMMONIA	NMVOC	NITROGENE OXIDES	SULPHUR OXIDES	BLACK CARBON	PARTICULATE MATTER	CARBON MONOXIDE
current submission	3.97	4.207	377.91	19.6	1.77	3.6854	34.6
previous submission	3.97	4.206	377.93	19.6	1.77	3.6852	34.6
absolute change	0.00	0.002	-0.02	0.00	0.00	0.0003	0.03
relative change	0.00%	0.04%	0.00%	0.00%	0.00%	0.01%	0.08%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 8.1 - Recalculations.

Uncertainties

For information on uncertainties, please see the main chapter on civil aviation.

Planned improvements

For information on planned improvements, please see main chapter on civil aviation.

[1), 6)] Allekotte et al. (2024): TREMOD Aviation (TREMOD AV) - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Heidelberg, Berlin: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., Berlin & Heidelberg, 2024.
[2)] Gores, S. (2024): Inventartool zum deutschen Flugverkehrsinventar 1990-2023, im Rahmen der Aktualisierung des Moduls TREMOD-AV im Transportemissionsmodell TREMOD, Berlin, 2024.
[5)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 1.A.3.a, 1.A.5.b Aviation, Annex 3, Table A3.2 and Conclusionhttps:*www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023/@@download/file; Copenhagen, 2023)] [(EUROCONTROL2022> Eurocontrol (2022): Advanced emission model (AEM); https://www.eurocontrol.int/model/advanced-emission-model; 2022.*

1.A.3.a ii (ii) - Domestic Civil Aviation: Cruise

NFR-specific inventory data

Short description

Category Code	Method	AD	EF
1.A.3.a ii (ii)	T1, T2, T3	NS, M	CS, D, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

In NFR category *1.A.3.a ii (ii) - Domestic Civil Aviation: Cruise* emissions from domestic flights between German airports during cruise stage (above 3,000 feet of altitude) are reported.

In the following, information on sub-category specific activity data, (implied) emission factors and emission estimates are provided.

Methodology

Actitvity Data

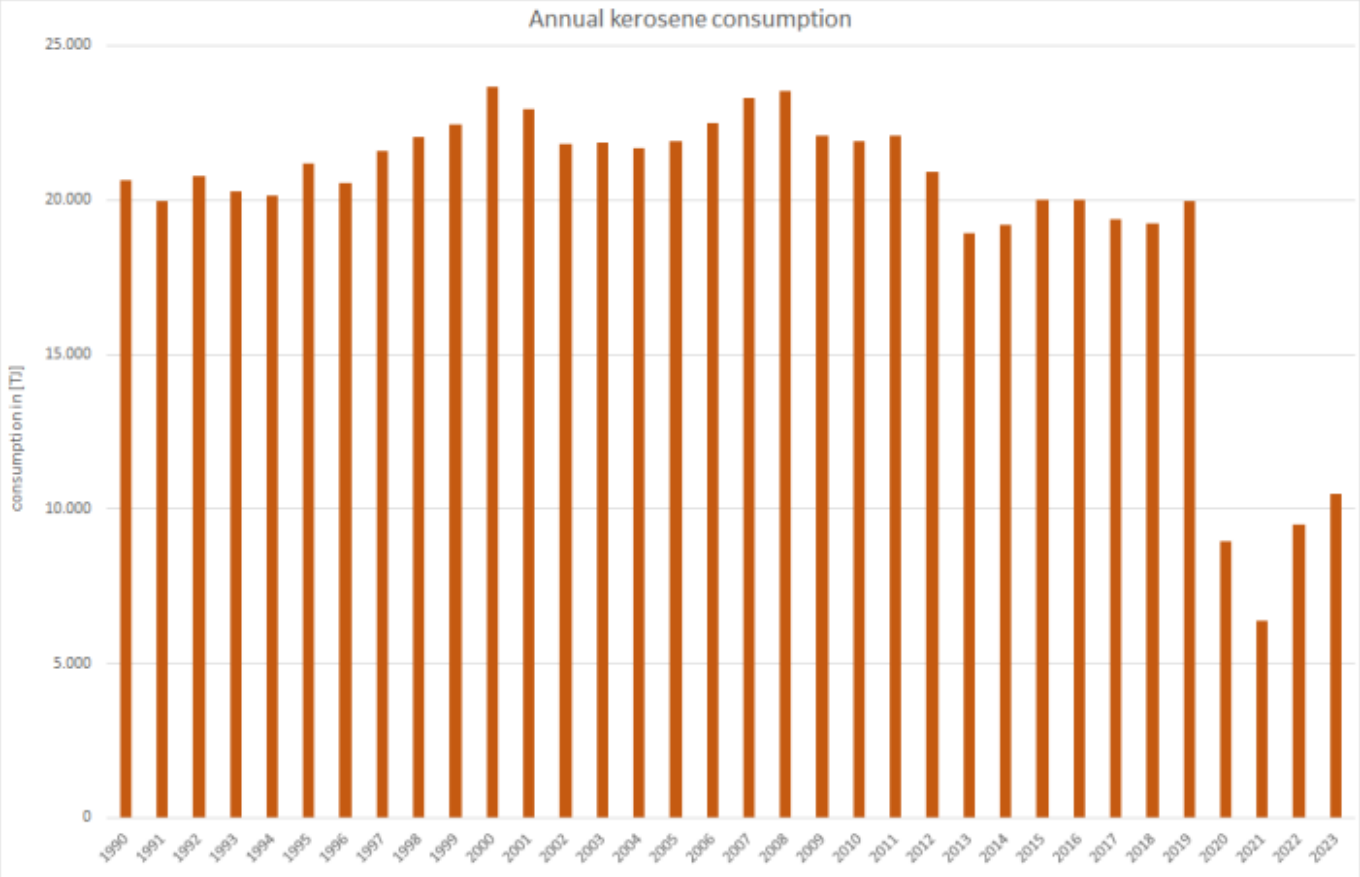
Specific fuel consumption during cruise-stage is calculated within TREMOD AV as described in the superordinate chapter.

Table 1: annual jet kerosene & avgas consumption during cruise-stage, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Kerosene	20,637	21,207	23,646	21,929	21,892	19,993	20,010	19,366	19,259	19,956	8,952	6,401	9,485	10,490
Avgas	1,833	858	843	523	427	429	356	353	337	275	182	115	127	81.4

source: Allekotte et al. (2024) [1)] & Gores (2024) [2)]

Here, with international flights coming close to pre-panemic levels again, fuel consumption of domestic flights shows a rather slow “recovery”, reaching only about 50% of its pre-pandemic level in 2022:



Emission factors

All country specific emission factors used for emission reporting were basically ascertained within UBA project FKZ 360 16 029 [3)] and have since then been compiled, revised and maintained in TREMOD AV (Allekotte et al. (2024)) [4)].

For more information, please see the superordinate chapter on civil aviation.

Table 2: Annual country-specific emission factors, in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
JET KEROSENE														
NH_3	3.98	3.95	3.95	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
NMVOC	16.0	17.6	18.6	20.1	21.1	23.7	19.0	19.7	20.5	23.7	36.3	35.8	28.2	21.2
NO_x	330	367	340	334	368	379	391	392	388	390	357	358	375	376

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
SO_x	19.7	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
BC	1.87	2.15	2.03	2.21	2.01	2.01	1.93	1.96	2.00	1.73	1.79	1.86	1.82	2.08
PM	3.89	4.49	4.23	4.60	4.19	4.18	4.02	4.08	4.16	3.61	3.74	3.88	3.79	4.33
CO	150	152	194	205	198	217	157	155	158	170	272	310	237	305
AVGAS														
NH_3	NE													
NMVOC	594	593	594	593	592	594	592	591	591	589	588	587	582	595
NO_x	150	149	149	150	149	150	149	149	149	147	147	147	146	150
SO_x	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
BC	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
$PM_{2.5}$, PM_{10}	2.77	2.78	2.78	2.77	2.78	2.77	2.77	2.77	2.78	2.78	2.78	2.78	2.78	2.78
TSP	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9
CO	20,142	20,216	20,229	20,160	20,305	20,208	20,265	20,286	20,319	20,478	20,495	20,526	20,701	20,217

[1] EF(TSP) also applied for PM_{10} and $PM_{2.5}$ (assumption: > 99% of TSP consists of $PM_{2.5}$)
[2] estimated via a f-BC of 0.48 as provided in EMEP/EEA (2023) [5)], Chapter: 1.A.3.a, 1.A.5.b Aviation, Annex 3, Table A3.2 and Conclusion

For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Trend discussion for Key Sources

NFR 1.A.3.a ii (ii) - Domestic Civil Aviation - Cruise is **not included in the national emission totals** and hence **not included in the key category analysis**.

Recalculations

Activity data have been revised as a result of the slightly increased percental share of jet kerosene allocated to over-all domestic flights (see description of re-calculations in super-ordinate chapter on 1.A.3.a). Here, as slightly more jet kerosene is allocated to NFR 1.A.3.a ii for 2022, the amounts allocated to NFR sub-categories 1.A.3.a ii(i) and 1.A.3.a ii(ii) have been increased accordingly.

Table 3: Revised annual fuel consumption in 1.A.3.a ii (ii), in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
JET KEROSENE													
current submission	20,637	21,207	23,646	21,929	21,892	19,993	20,010	19,366	19,259	19,956	8,952	6,401	9.485
previous submission	20,637	21,207	23,646	21,929	21,892	19,993	20,010	19,366	19,259	19,956	8,952	6,401	9.481
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.29
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%
AVGAS													
current submission	1,833	858	843	523	427	429	356	353	337	275	182	115	127

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
previous submission	1,833	858	843	523	427	429	356	353	337	275	182	115	127
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

In addition, rather small revisions occur for several country-specific **emission factors** derived from Allekotte et al. (2024) [6)] and for 2022.

Table 4: Revised annual country-specific emission factors for jet kerosene in 1.A.3.a ii (ii), in [kg/TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
AMMONIA													
current submission	3.98	3.95	3.95	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
previous submission	3.98	3.95	3.95	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NMVOC													
current submission	16.0	17.6	18.6	20.1	21.1	23.7	19.0	19.7	20.5	23.7	36.3	35.8	28.23
previous submission	16.0	17.6	18.6	20.1	21.1	23.7	19.0	19.7	20.5	23.7	36.3	35.8	28.24
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.03%
NITROGENE OXIDES													
current submission	330	367	340	334	368	379	391	392	388	390	357	358	375
previous submission	330	367	340	334	368	379	391	392	388	390	357	358	375
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
SULPHUR OXIDES													
current submission	19.7	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
previous submission	19.7	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
BLACK CARBON													
current submission	1.87	2.15	2.03	2.21	2.01	2.01	1.93	1.96	2.00	1.73	1.79	1.86	1.8207
previous submission	1.87	2.15	2.03	2.21	2.01	2.01	1.93	1.96	2.00	1.73	1.79	1.86	1.8204
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0003
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%
PARTICULATE MATTER													
current submission	3.89	4.49	4.23	4.60	4.19	4.18	4.02	4.08	4.16	3.61	3.74	3.88	3.793
previous submission	3.89	4.49	4.23	4.60	4.19	4.18	4.02	4.08	4.16	3.61	3.74	3.88	3.792
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%
CARBON MONOXIDE													
current submission	150	152	194	205	198	217	157	155	158	170	272	310	237.03
previous submission	150	152	194	205	198	217	157	155	158	170	272	310	237.10
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.07
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.03%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 8.1 - Recalculations.

Uncertainties

For information on uncertainties, please see the main chapter on civil aviation.

Planned improvements

For information on planned improvements, please see main chapter on civil aviation.

[1), 4), 6)] Allekotte et al. (2024): TREMOD Aviation (TREMOD AV) - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Heidelberg, Berlin: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., Berlin & Heidelberg, 2024.
[2)] Gores, S. (2024): Inventartool zum deutschen Flugverkehrsinventar 1990-2023, im Rahmen der Aktualisierung des Moduls TREMOD-AV im Transportemissionsmodell TREMOD, Berlin, 2024.
[3)] Knörr, W., Schacht, A., & Gores, S. (2010): Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV): Endbericht. Endbericht zum F+E-Vorhaben 360 16 029, URL: https://www.umweltbundesamt.de/publikationen/entwicklung-eines-modells-zur-berechnung; Berlin & Heidelberg, 2012.
[5)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 1.A.3.a, 1.A.5.b Aviation, https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023/@@download/file; Copenhagen, 2023

1.A.3.b - Transport: Road Transport

Short description

In category *1.A.3.b - Road Transport* emissions from fuel combustion activities as well as abrasive and fugitive emissions are reported within the following categories:

NFR-Code	Name of Category
Emissions from Fuel Combustion in Road Vehicles	
1.A.3.b i	Passenger Cars - PCs
1.A.3.b ii	Light Duty Vehicles - LDVs
1.A.3.b iii	Heavy Duty Vehicles - HDVs
1.A.3.b iv	Mopeds & Motorcycles - MPDs & MCs
Fugitive Emissions from Road Vehicles	
1.A.3.b v	Gasoline Evaporation
Emissions from Tyre and Brake Wear & Road Abrasion	
1.A.3.b vi	Automobile Tyre and Brake Wear
1.A.3.b vii	Automobile Road Abrasion

Emissions from motorised road traffic in Germany are reported under this category. It includes traffic on public roads within Germany, except for agricultural and forestry transports and military transports. Calculations are made for the vehicle categories of passenger cars, motorcycles, light duty vehicles, heavy duty vehicles and buses. For calculation purposes, the vehicle categories are broken down into so-called vehicle layers with the same emissions behaviour. To this end, vehicle categories are also broken down by type of fuel used, vehicle size (trucks and buses by weight class; automobiles and motorcycles by engine displacement) and pollution control equipment used, as defined by EU directives for emissions control (“EURO norms”), and by regional traffic distribution (outside of cities, in cities and autobahn).

Since 1990, emissions of NO_x, CO, NMVOC and SO_2 from road transports have decreased sharply, due to catalytic-converter use and engine improvements resulting from continual tightening of emissions laws, and due to improved fuel quality.

For buses and heavy duty vehicles (over 3.5 t total permissible vehicle weight), maximum permissible levels of hydrocarbon (HC, incl. NMVOC) emissions were lowered especially sharply (-40%) via the introduction of the EURO3 standard in 2000. Since EURO3 vehicles were very quick to reach the market as of 2000, the emission factor for hydrocarbon emissions from diesel fuel - and the relevant emissions themselves – decreased considerably after 2000.

Methodology

Emissions are calculated with the aid of the TREMOD, the “Transport Emission Estimation Model” maintained by Knörr et al. [1)].

This model adopts a “bottom-up” (tier3) approach whereby mileage of the individual vehicle layers is multiplied by region-specific emission factors. For passenger cars and light duty vehicles, a “cold start surplus” is also added. The total consumption calculated on the basis of fuel type is compared with the consumption according to the Energy Balance. The emissions are then corrected with the aid of factors obtained from this comparison process. For petrol-powered vehicles, the evaporation emissions of VOC are calculated in keeping with the pollution-control technology used. From the emissions and fuel consumption for the various vehicle layers, aggregated, fuelbased emission factors (kg of emissions per TJ of fuel consumption) are derived, and then the emission factors are forwarded to the CSE via a relevant interface. In keeping with the CORINAIR report structure, these factors are differentiated only by type of fuel, type of road (autobahn, rural road, city road) and, within the vehicle categories, by “without/with emissions-control equipment”. The following emissions-control categories are differentiated:

For calculation with TREMOD, extensive basic data from generally accessible statistics and special surveys were used, co-ordinated, and supplemented. An overview of the principal sources and key assumptions is given below. Detailed descriptions of the databases, including information on the sources used, and the calculation methods used in TREMOD, are provided in the aforementioned IFEU report.

Activity Data

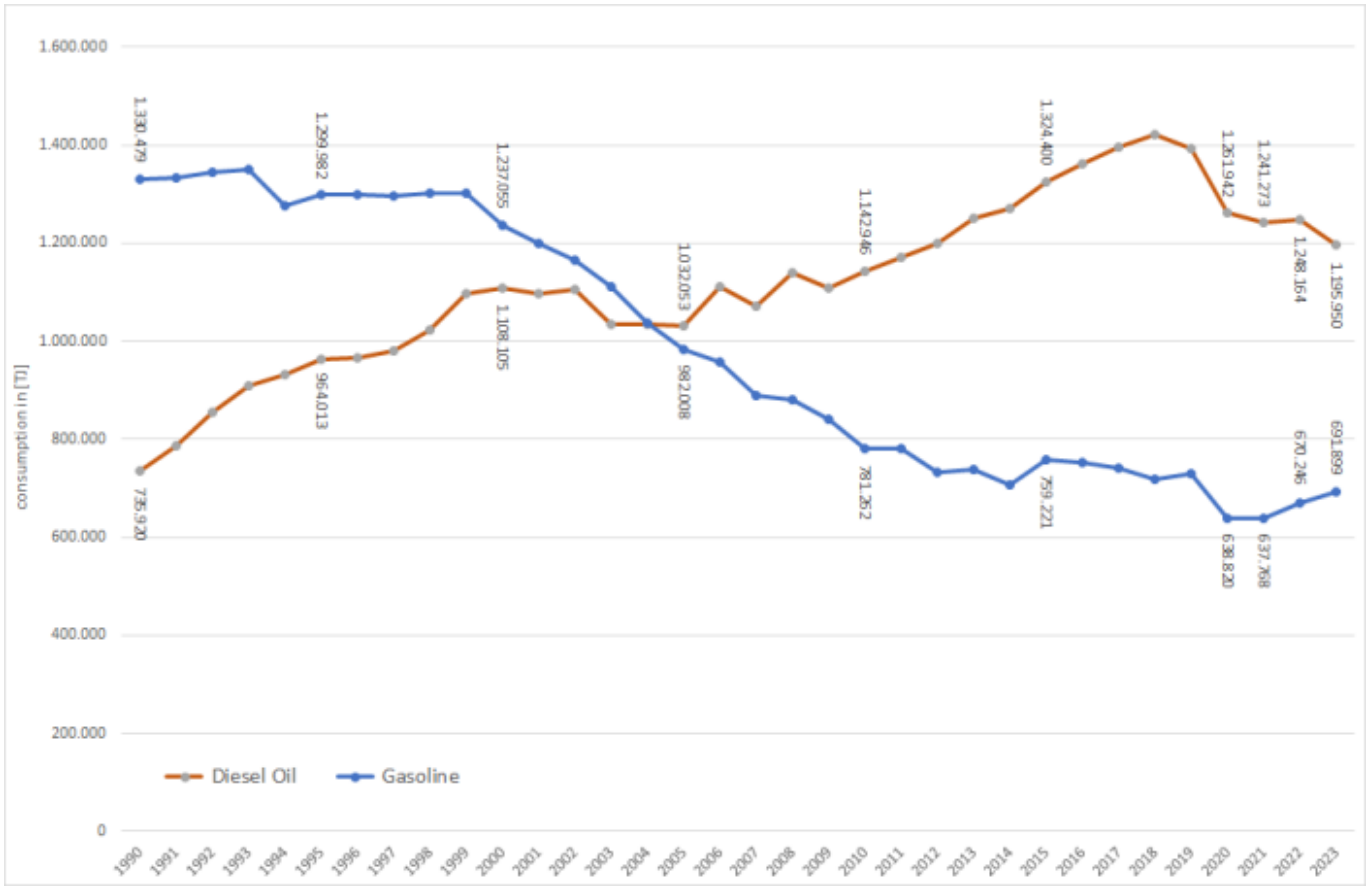
The basis for CSE data collection for the road-transport sector consists of fuel consumption data provided by the Working Group on Energy Balances (AGEB) [2)]. For each year, the sum of the activity rates for the various individual structural elements must correspond to the Energy Balance data, in terajoule. The relevant basic Energy Balance data is shown in the table below.

Table 1: Fuel consumption in German road transport, in terajoules

	Diesel oil	Gasoline	LPG	Natural Gas[1]	Petroleum[2]	Biodiesel	Biogasoline	Biomethane	Lubricants[3]	TOTAL
1990	735,920	1,330,479	138	0					2,543	2,069,080
1991	785,174	1,332,285	137	0					1,702	2,119,298
1992	853,502	1,344,129	229	0					1,299	2,199,159
1993	907,787	1,350,617	184	0	473				872	2,259,933
1994	932,060	1,276,637	184	0	559				596	2,210,036
1995	964,013	1,299,982	138	0	610	1,504			455	2,266,702
1996	964,580	1,299,879	115	0	638	2,046			372	2,267,630
1997	979,586	1,297,487	106	0	357	3,652			266	2,281,454
1998	1,022,794	1,300,463	106	0	637	4,081			206	2,328,287
1999	1,097,036	1,300,602	100	0	637	5,370			116	2,403,861
2000	1,108,105	1,237,055	94	0	414	12,276			82.7	2,358,027
2001	1,097,416	1,199,318	98	0	471	16,740			74.5	2,314,117
2002	1,105,842	1,166,381	607	0	472	20,460			77.3	2,293,839
2003	1,035,240	1,111,873	697	2,488	0	29,948	0		72.8	2,180,319
2004	1,035,496	1,035,690	1,892	2,774	0	38,831	1,142		72.4	2,115,897
2005	1,032,053	982,008	2,369	3,127	0	71,956	6,807		77.7	2,098,398
2006	1,112,292	958,059	6,399	4,446	0	130,508	13,403		79.6	2,225,187
2007	1,070,762	889,973	10,519	5,845	0	143,677	12,041		79.7	2,132,896
2008	1,139,350	879,208	17,732	7,130	0	109,987	16,310	14.0	83.6	2,169,815
2009	1,106,921	841,259	23,777	8,396	0	89,978	23,694	47.0	88.7	2,094,161
2010	1,142,946	781,262	22,982	8,498	0	89,399	30,350	270	81.6	2,075,788
2011	1,170,553	779,716	23,332	8,438	0	83,237	32,065	333	80.1	2,097,754
2012	1,199,136	731,077	20,860	7,669	0	85,998	32,548	1,200	75.4	2,078,565
2013	1,249,371	737,845	22,682	5,652	0	75,732	31,434	1,737	77.7	2,124,531
2014	1,271,232	706,319	20,247	5,855	0	79,256	32,036	1,617	74.2	2,116,637
2015	1,324,400	759,221	18,709	4,595	0	73,570	30,646	1,242	83.3	2,212,467
2016	1,360,456	752,476	17,767	4,006	0	73,739	30,717	1,363	82.6	2,240,606
2017	1,395,407	740,633	15,775	2,632	0	76,061	30,240	1,603	79.5	2,262,431
2018	1,420,095	716,959	16,922	3,163	0	80,127	31,029	1,399	78.5	2,269,774
2019	1,393,821	729,626	14,692	2,377	0	79,063	30,063	2,378	79.6	2,252,099
2020	1,261,942	638,820	10,213	2,881	0	103,219	28,640	3,181	81.6	2,048,976
2021	1,241,273	637,768	10,138	7,144	0	87,043	30,050	3,474	72.2	2,016,964
2022	1,248,164	670,246	11,761	7,749	0	86,588	31,064	3,821	78.6	2,059,472
2023	1,195,950	691,899	7,927	6,886	0	88,638	32,683	5,218	69.5	2,029,271

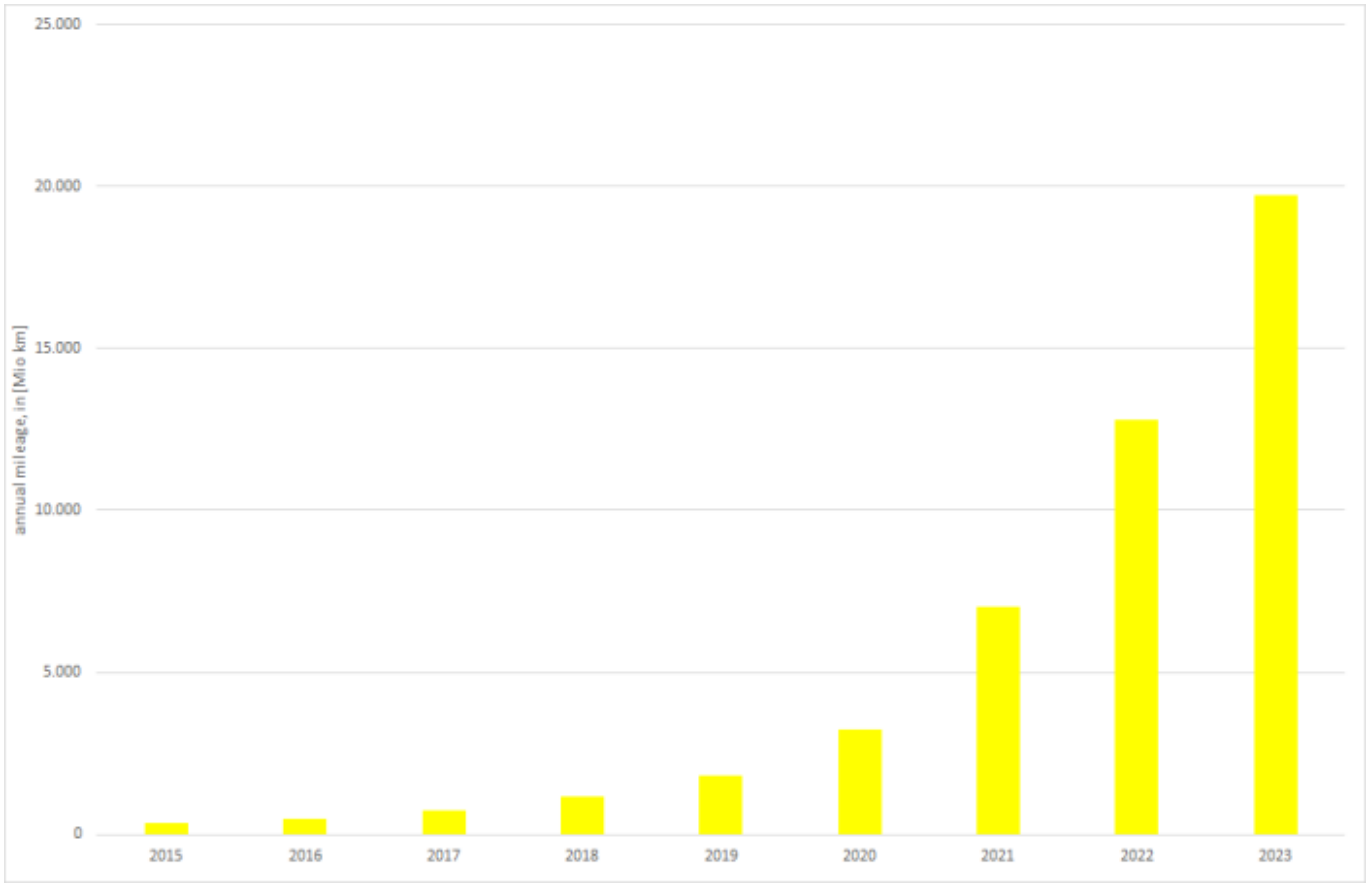
[1]: including both CNG (Compressed Natural Gas) and LNG (Liquefied Natural Gas)
[2]: applied only from 1993 to 2002 in a small number of buses (se chapter on NFR 1.A.3.b iii)
[3]: amounts of lubricants unintentionally co-incinerated in road vehicles (lubricants intentionally co-incinerated in 2-stroke road vehicles are taken into account in NFR 2.D.3.i Mobile Use of Lubricants

The following chart illustrates the trend to diesel vehicles operated in Germany, the so-called “Dieselization” with the amounts of fossil diesel oil exceeing those of fossil gasoline fuels from 2004 onwards.



For more information on the derivation of activity data and the emission factors applied, please refer to the sub-ordinate chapters as well as Appendix 2.2.

Chart 2 illustrates the increase in annual mileage of electric road vehicles in 10^6 kilometers. Despite the exponential growth, only about 1.8 per cent of annual mileage was “electric” in 2022 (13 Mio km of 682 Mio km).



Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by (Knörr et al. (2009)) [3)].

Uncertainty estimates for **emission factors** for all 1.A.3.b sub-categories were compiled during the PAREST research project. Here, the final report has not yet been published.

Recalculations



Basically, recalculations result from a) the revision of the National Energy Balance (for most recent years) and b) routine revisions of the underlying TREMOD model (recent years or entire time series, depending on outline of revision).

For more details please refer to the related sub-chapters as linked above.

Planned improvements

Besides the routine revision of the TREMOD model, no specific improvements are planned.

[1)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2024.

[2)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

[3)] Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

1.A.3.b i - iv - Emissions from fuel combustion in Road Vehicles (OVERVIEW)

Short description

This overview chapter provides information on the emissions from fuel combustion activities in road transport sub-categories *1.A.3.b i, ii, iii, and iv*.

NFR-Code	Name of Category
1.A.3.b i	Passenger Cars
1.A.3.b ii	Light Duty Vehicles
1.A.3.b iii	Heavy Duty Vehicles
1.A.3.b iv	Mopeds & Motorcycles

Methodology

Activity data

Basically, total inland fuel deliveries are available from the National Energy Balances (NEBs) (AGEB, 2024) [1)], line 62: Straßenverkehr (Road Transport).

Based upon these primary activity data, specific consumption data for the different types of road vehicles are generated within TREMOD [2)].



For further details see main chapter 1.A.3.b - Road Transport as wells as the sub-category chapters linked above.

Emission factors

The majority of emissions factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, version 4.2) [3)] where they are provided on a tier3 level mostly and processed within the TREMOD software used by the party [4)].



With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [2)]

As it is not possible to present these tier3 values in a comprehendible way, the NFR sub-chapters linked above provide sets of fuel-specific implied emission factors instead.

For heavy-metal (other then lead from leaded gasoline) and PAH exhaust-emissions, default emission factors from (EMEP/EEA, 2023) [5)] have been applied. Regarding PCDD/F, tier1 EF from (Rentz et al., 2008) [6)] are used instead.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Trends of exhaust emissions from road transport vehicles

For **ammonia emissions**, the increasing use of catalytic converters in gasoline driven cars in the 1990s lead to a steep increase whereas both the technical development of the converters and the ongoing shift from gasoline to diesel cars resulted in decreasing emissions in the following years.

The observed trends for **NO_x, NMVOC and CO emissions** represent the changes in legislatory emission limits and the regarding implementation of mitigation technologies. The following table provides an overview of the implemetation of Euro norms in Germany.

Table 1: Overview of Euro norms and their implementation in Germany

	Type Approval for new vehicle types	Type Approval for new vehicles	Testing Cycle
PASSENGER CARS & LIGHT-DUTY VEHICLES[7)]			
Euro Norm 1	since 01. Juli 1992	since 01. Januar 1993	NEFZ
Euro 2	since 01. Januar 1996	since 01. Januar 1997	NEFZ
Euro 3	since 01. Januar 2000	since 01. Januar 2001	NEFZ
Euro 4	since 01. Januar 2005	since 01. Januar 2006	NEFZ
Euro 5a[8)]	since 01. September 2009	since 01. Januar 2011	NEFZ
Euro 5b*	since 01. September 2011	since 01. Januar 2013	NEFZ
Euro 6b[9)]	since 01. September 2014	since 01. September 2015	NEFZ
Euro 6c	since 01. September 2017	since 01. September 2018	WLTC
Euro 6d-Temp	since 01. September 2017	since 01. September 2019	WLTC
Euro 6d	Freiwillige Einstufung	Freiwillige Einstufung	WLTC
Euro 6d-ISC-FCM	since 01.01.2020 (36AP) / 10.01.2021 (36AQ-AR)	Ab 01.01.2021 (36AP) / 01.01.2022 (36AQ-AR)	WLTC
Ero 7[10)]	as of 29.11.2026	as of 29.11.2027	WLTC
* only for gasoline			
BUSES & TRUCKS[11)]			
Euro I	01. Jan 92		ESC R-49
Euro II	01. Okt 96		ESC R-49
Euro III	01. Okt 00		ESC&ELR, ETC
Euro IV	01. Okt 05		ESC&ELR, ETC
Euro V	01. Okt 08		ESC&ELR, ETC
Euro VI[12)]	01. Okt 13		WHTC, WHSC
Euro VII[13)]	as of 29.05.2028	as of 29.05.2029	
MOTORCYCLES[14)]			
Euro 1	since 17. Juni 1999		ECE R47
Euro 2	since 17. Juni 2002		ECE R47
Euro 4[15)]	since 01. Januar 2017	since 01. Januar 2018	ECE R47
Euro 5[16)]	since 01. Januar 2020	since 01. Januar 2021	WMTC
MOPEDS			
Euro 1	since 17. Juni 1999		ECE R47
Euro 2	since 17. Juni 2002		ECE R47
Euro 4[17)]	2016	2017	

Trends for **sulphur dioxide** show charcteristics very different from those shown above. Here, the strong dependence on increasing fuel qualities leads to an cascaded downward trend of **SO_2 emissions**, influenced only slightly by increases in fuel consumption and mileage.

The following table provides the development of sulphur contents over the years for Old (OGL) and New German Länder (NGL) and Germany (GER).

Table 2: Development of fuel sulphur contents in Germany

Area covered	Year(s) covered	Gasoline	Diesel oil
EAST GERMANY (DDR)	until 1988	500 ppm	6,000 ppm
	1989-1990	500 ppm	6,000 ppm
WEST GERMANY (BRD)	until 1984	250 ppm	2,700 ppm
	1985		2,500 ppm
	1986		2,100 ppm
	1987		
	1988		1,700 ppm
	1989		
	1990	220 ppm	
GERMANY	1991	220 ppm	1,300 ppm
	1992		
	1993		
	1994		
	1995	180 ppm	
	1996		600 ppm
	1997		400 ppm
	1998-2000	70 ppm	300 ppm
	2001	55 ppm	250 ppm
	2002	25 ppm	40 ppm
	since 2003	8 ppm	8 ppm

For **exhaust particulate matter emissions** from diesel road vehicles, the party assumes that nearly all particles emitted are within the $PM_{2.5}$ range, resulting in similar emission values for $PM_{2.5}$, PM_{10}, and TSP. Excumptions from this assumption can be observed for gasoline road vehicles for the years until 1997 when **additional TSP emissions** resulted **from the use of leaded gasoline** that was banned in 1997. Furthermore, **black carbon** emissions are estimated via implied emission factors derived from fractions of PM as provided in [18)].

For **Heavy Metals** and **PAHs**, emissions are calculated with tier1 default EF from [19)] resulting in trends that simply reflect the annual fuel consumption.

Table 3-86: Heavy metal emission factors for all vehicle categories in ppm/wt fuel

Category	Pb	Cd	Cu	Cr	Ni	Se	Zn	Hg	As
Passenger cars, petrol	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003
Passenger cars, diesel	0.0005	5 E-05	0.0057	0.0085	0.0002	0.0001	0.018	0.0053	0.0001
LCVs, petrol	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003
LCVs, diesel	0.0005	5 E-05	0.0057	0.0085	0.0002	0.0001	0.018	0.0053	0.0001
HDVs, petrol	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003
HDVs, diesel	0.0005	5 E-05	0.0057	0.0085	0.0002	0.0001	0.018	0.0053	0.0001
L-category	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003

Here, the only excumption are **lead emissions from leaded gasoline** that was in use until 1996 with lead contents provided in the table below:

Table 3: Development of gasoline's lead content in Germany

Area covered	Year(s) covered	Lead content
EAST GERMANY (GDR)	1989-1990	126 mg/l
WEST GERMANY (BRD)	1990	42 mg/l

Area covered	Year(s) covered	Lead content
GERMANY	1991	29 mg/l
	1992	20 mg/l
	1993	16 mg/l
	1994	11 mg/l
	1995	8 mg/l
	1996	4 mg/l
	since 1997	0 mg/l (banned)

Recalculations

Recalculations of exhaust-emissions are mainly based on (i) the **finalisation of the most recent National Energy Balance** as well as (ii) the **routine revision the underlying TREMOD model**.

However, for the current submission, recalculations have been carried out due to the finalization of the National Energy Balance for 2022 with the domestic biofuels deliveries provided in the Renewable Energy Statistics and modelled in TREMOD.

For more information, please see the specific chapters linked above.

Table 4: Revised domestic fossil fuel deliveries as provided in line 62 (road transportation) of the National Energy Balance 2022, in terajoules [TJ]

	DIESEL FUEL	BIODIESEL	GASOLINE	BIO-GASOLINE	LPG	NATURAL GAS	BIO-METHANE	NFR TOTAL
current submission	1,248,164	86,588	670,246	31,064	11,761	7,749	3,821	**2,070,471**
previous submission	1,245,609	86,559	670,318	31,067	11,796	3,119	3,821	**2,063,424**
absolute change	2,555	29.0	-71.6	-3.32	-34.9	4,630	0.00	**7,046**
relative change	0.21%	0.03%	-0.01%	-0.01%	-0.30%	148%	0.00%	**0.34%**

[1)] AGEB, 2024: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024
[2), 4)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2024.
[3)] Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf - Dokumentation, Bern, 2022.
[5)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2019; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023; Copenhagen, 2023.
[6)] Rentz et al. (2008): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, January 2008 - URL: http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer
[7)] UBA (2016): Themen > Verkehr > Emissionsstandards > Pkw und leichte Nutzfahrzeuge: https://www.umweltbundesamt.de/sites/default/files/medien/376/bilder/dateien/tabelle_grenzwerte_fuer_schadstoffemissionen_von_pkw.pdf; Umweltbundesamt, Dessau-Roßlau, 2016
[8), 9)] EU (2007): REGULATION (EC) No 715/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information - https://data.europa.eu/eli/reg/2007/715/oj
[10), 13)] EU (2024): Regulation (EU) 2024/1257 of the European Parliament and of the Council of 24 April 2024 on type-approval of motor vehicles and engines and of systems, components and separate technical units intended for such vehicles, with

respect to their emissions and battery durability (Euro 7), amending Regulation (EU) 2018/858 of the European Parliament and of the Council and repealing Regulations (EC) No 715/2007 and (EC) No 595/2009 of the European Parliament and of the Council, Commission Regulation (EU) No 582/2011, Commission Regulation (EU) 2017/1151, Commission Regulation (EU) 2017/2400 and Commission Implementing Regulation (EU) 2022/1362; http://data.europa.eu/eli/reg/2024/1257/oj

[11)] UBA (2024): Themen > Verkehr > Emissionsstandards > Schwere Nutzfahrzeuge: https://www.umweltbundesamt.de/sites/default/files/medien/366/bilder/dateien/2024_tabelle_grenzwerte_snf_busse.pdf; Umweltbundesamt, Dessau-Roßlau, 2024

[12)] EU (2009): REGULATION (EC) No 595/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information and amending Regulation (EC) No 715/2007 and Directive 2007/46/EC and repealing Directives 80/1269/EEC, 2005/55/EC and 2005/78/EC - https://data.europa.eu/eli/reg/2009/595/oj

[14)] UBA (2015): Themen > Verkehr > Emissionsstandards > Motorisierte Zweiräder: https://www.umweltbundesamt.de/sites/default/files/medien/376/bilder/grenzwerte_fuer_schadstoffemissionen_motorisierter_zweiraeder_1.png; Umweltbundesamt, Dessau-Roßlau, 2015

[15)], [16)], [17)] EU (2013): Regulation (EU) No 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles - Consolidated text; http://data.europa.eu/eli/reg/2013/168/2024-11-27

[2)]

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.A.3.b i - Road transport: Passenger cars

Short description

In sub-category *1.A.3.b i - Road transport: Passenger cars* emissions from fuel combustion in passenger cars (PCs) are reported.

Category Code	Method	AD	EF
1.A.3.b i	T1, T3	NS, M	CS, M, D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
L/T	L/T	-/-	-/-	L/T	L/T	-/-	L/T	L/T	L/T	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Detailed information on the methods applied is provided in the superordinate chapter .

Activity data

Specific consumption data for passenger cars is generated within TREMOD [1)].

The following table gives an overview of annual amounts of the fuels consumed by passenger cars in Germany.

Table 1: Annual passenger car fuel consumption, in terajoule

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel oil	266,175	321,615	348,554	459,150	493,060	644,577	667,913	668,958	642,258	643,791	520,027	528,230	550,835	532,067
Gasoline	1,273,347	1,258,708	1,194,743	948,080	755,474	733,505	726,576	714,892	691,702	703,555	613,047	613,541	644,312	667,928
LPG	138	138	94,0	2,369	22,982	18,709	17,767	15,775	16,922	14,692	10,213	10,138	11,761	7,927
Natural Gas	0	0	0	1,628	5,213	2,729	2,403	1,591	1,926	1,314	1,151	2,045	1,855	1,573
Biodiesel	0	502	3,861	32,012	38,566	35,806	36,202	36,464	36,239	36,518	42,535	37,042	38,213	39,434
Biogasoline	0	0	0	6,572	29,348	29,608	29,660	29,189	29,936	28,989	27,485	28,909	29,862	31,551
Boimethane	0	0	0	0	166	738	818	969	852	1,314	1,271	994	914	1,192
Σ 1.A.3.b i	**1,539,661**	**1,580,963**	**1,547,252**	**1,449,811**	**1,344,808**	**1,465,672**	**1,481,339**	**1,467,839**	**1,419,835**	**1,430,173**	**1,215,728**	**1,220,899**	**1,277,751**	**1,281,672**

Here, the following charts underline the ongoing shift from gasoline to diesel-powered passenger cars, that started around 1999/2000.

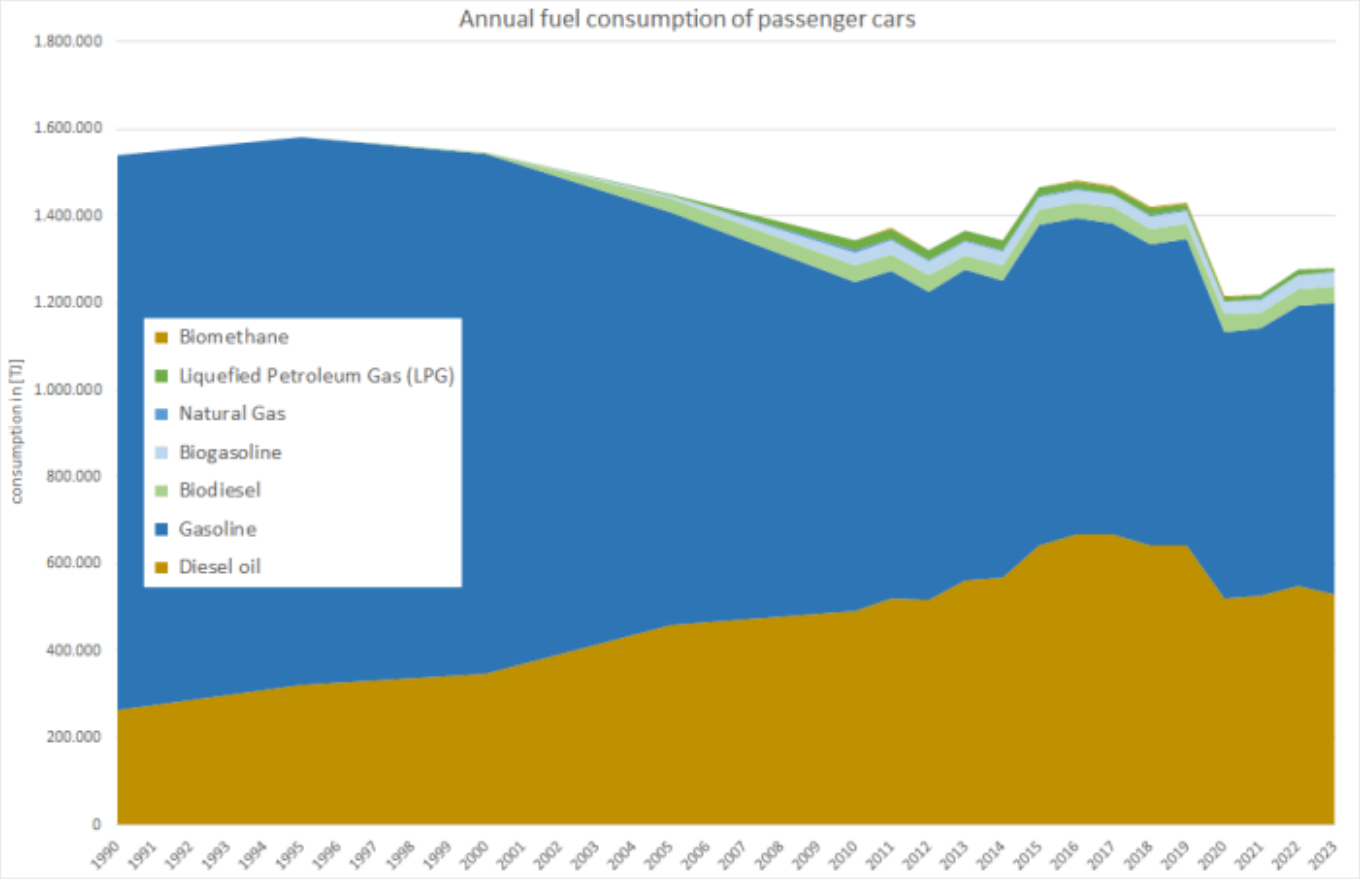
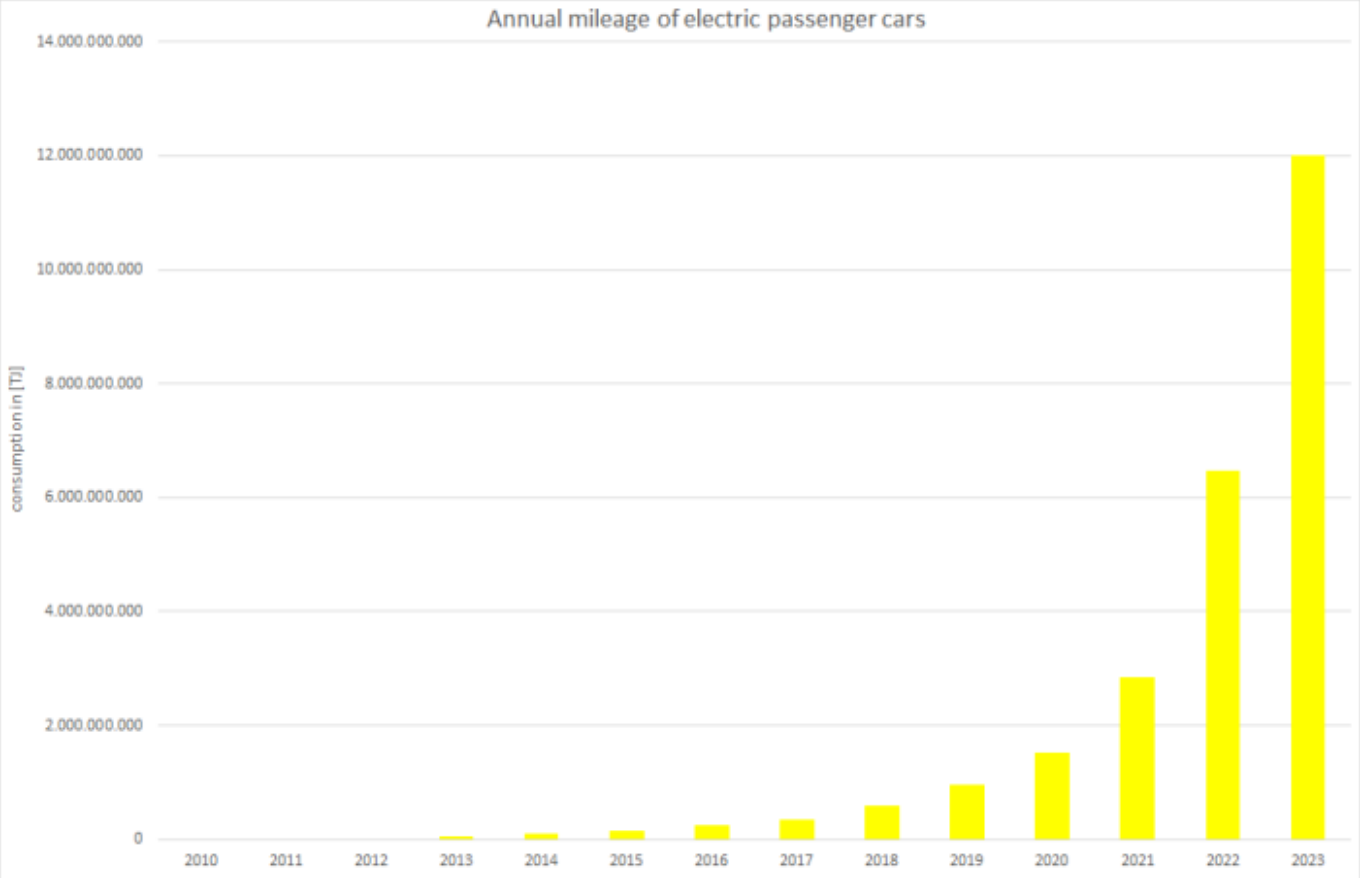


Table 2: Annual mileage of electric light-duty vehicles, as of 2012, in [km]

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
52,724,521	88,842,736	152,233,306	240,661,045	356,085,922	582,598,538	946,895,086	1,533,759,731	2,849,336,422	6,481,152,506	12,012,568,424	18,591,561,214



For further information on mileage and abrasion-related emissions, please refer to sub-chapters on emissions from tyre & brake wear and road abrasion.

Emission factors

The majority of emission factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, versions 4.1 and 4.2) [2),3)], where they are provided on a tier3 level mostly and processed within TREMOD [4)].

However, it is not possible to present these highly specific tier3 values in a comprehendible way here.

With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [3)]

For heavy-metal (other then lead from leaded gasoline) and PAH exhaust-emissions, default emission factors from the 2023 EMEP/EEA Guidebook (EMEP/EEA, 2023), Table 3-86 have been applied [5)] (see super-ordinate chapter here).

Regarding PCDD/F, tier1 EF from (Rentz et al., 2008) [6)] are used instead.

The following table provides an overview of the EF. Please note, that the values for heavy-metal (in [g/TJ]) and PAH (in [mg/TJ]) exhaust-emissions have been estimated from the EMEP/EEA defaults provided in [ppm/wt].

Table 3: Overview of tier1 EF applied for heavy metals and POPs exhaust-emissions

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	B[a]P	B[b]F	B[k]F	I[1,2,3-c,d]p	PAH 1-4	PCDD/F
	[g/TJ]									[mg/TJ]					[µg/km]
Diesel oil	0.012	0.001	0.123	0.002	0.198	0.133	0.005	0.002	0.419	498	521	275	493	1.788	

Biodiesel[1]	0.013	0.001	0.142	0.003	0.228	0.153	0.005	0.003	0.483	575	601	317	569	2.062	
Gasoline fuels	0.037	0.005	0.200	0.007	0.145	0.103	0.053	0.005	0.758	96	140	69	158	464	
CNG[2] **& biogas**[3]	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
LPG[4]	NE	NE	NE	NE	NE	NE	NE	NE	NE	4.35	0.00	4.35	4.35	13.0	
all fuels															0.000006

[1] values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel
[2] no specific default available from [7]; value derived from CNG powered busses
[3] no specific default available from [8]; values available for CNG also applied for biogas
[4] no specific default available from [9]; value derived from LPG powered passenger cars

Discussion of emission trends

Table 4: Outcome of Key Category Analysis

for:	**NO_x**	**NMVOC**	**$PM_{2.5}$**	**PM_{10}**	**BC**	**CO**	**Pb**
by:	Level / Trend	L/T	L/T	L/T	L/T	L/T	L/T

Non-methane volatile organic compounds, nitrogen oxides, and carbon monoxide

Since 1990, exhaust emissions of **nitrogen oxides**, **NMVOC**, and **carbon monoxide** have decreased sharply due to catalytic-converter use and engine improvements resulting from ongoing tightening of emissions laws and improved fuel quality.

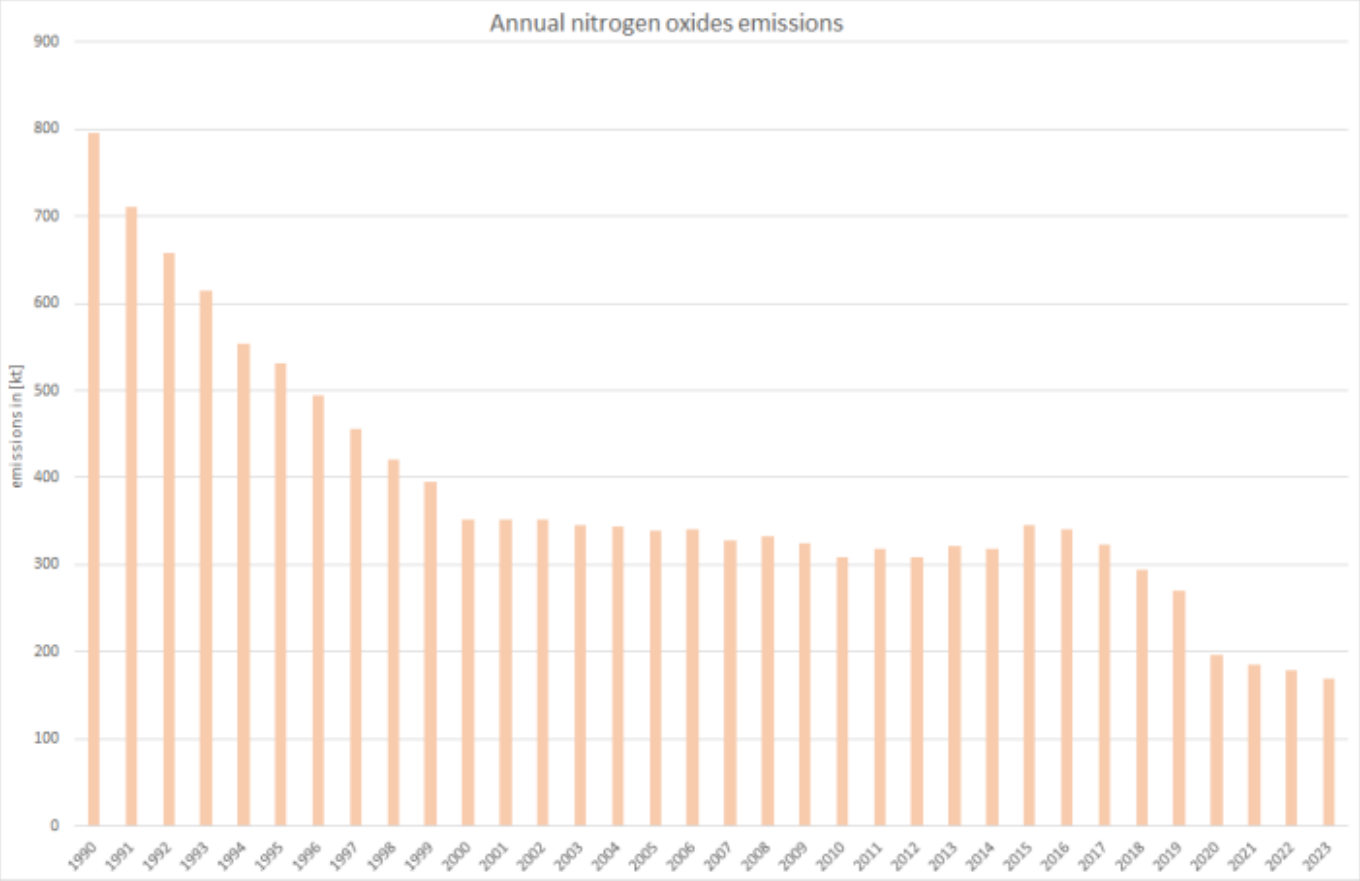
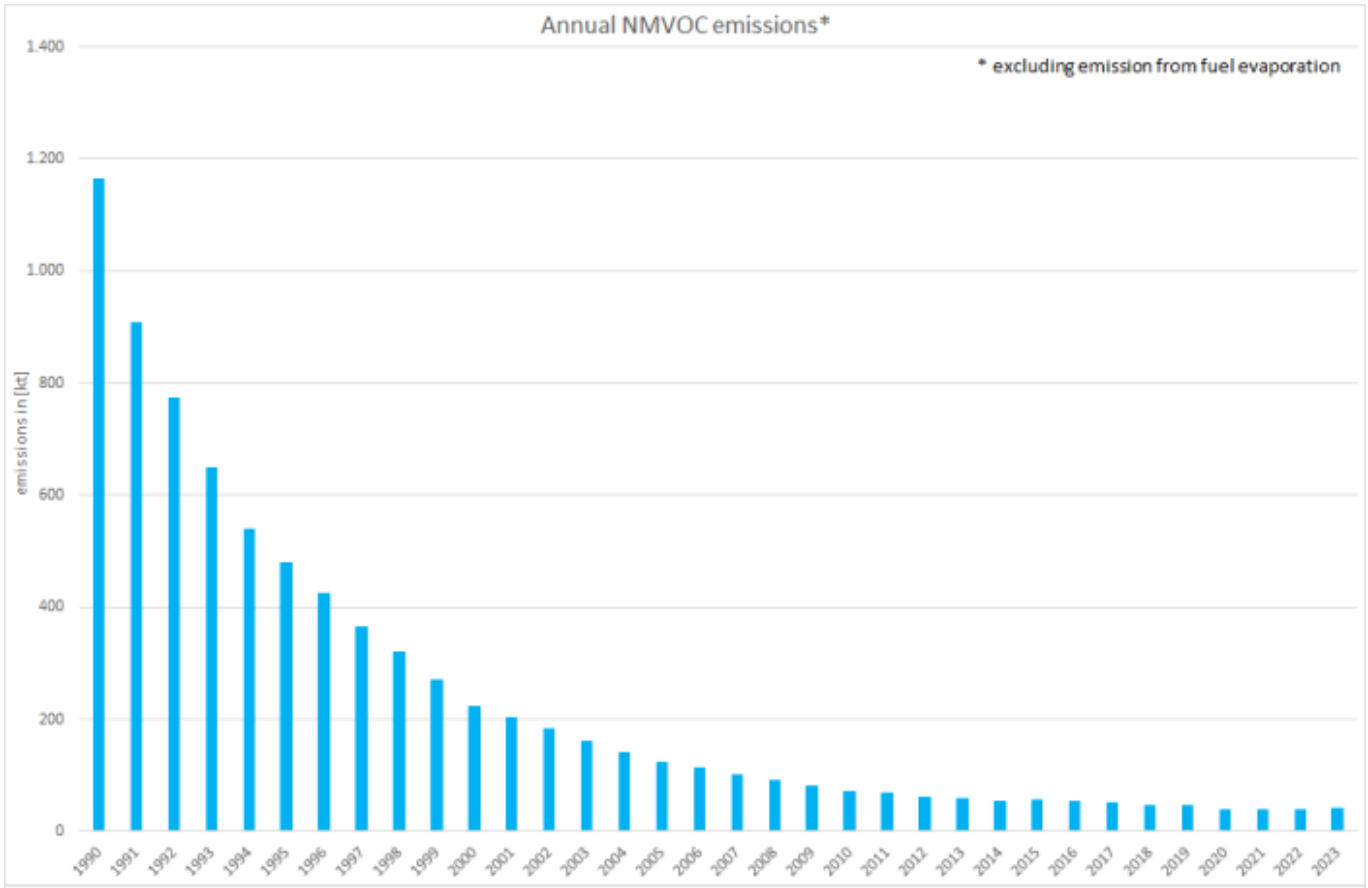


Table 5: EURO norms and their effect on limit values of NO_x emissions from passenger cars, in [mg/km]

exhaust emission standard (EURO norm)	**Euro 1**	**Euro 2**	**Euro 3**	**Euro 4**	**Euro 5**	**Euro 6a/b**	**Euro 6c**	**Euro 6d**
Diesel	-	-	500	250	180	80		

Gasoline	-	-	150	80	60	60



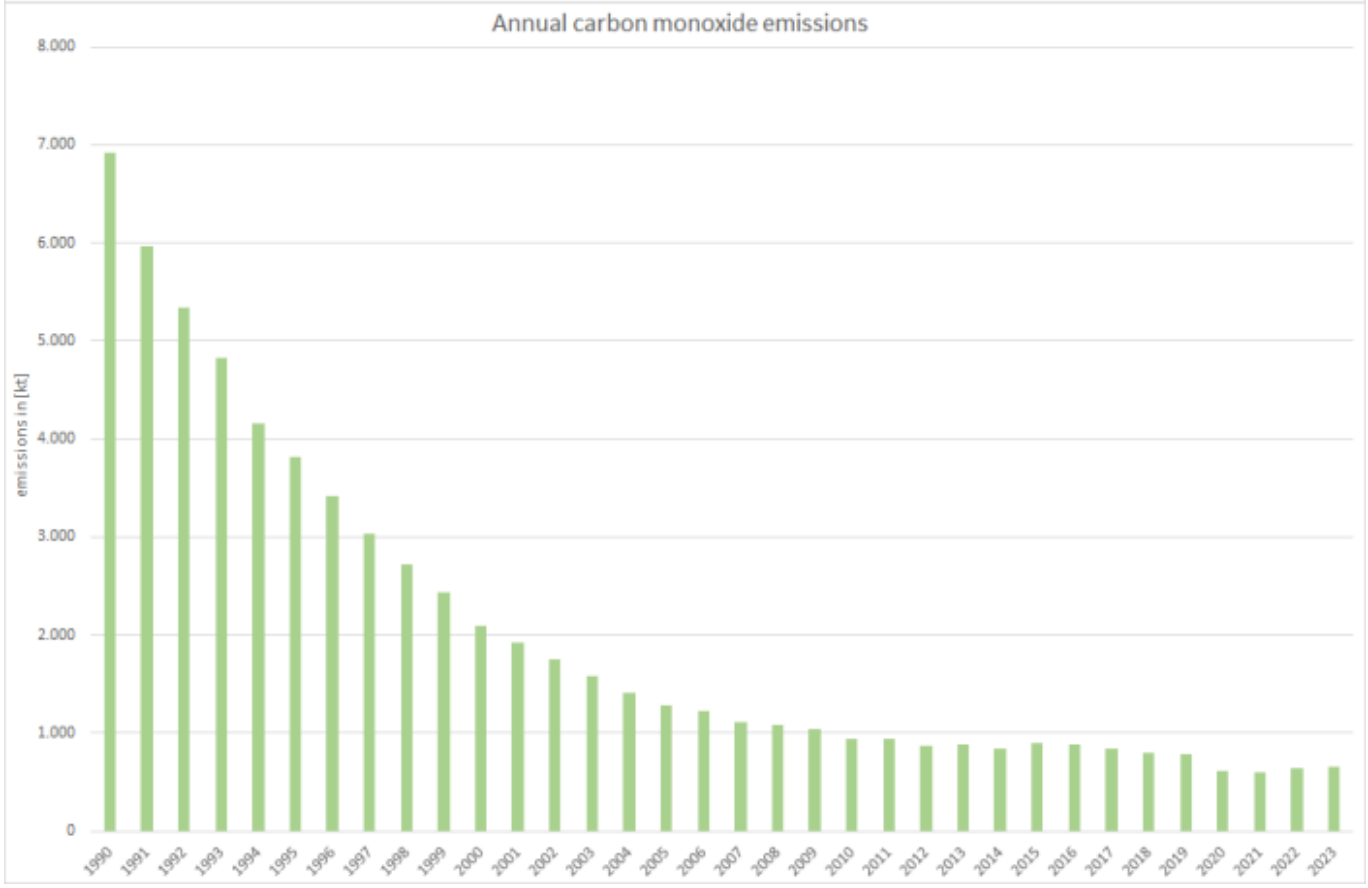


Table 6: EURO norms and their effect on limit values of CO emissions from passenger cars, in [mg/km]

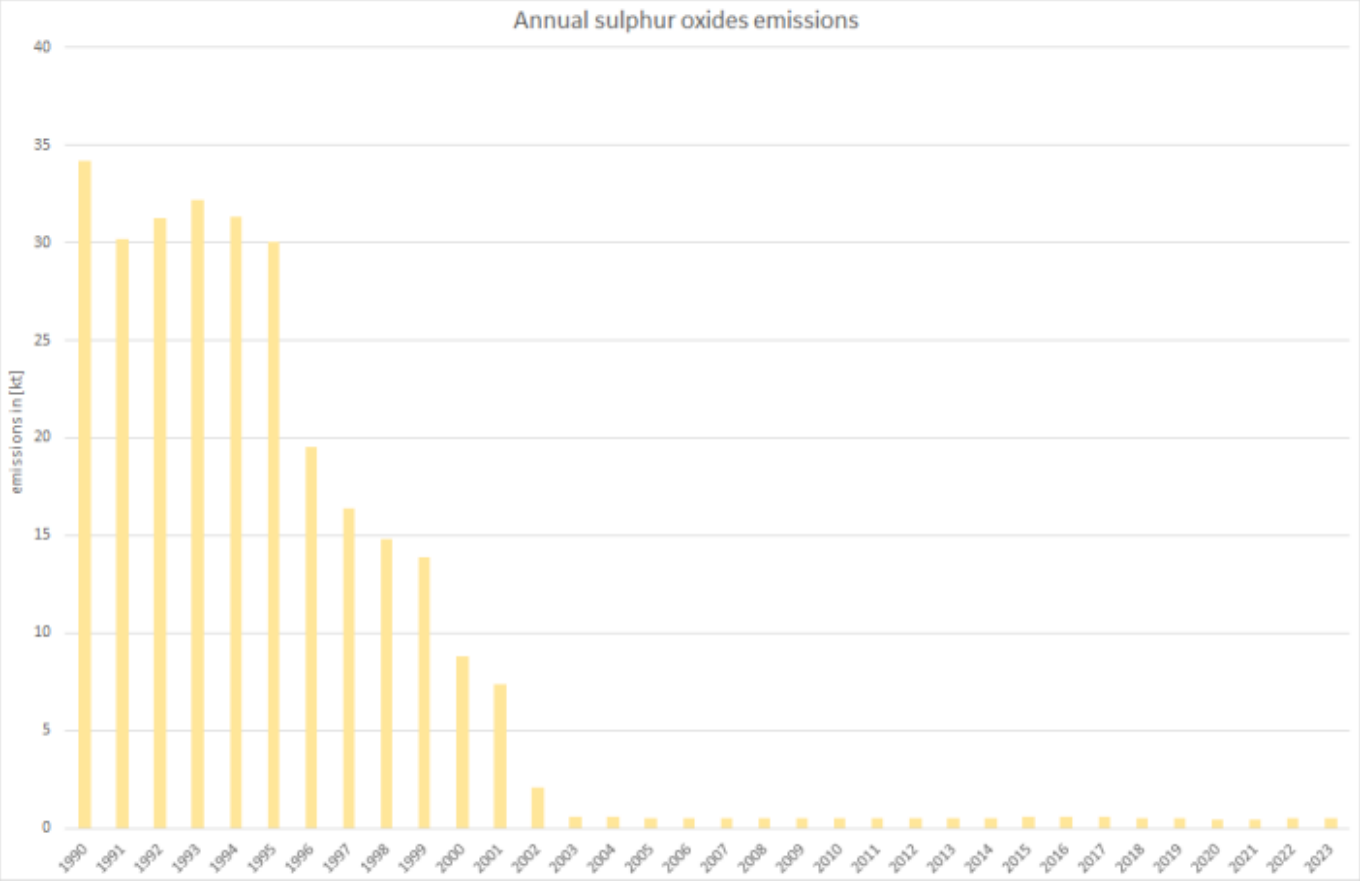
exhaust emission standard (EURO norm)	**Euro 1**	**Euro 2**	**Euro 3**	**Euro 4**	**Euro 5**	**Euro 6a/b**	**Euro 6c**	**Euro 6d**

Diesel	2,720 / 3,160	1,000	640	500	500	500
Gasoline	2,720 / 3,160	2,200	2,300	1,000	1,000	1,000

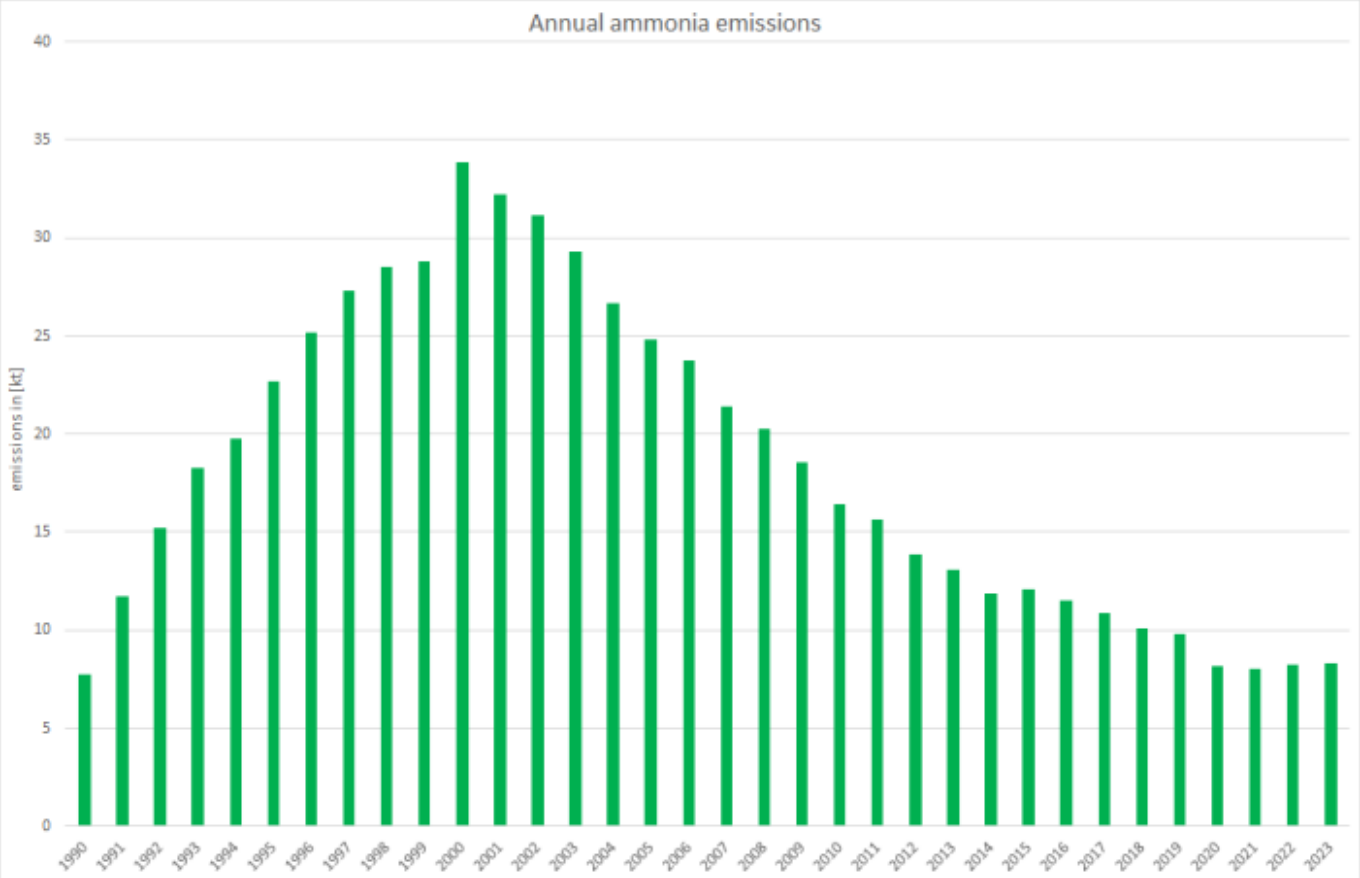
Ammonia and sulphur dioxide

As for the entire road transport sector, the trends for **sulphur dioxide** and **ammonia** exhaust emissions from passenger cars show charcteristics very different from those shown above.

Here, the strong dependence on increasing fuel qualities (sulphur content) leads to an cascaded downward trend of emissions , influenced only slightly by increases in fuel consumption and mileage.



For **ammonia** emissions, the increasing use of catalytic converters in gasoline driven cars in the 1990s lead to a steep increase whereas both the technical development of the converters and the ongoing shift from gasoline to diesel cars resulted in decreasing emissions in the following years.



Particulate matter & Black carbon

(from fuel combustion only; no wear/abrasion included)

Starting in the middle of the 1990s, a so-called “diesel boom” began, leading to a switch from gasoline to diesel powered passenger cars. As the newly registered diesel cars had to meet the EURO2 standard (in force since 1996/'97) with a PM limit value less than half the EURO1 value, the growing diesel consumption was overcompensated qickly by the mitigation technologies implemented due to the new EURO norm. During the following years, new EURO norms came into force. With the still ongoing “diesel boom” those norms led to a stabilisation (EURO3, 2000/'01) of emissions and to another strong decrease of PM emissions (EURO4, 2005/'06), respectively. Over-all, the increased consumption of diesel in passenger cars was overastimated by the implemented mitigation technologies. The table below shows the evolution of the limit value for particle emissions from passenger cars with diesel engines.

With this submission, Black Carbon (BC) emissions are reported for the first time. Here, EF are estimated based on as fractions of PM as provided in [10)]. Due to this fuel-specific fractions, the trend of BC emissions reflects the ongoing shift from gasoline to diesel (“dieselisation”).

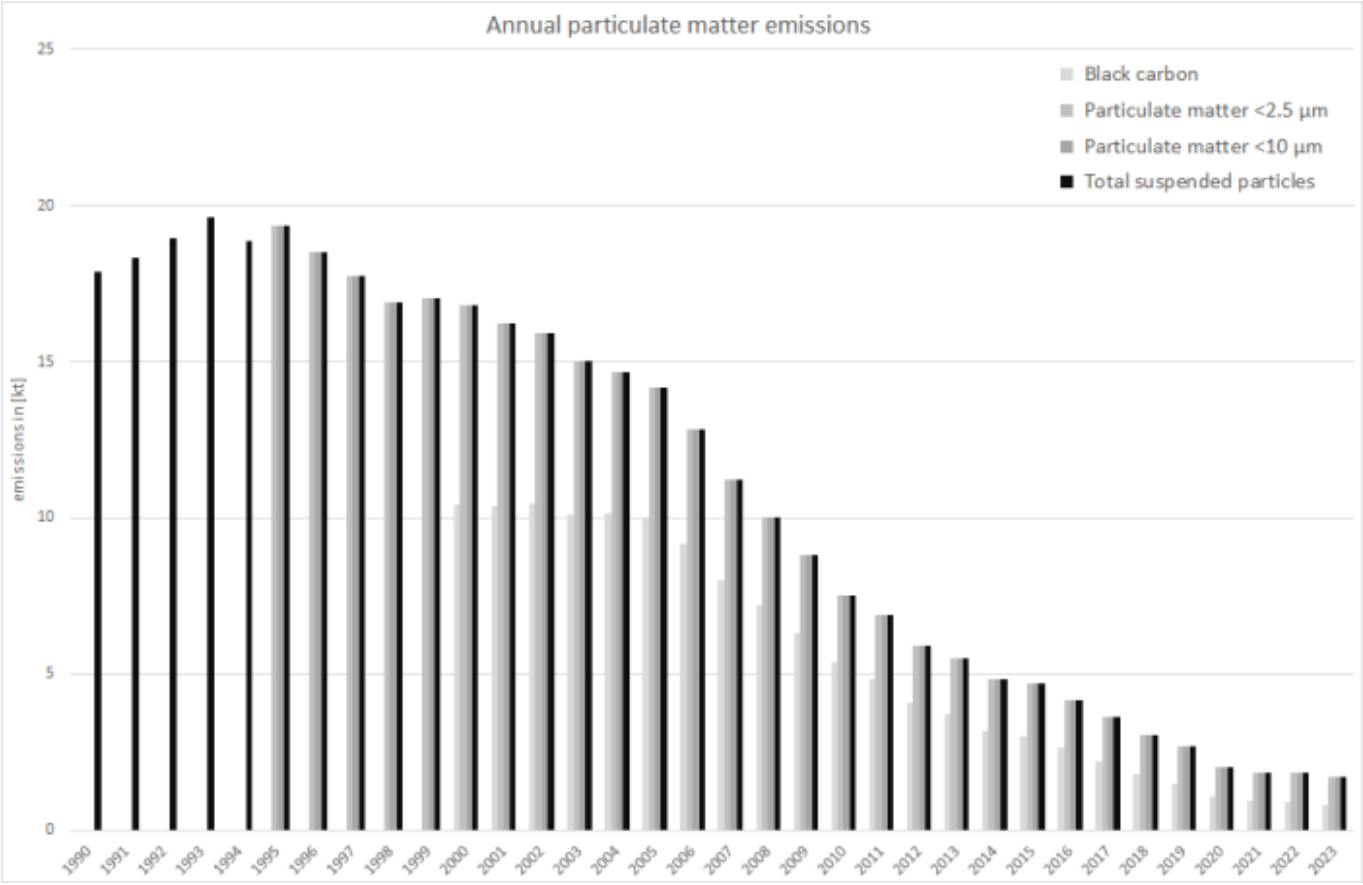


Table 7: EURO norms and their effect on limit values of PM emissions from passenger cars

exhaust emission standard (EURO norm)	**Euro 1**	**Euro 2**	**Euro 3**	**Euro 4**	**Euro 5**	**Euro 6a/b**	**Euro 6c**	**Euro 6d**
limit values in [mg/km]								
Diesel	**180**	**80/100**[1]	**50**	**25**	**4.5**	**4.5**		
Gasoline	-	-	-	-	**4.5**	**4.5**		
limit values in [number of particles]								
Diesel	-	-	-	-	6×10^{11}			
Gasoline	-	-	-	-	-	6×10^{11}		

[1] for direct injection engines

Recalculations

Compared to submission 2024, recalculations result mainly from a revision of the underlying National Energy Balance (NEB) for 2022 and the routine revision of the underlying TREMOD model affecting the years 2021 and 2022.

Table 8: Revised fuel consumption data, in terajoules

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**	**2022**
DIESEL OIL									
current Submission	266,175	321,615	348,554	459,150	493,060	644,577	520,027	528,230	550,835
previous Submission	266,175	321,615	348,554	459,150	493,060	644,577	520,027	527,812	550,366
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	418	469
relative change	0.00%	0.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.08%	0.09%
BIODIESEL									
current Submission		502	3,861	32,012	38,566	35,806	42,535	37,042	38,213
previous Submission		502	3,861	32,012	38,566	35,806	42,535	37,012	38,246
absolute change		0.00	0.00	0.00	0.00	0.00	0.00	29.3	-33.0
relative change		0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	0.08%	-0.09%

	1990	1995	2000	2005	2010	2015	2020	2021	2022
GASOLINE									
current Submission	1,273,347	1,258,708	1,194,743	948,080	755,474	733,505	613,047	613,541	644,312
previous Submission	1,273,347	1,258,708	1,194,743	948,080	755,474	733,505	613,047	613,111	643,769
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	430	543
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.07%	0.08%
BIOGASOLINE									
Submission 2023				6,572	29,348	29,608	27,485	28,909	29,862
Submission 2022				6,572	29,348	29,608	27,485	28,889	29,836
absolute change				0.00	0.00	0.00	0.00	20.2	25.2
relative change				0.00%	0.00%	0.00%	0.00%	0.07%	0.08%
LPG (LIQUEFIED PETROLEUM GAS)									
current Submission	138	138	94.0	2,369	22,982	18,709	10,213	10,138	11,761
previous Submission	138	138	94.0	2,369	22,982	18,709	10,213	10,138	11,796
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-34.9
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.30%
NATURAL GAS									
current Submission				1,628	5,213	2,729	1,151	2,045	1,855
previous Submission				1,628	5,213	2,729	1,151	1,037	746
absolute change				0.00	0.00	0.00	0.00	1.008	1.109
relative change				0.00%	0.00%	0.00%	0.00%	97.2%	148.7%
BIOMETHANE									
current Submission					166	738	1,271	994	914
previous Submission					166	738	1,271	981	914
absolute change					0.00	0.00	0.00	13.0	0.88
relative change					0.00%	0.00%	0.00%	1.33%	0.10%
TOTAL FUEL CONSUMPTION OF PASSENGER CARS									
current Submission	1,539,661	1,580,963	1,547,252	1,449,811	1,344,808	1,465,835	1,217,847	1,225,841	1,287,120
previous Submission	1,539,661	1,580,963	1,547,252	1,449,811	1,344,808	1,465,835	1,217,847	1,223,828	1,285,067
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.013	2.052
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.16%	0.16%

Due to the variety of tier3 **emission factors** applied, it is not possible to display any changes in these data sets in a comprehendible way.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

[1), 4)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2024.

[2)] Keller et al. (2019): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8_HBEFA41_Development_Report.pdf - Dokumentation, Bern, 2019.

[3)] Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook

Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf - Dokumentation, Bern, 2022.

[5)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/@@download/file; Table 3-82: Heavy metal emission factors for all vehicle categories in ppm/wt fuel; Copenhagen, 2023.

[6)] Rentz et al. (2008): Otto Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung, Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte 01/2008, http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer; Dessau-Roßlau, 2008

[7)], [8)], [9)], [10)] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook 2019; https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/view; Copenhagen, 2019.

[3)] During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.A3.b ii - Transport: Road Transport: Light Duty Vehicles

Short description

In sub-category *1.A.3.b ii - Road Transport: Light Duty Vehicles* emissions from fuel combustion in Light Duty Vehicles (LDVs) are reported.

Category Code	Method	AD	EF
1.A.3.b ii	T1, T3	NS, M	CS, M, D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
L/-	-/-	-/-	-/-	**L/T**	**L/T**	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

Specific consumption data for light-duty vehicles (LDV) are generated within TREMOD [1)]. - The following table provides an overview of annual amounts of fuels consumed by LDV in Germany.

Table 1: Annual fuel consumption of light duty vehicles, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel oil	32,966	88,993	123,189	119,188	112,451	140,613	147,686	151,176	150,871	154,885	142,818	153,829	159,891	157,548
Gasoline	34,782	21,433	18,095	10,969	6,811	6,545	6,627	6,729	6,934	7,465	7,194	7,718	8,104	8,126
Naural Gas				355	1,225	704	620	409	475	304	276	493	427	339
Biodiesel		139	1,365	8,310	8,796	7,811	8,005	8,240	8,513	8,786	11,682	10,787	11,092	11,677
Biogasoline				76.0	265	264	271	275	300	308	323	364	376	384
Biomethane					38.9	190	211	249	210	304	304	240	211	257
Σ 1.A.3.b ii	**67,748**	**110,566**	**142,649**	**138,898**	**129,587**	**156,127**	**163,420**	**167,077**	**167,302**	**172,050**	**162,596**	**173,431**	**180,100**	**178,330**

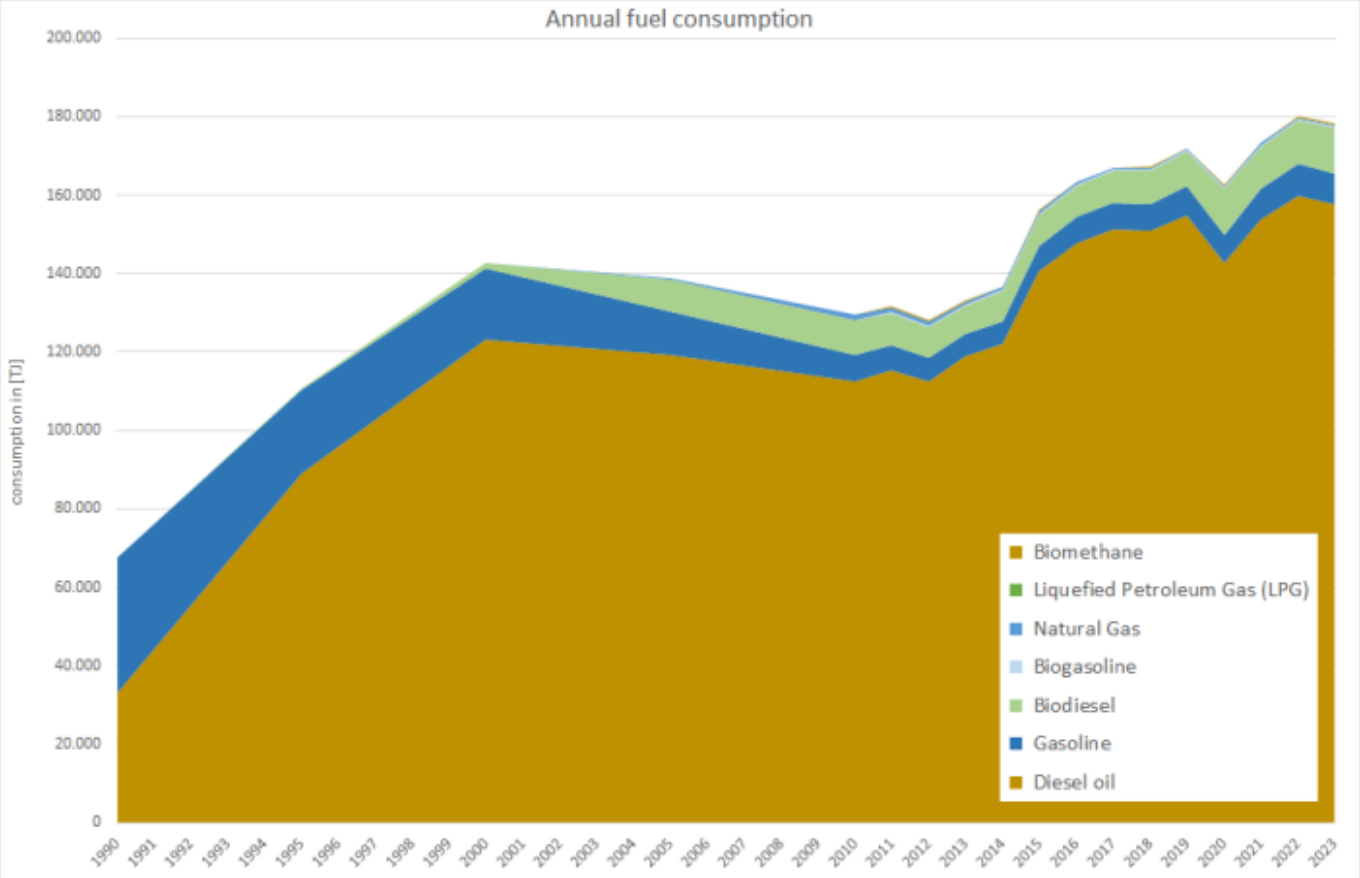
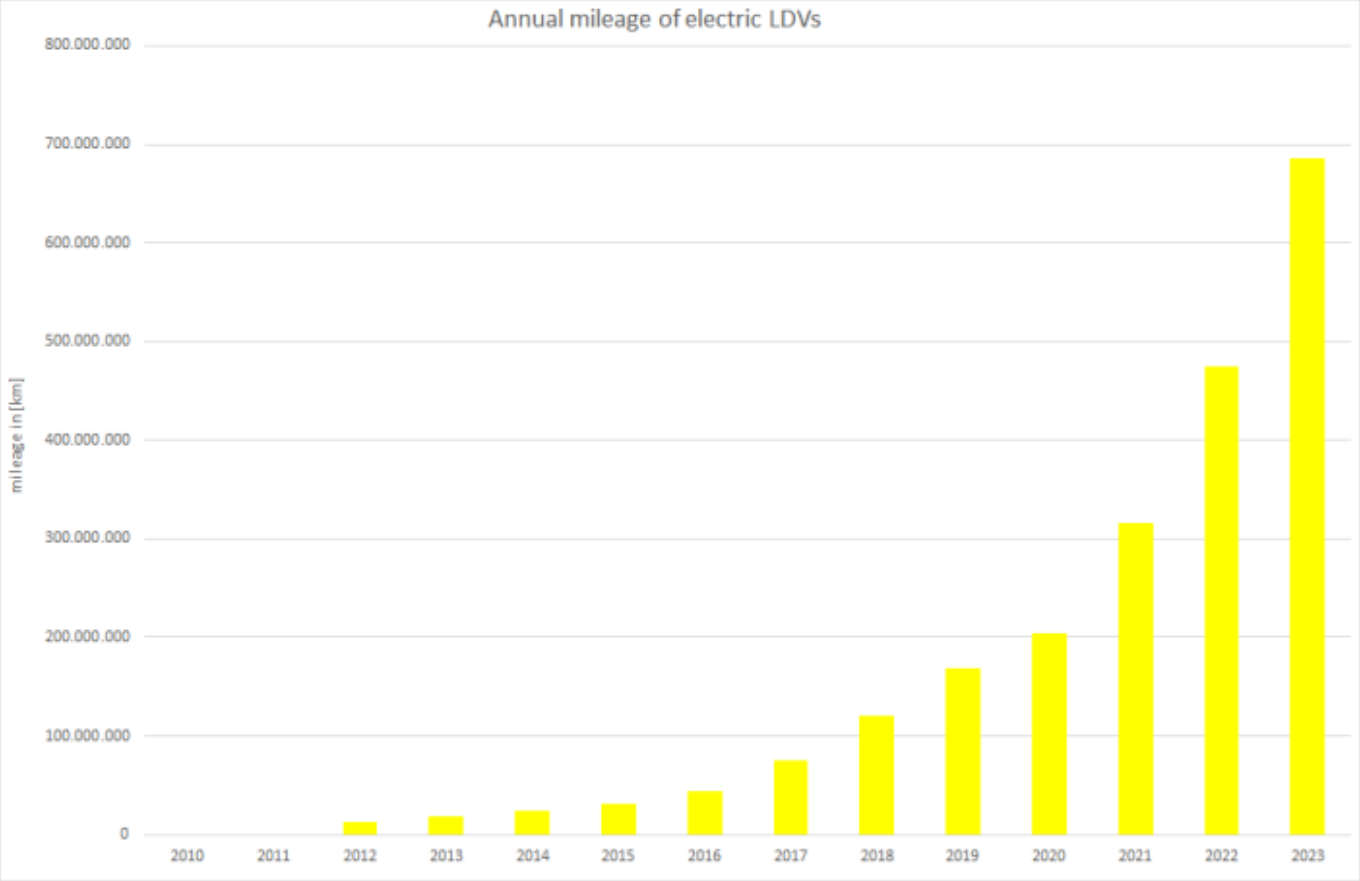


Table 2: Annual mileage of electric light-duty vehicles, as of 2012, in [km]

2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
0	0	13,145,691	19,091,888	24,469,124	30,645,631	43,567,136	75,361,445	120,918,164	168,589,517	203,898,902	316,336,637	475,057,402	685,881,192



For further information on mileage and abrasion-related emissions, please refer to sub-chapters on emissions from tyre & brake wear and road abrasion.

Emission factors

The majority of emission factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, versions 4.1 and 4.2) [2)],[3)] where they are provided on a tier3 level mostly and processed within TREMOD [4)].

However, it is not possible to present these highly specific tier3 values here in a comprehendible way .

With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [4)]

For heavy-metal (other then lead from leaded gasoline) and PAH exhaust-emissions, default emission factors from the 2023 EMEP/EEA Guidebook (EMEP/EEA, 2023), Table 3-86 have been applied [5)] (see super-ordinate chapter here).

Regarding PCDD/F, tier1 EF from (Rentz et al., 2008) [6)] are used instead.

The following table provides an overview of the EF. Please note, that the values for heavy-metal (in [g/TJ]) and PAH (in [mg/TJ]) exhaust-emissions have been estimated from the EMEP/EEA defaults provided in [ppm/wt].

Table 3: Overview of tier1 EF applied for heavy metals and POPs exhaust-emissions

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	B[a]P	B[b]F	B[k]F	I[1,2,3-c,d]p	PAH 1-4	PCDD/F
	[g/TJ]									[mg/TJ]					[µg/km]
Diesel oil	0.012	0.001	0.123	0.002	0.198	0.133	0.005	0.002	0.419	498	521	275	493	1.788	

Biodiesel[1]	0.013	0.001	0.142	0.003	0.228	0.153	0.005	0.003	0.483	575	601	317	569	2.062	
Gasoline fuels	0.037	0.005	0.200	0.007	0.145	0.103	0.053	0.005	0.758	96	140	69	158	464	
CNG[2] **& biogas**[3]	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
LPG[4]	NE	NE	NE	NE	NE	NE	NE	NE	NE	4.35	0.00	4.35	4.35	13.0	
all fuels															0.000006

[1] values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel
[2] no specific default available from [7]; value derived from CNG powered busses
[3] no specific default available from [8]; values available for CNG also applied for biogas
[4] no specific default available from [9]; value derived from LPG powered passenger cars

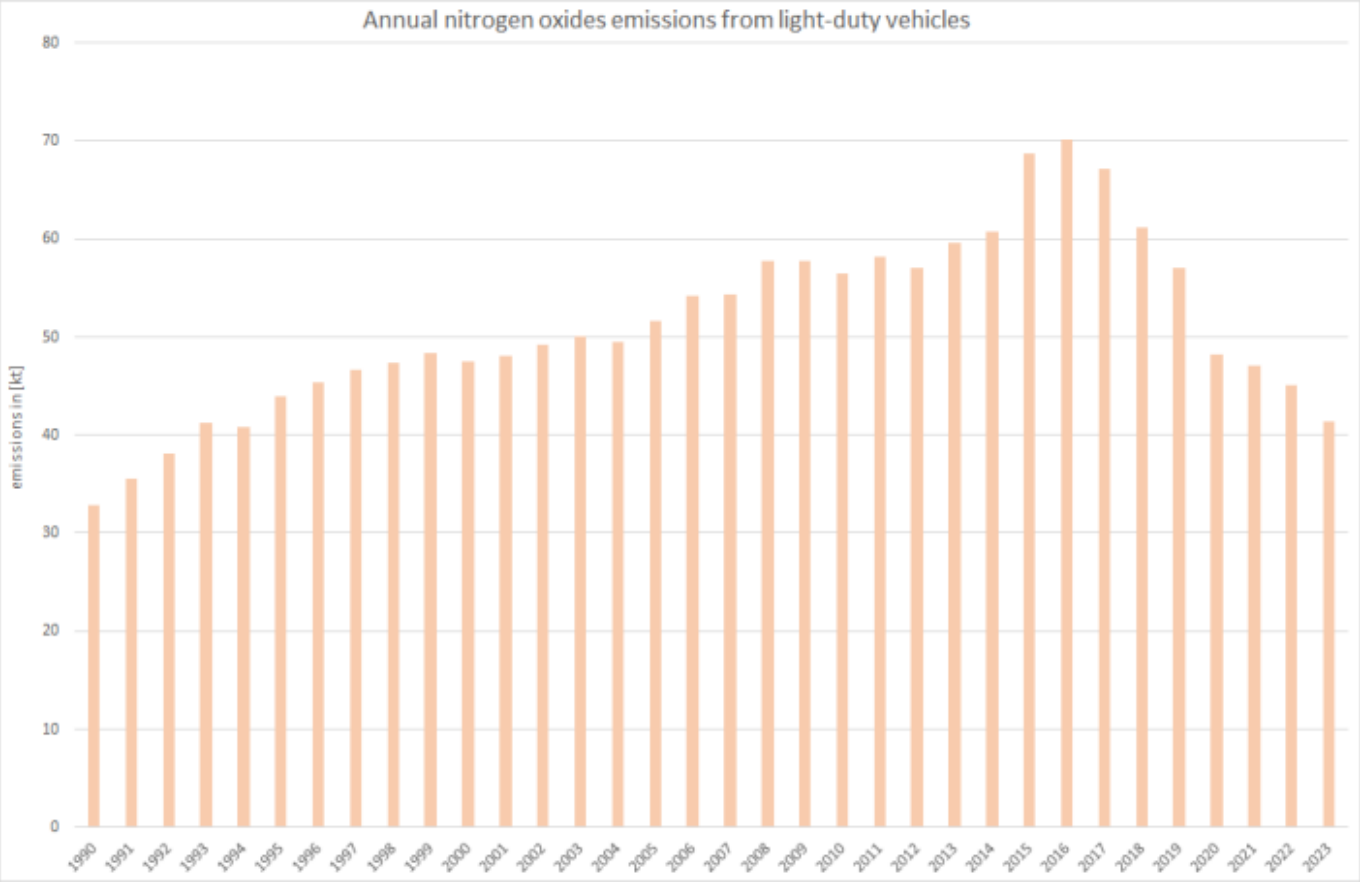
Discussion of emission trends

Table 4: Outcome of Key Category Analysis

for:	**NO_x**	**$PM_{2.5}$**	**PM_{10}**	**BC**
by:	Level /-	L/Trend	L/T	L/T

Nitrogen oxides

NO_x emissions increased steadily until 2002 following the shift to diesel engines. During the last ten years, emissions decline steadily due to catalytic-converter use and engine improvements resulting from ongoing tightening of emissions laws and improved fuel quality.

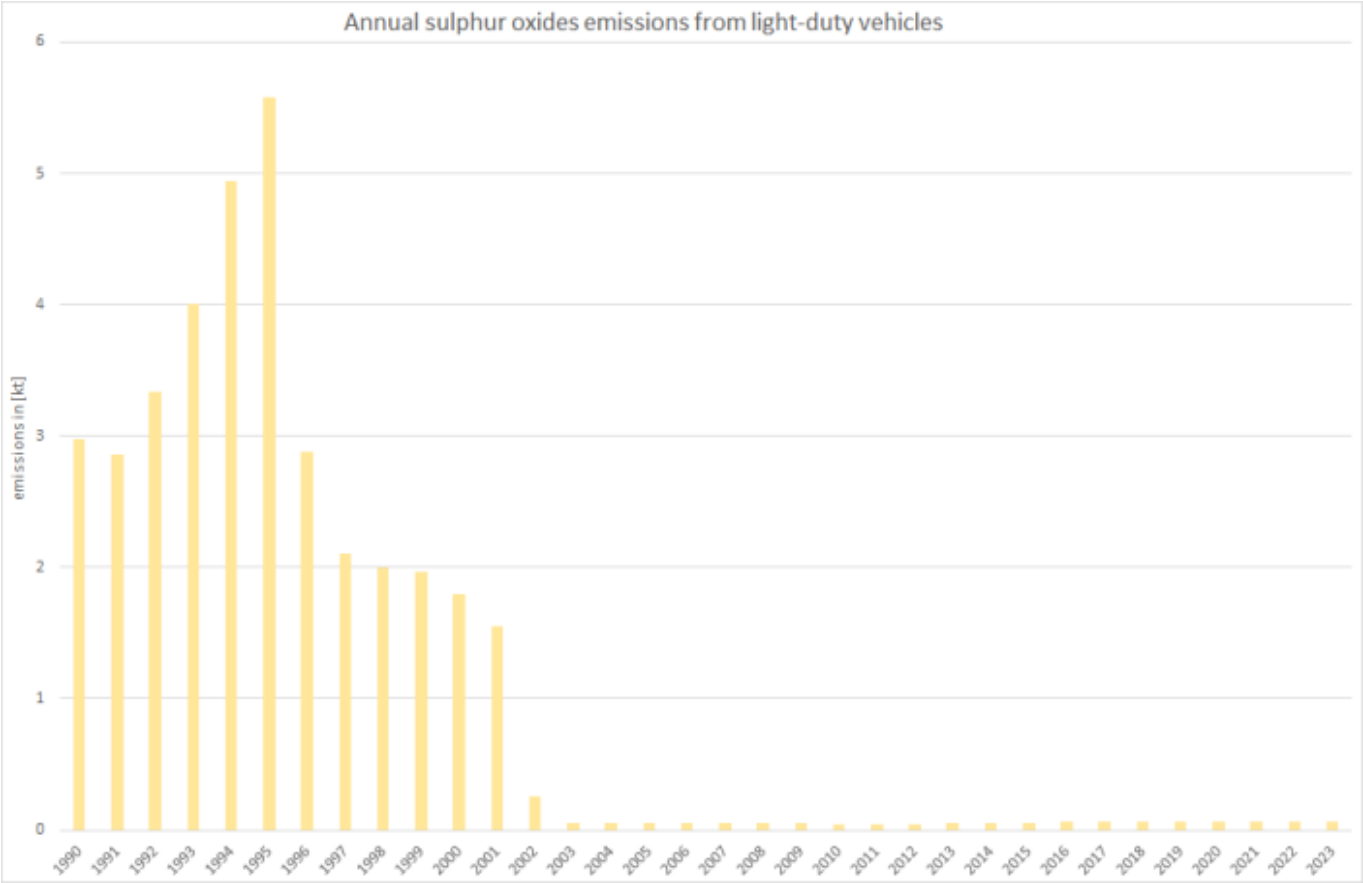


Ammonia and sulphur dioxide

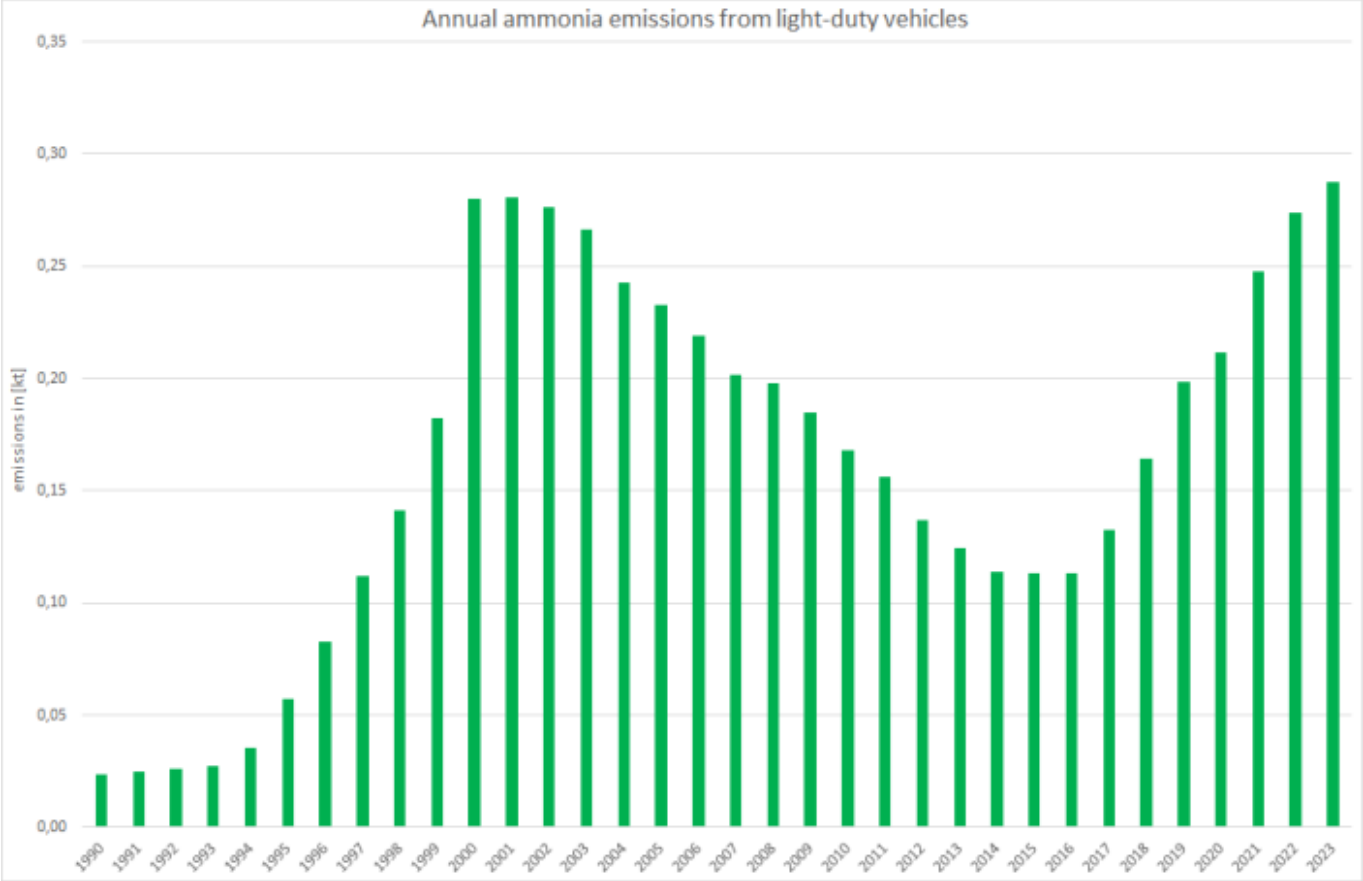
As for the entire road transport sector, the trends for **sulphur dioxide** and **ammonia** exhaust emissions from passenger

cars show charcteristics very different from those shown above.

Here, the strong dependence on increasing fuel qualities (sulphur content) leads to an cascaded downward trend of emissions, influenced only slightly by increases in fuel consumption and mileage.



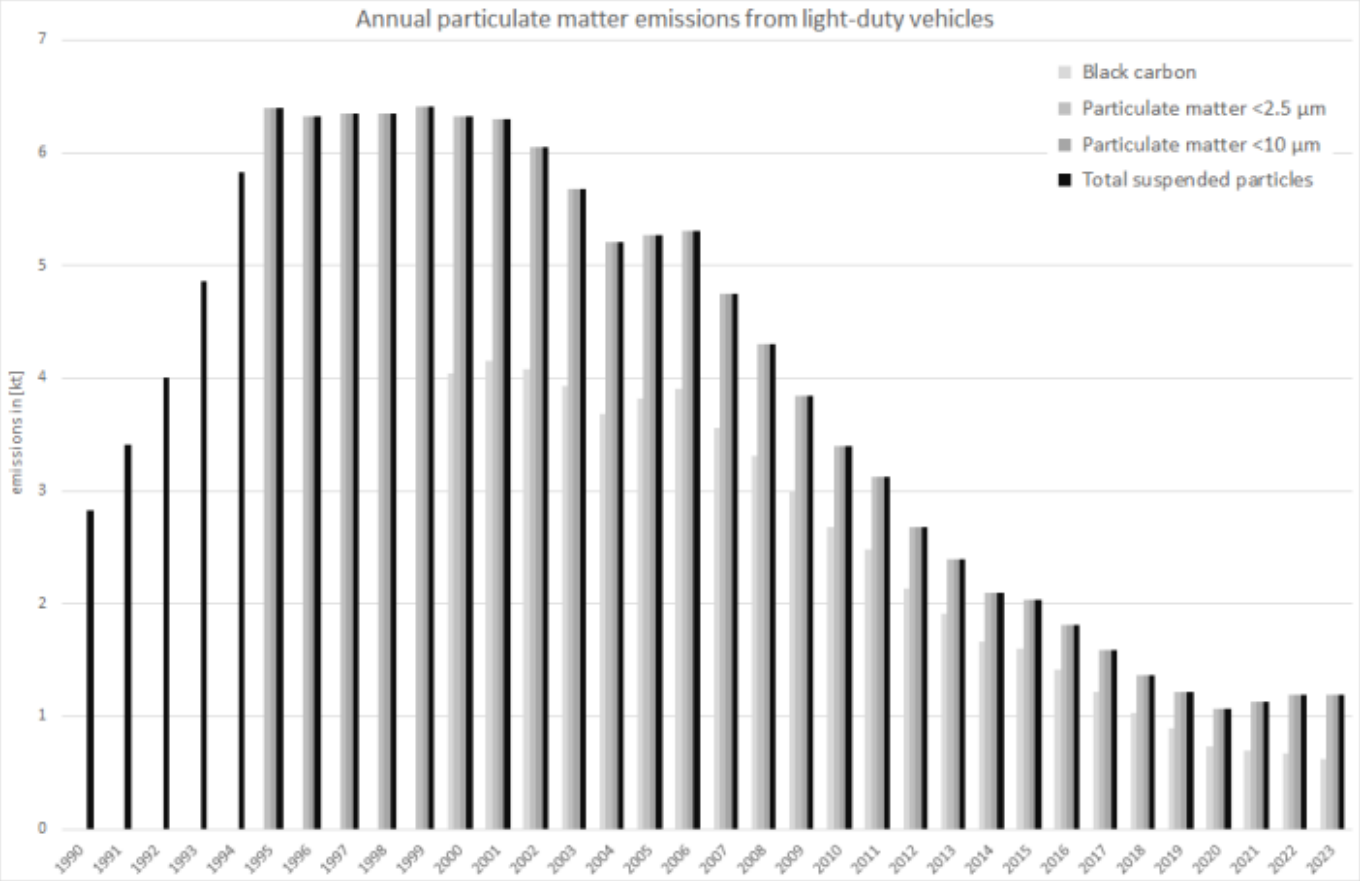
For **ammonia** emissions the increasing use of catalytic converters in gasoline driven cars in the 1990s lead to a steep increase whereas both the technical development of the converters and the ongoing shift from gasoline to diesel cars resulted in decreasing emissions in the following years.



Particulate matter & Black carbon

Starting in the middle of the 1990s, a so-called “diesel boom” began, leading to a switch from gasoline to diesel powered passenger cars. As the newly registered diesel cars had to meet the EURO2 standard (in force since 1996/'97) with a PM limit value less than half the EURO1 value, the growing diesel consumption was overcompensated qickly by the mitigation technologies implemented due to the new EURO norm. During the following years, new EURO norms came into force.

With the still ongoing “diesel boom” those norms led to a stabilisation (EURO3, 2000/'01) of emissions and to another strong decrease of PM emissions (EURO4, 2005/'06), respectively. Over-all, the increased consumption of diesel in passenger cars was over-estimated by the implemented mitigation technologies.



Recalculations

Compared to submission 2024, **activity data** have only been revised for 2022 and 2023.

Table 4: Revised fuel consumption data, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL OIL													
current submission	32,966	88,993	123,189	119,188	112,451	140,613	147,686	151,176	150,871	154,885	142,818	153,829	159,891
previous submission	32,966	88,993	123,189	119,188	112,451	140,613	147,686	151,176	150,871	154,885	142,818	156,557	162,678
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2,728	-2,787
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-1.74%	-1.71%
BIODIESEL													
current submission		139	1,365	8,310	8,796	7,811	8,005	8,240	8,513	8,786	11,682	10,787	11,092
previous submission		139	1,365	8,310	8,796	7,811	8,005	8,240	8,513	8,786	11,682	10,978	11,305
absolute change		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-191	-213
relative change		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-1.74%	-1.88%
GASOLINE													
current submission	34,782	21,433	18,095	10,969	6,811	6,545	6,627	6,729	6,934	7,465	7,194	7,718	8,104
previous submission	34,782	21,433	18,095	10,969	6,811	6,545	6,627	6,729	6,934	7,465	7,194	7,855	8,249
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-137	-145

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-1.74%	-1.76%
BIOGASOLINE													
current submission				76.0	265	264	271	275	300	308	323	364	376
previous submission				76.0	265	264	271	275	300	308	323	370	382
absolute change				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-6.45	-6.72
relative change				0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-1.74%	-1.76%
NATURAL GAS													
current submission				355	1,225	704	620	409	475	304	276	493	427
previous submission				355	1,225	704	620	409	475	304	276	255	175
absolute change				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	238	252
relative change				0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	93.6%	144%
BIOMETHANE													
current submission					38.9	190	211	249	210	304	304	240	211
previous submission					38.9	190	211	249	210	304	304	241	214
absolute change					0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1.26	-3.71
relative change					0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.52%	-1.73%
NFR 1.A.3.b ii TOTAL													
current submission	67,748	110,566	142,649	138,898	129,587	156,171	163,481	167,179	167,465	172,282	162,880	173,889	180,804
previous submission	67,748	110,566	142,649	138,898	129,587	156,171	163,481	167,179	167,465	172,282	162,880	176,714	183,721
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2,826	-2,917
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-1.60%	-1.59%

Due to the variety of tier3 **emission factors** applied, it is not possible to display any changes in these data sets in a comprehendible way.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

[1), 4)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2024.

[2)] Keller et al. (2019): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8_HBEFA41_Development_Report.pdf - Dokumentation, Bern, 2019.

[3)] Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf - Dokumentation, Bern, 2022.

[5)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/@@download/file; Table 3-82: Heavy metal emission factors for all vehicle categories in ppm/wt fuel; Copenhagen, 2023.

[6)] Rentz et al. (2008): Otto Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung, Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte 01/2008, http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer; Dessau-Roßlau, 2008

[7), 8), 9)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019; https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/view; Copenhagen, 2019.

[4)] During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.A.3.b iii - Transport: Road Transport: Heavy Duty Vehicles and Buses

Short description

In sub-category *1.A.3.b iii - Road Transport: Heavy Duty Vehicles and Buses* emissions from fuel combustion in trucks, lorries, buses etc. are reported.



Category Code	Method	AD	EF
1.A.3.b iii	T1, T3	NS, M	CS, M, D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
L/T	-/-	-/-	-/-	**L/T**	**L/T**	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

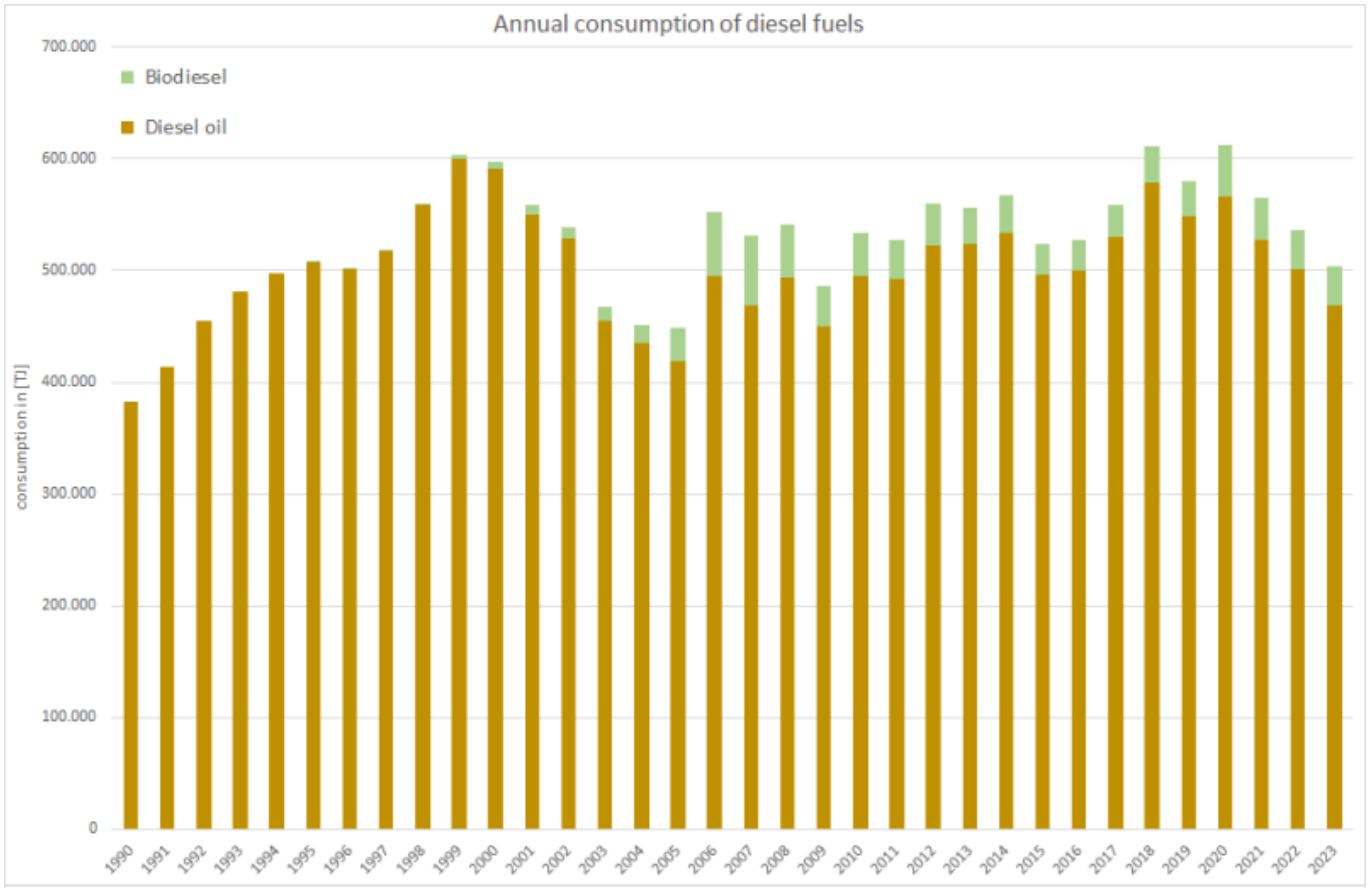
Activity data

Specific consumption data for heavy-duty vehicles (trucks and lorries) and buses are generated within TREMOD [1)]. - The following tables provide an overview of annual amounts of fuels consumed by these vehicles in Germany.

Table 1: Annual fuel consumption of trucks and lorries, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
thereof: Buses														
Diesel oil	54,436	46,012	45,864	34,647	42,817	43,298	44,344	45,118	48,219	46,769	32,612	31,700	35,743	37,238
Biodiesel		72	508	2,416	3,349	2,405	2,403	2,459	2,721	2,653	2,667	2,223	2,480	2,760
Natural Gas (CNG & LNG)				1,144	2,060	952	805	497	545	338	291	480	408	311
Biomethane					65.4	257	274	303	241	339	322	233	201	236
Petroleum		610	414											
Σ Buses	**54,436**	**46,694**	**46,786**	**38,206**	**48,291**	**46,913**	**47,827**	**48,378**	**51,726**	**50,099**	**35,892**	**34,636**	**38,832**	**40,545**
thereof: Trucks & Lorries														
Diesel oil	382,343	507,393	590,498	419,069	494,618	495,912	500,514	530,155	578,748	548,376	566,485	527,514	501,696	469,097
Biodiesel		792	6,542	29,218	38,688	27,548	27,129	28,898	32,655	31,106	46,335	36,992	34,804	34,767
Natural Gas (CNG & LNG)						210	177	135	217	421	1,163	4,127	5,059	4,663
Biomethane						56.8	60.1	82.1	96.2	421	1,284	2,007	2,495	3,533
Σ Trucks & Lorries	**382,343**	**508,185**	**597,040**	**448,287**	**533,306**	**523,727**	**527,879**	**559,270**	**611,717**	**580,324**	**615,267**	**570,639**	**544,053**	**512,060**
HDVs over-all														
Diesel oil	436,779	553,405	636,362	453,716	537,434	539,210	544,857	575,273	626,967	595,144	599,097	559,214	537,439	506,335
Biodiesel		863	7,050	31,633	42,037	29,953	29,532	31,357	35,376	33,759	49,002	39,215	37,283	37,527
Natural Gas (CNG & LNG)				1,144	2,060	1,162	982	632	763	760	1,454	4,607	5,468	4,974
Biomethane					65	314	334	385	337	760	1,606	2,240	2,696	3,769
Petroleum		610	414											
Σ 1.A.3.b iii	**436,779**	**554,878**	**643,825**	**486,493**	**581,597**	**570,639**	**575,706**	**607,647**	**663,443**	**630,423**	**651,159**	**605,275**	**582,886**	**552,605**

source: TREMOD [2)]



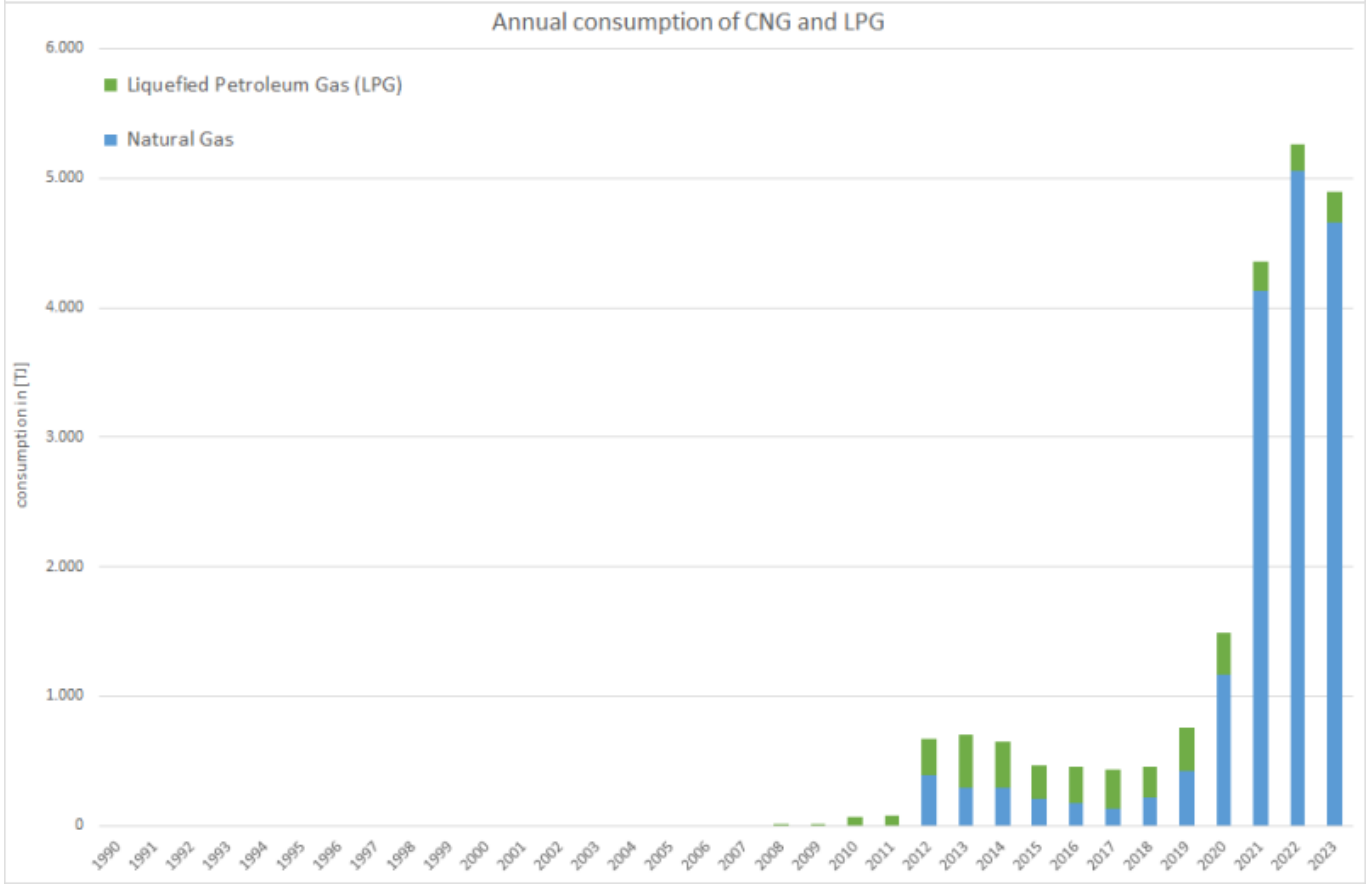
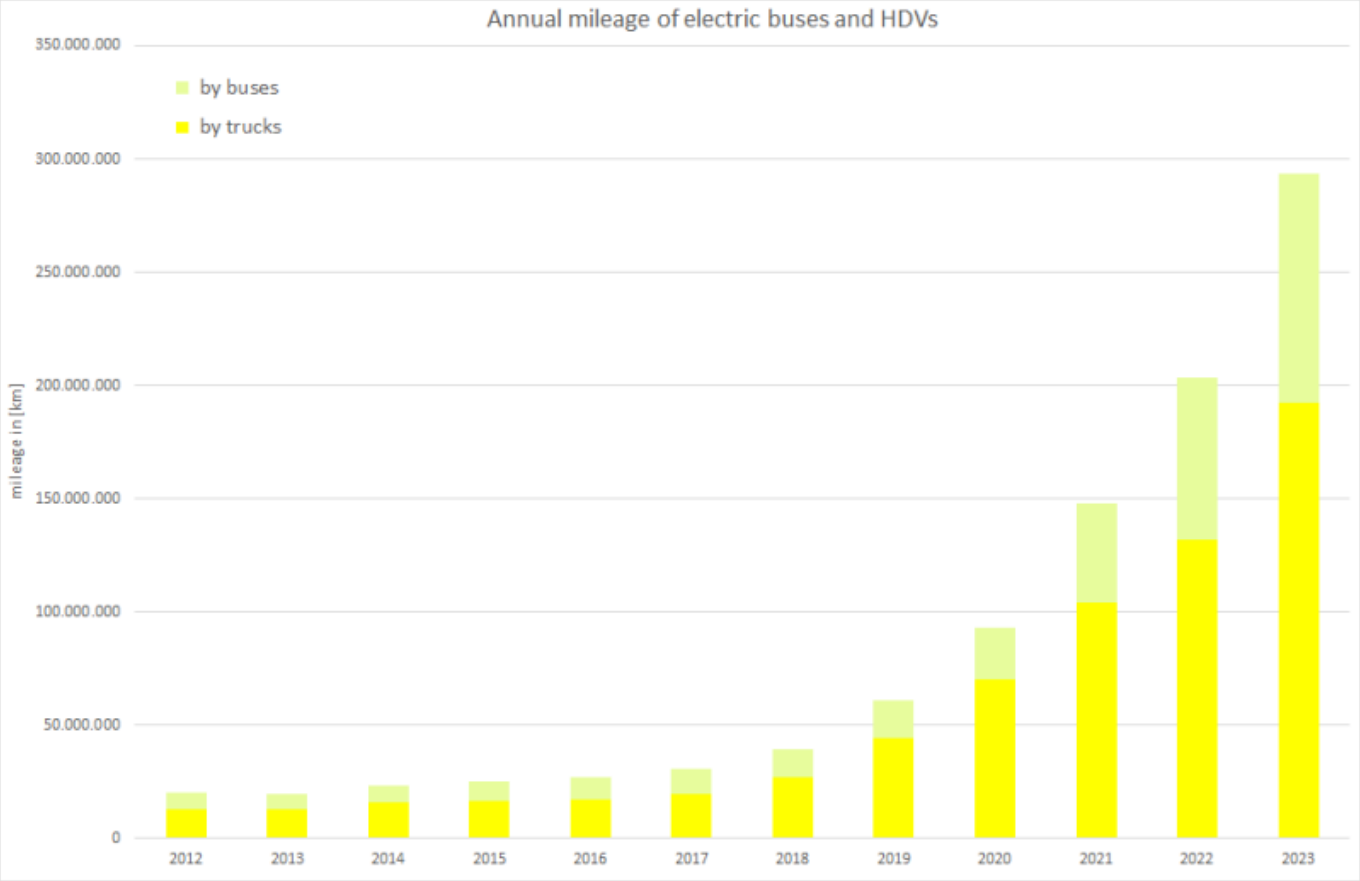


Table 2: Annual mileage of electric buses and trucks, as of 2012, in [km]

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
e-buses	8,487,329	9,845,760	10,876,484	12,152,006	16,751,955	22,652,366	44,265,774	73,852,059	17,202,225	18,705,389	46,436,326
e-trucks	16,622,028	17,425,009	19,612,927	26,890,851	44,461,550	70,219,861	103,916,921	132,048,817	53,621,255	53,399,717	78,383,254



For more information on mileage and abrasion-related emisisons, please refer to sub-chapters on emissions from tyre & brake wear and road abrasion.

Emission factors

The majority of emission factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, versions 4.1 and 4.2) [3], [4] where they are provided on a tier3 level mostly and processed within the TREMOD software used by the party [5].

However, it is not possible to present these tier3 values in a comprehendible way here.

With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [5]

For heavy-metal (other then lead from leaded gasoline) and PAH exhaust-emissions, default emission factors from the 2023 EMEP/EEA Guidebook (EMEP/EEA, 2023), Table 3-86 have been applied [6] (see super-ordinate chapter here).

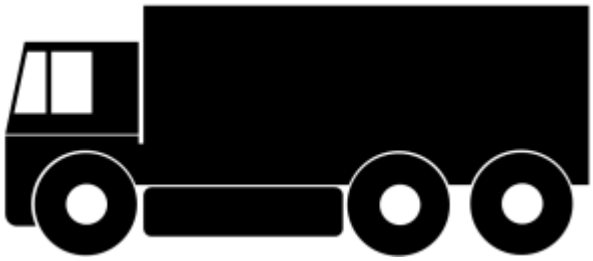
Regarding PCDD/F, tier1 EF from (Rentz et al., 2008) [7] are used instead.

The following table provides an overview of the EF. Please note, that the values for heavy-metal (in [g/TJ]) and PAH (in [mg/TJ]) exhaust-emissions have been estimated from the EMEP/EEA defaults provided in [ppm/wt].

Table 3: Overview of tier1 EF applied for heavy metals and POPs exhaust-emissions

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	B[a]P	B[b]F	B[k]F	I[...]P	PAH 1-4	PCDD/F
	[g/TJ]									[mg/TJ]					[µg/km]
Diesel oil	0.012	0.001	0.123	0.002	0.198	0.133	0.005	0.002	0.419	498	521	275	493	1,788	
Biodiesel	0.013	0.001	0.142	0.003	0.228	0.153	0.005	0.003	0.483	575	601	317	569	2,062	

CNG & Biogas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
Petroleum	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
all fuels: buses															0.000019
all fuels: trucks & lorries															0.000016



Discussion of emission trends

Table 4: Outcome of Key Category Analysis

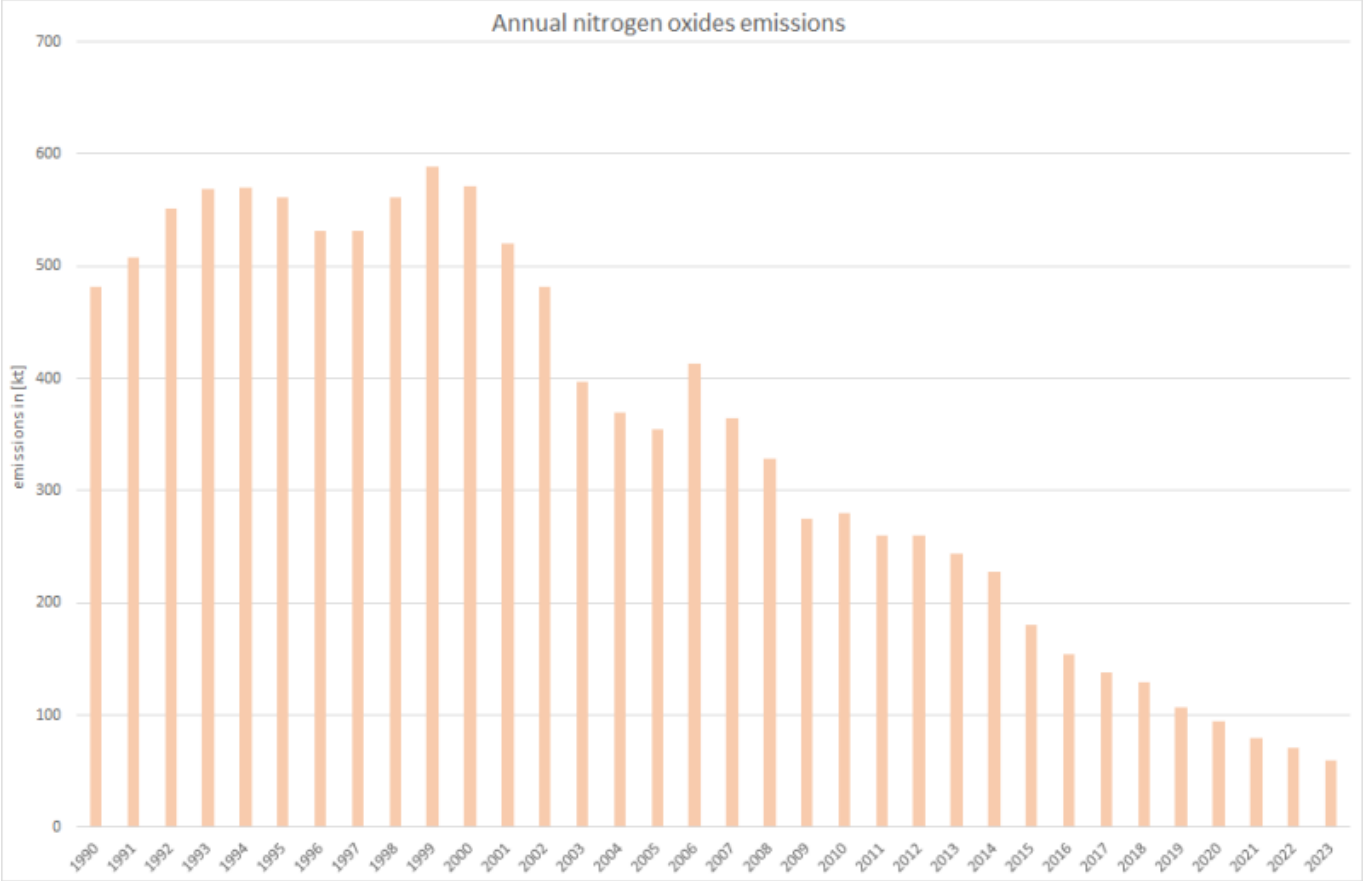
for:	**NO_x**	**$PM_{2.5}$**	**PM_{10}**	**BC**
by:	Level / Trend	L/T	L/T	L/T

Nitrogen oxides

Until 2005, NO_x emissions followed mileage and fuel consumption. Since 2006, in contrast to nearly unchanged fuel consumption, emissions have decreased due to controlled catalytic-converter use and engine improvements resulting from continual tightening of emissions laws.

Table 5: EURO norms and their effect on limit values of NO_x emissions from diesel heavy-duty vehicles, in [g/kWh]

pre-Euro	**Euro I**	**Euro II**	**Euro III**	**Euro IV**	**Euro V**	**Euro VI**[8)9)]
14.4	8 / 9	7	5	3.5	2	0.4 / 0.46

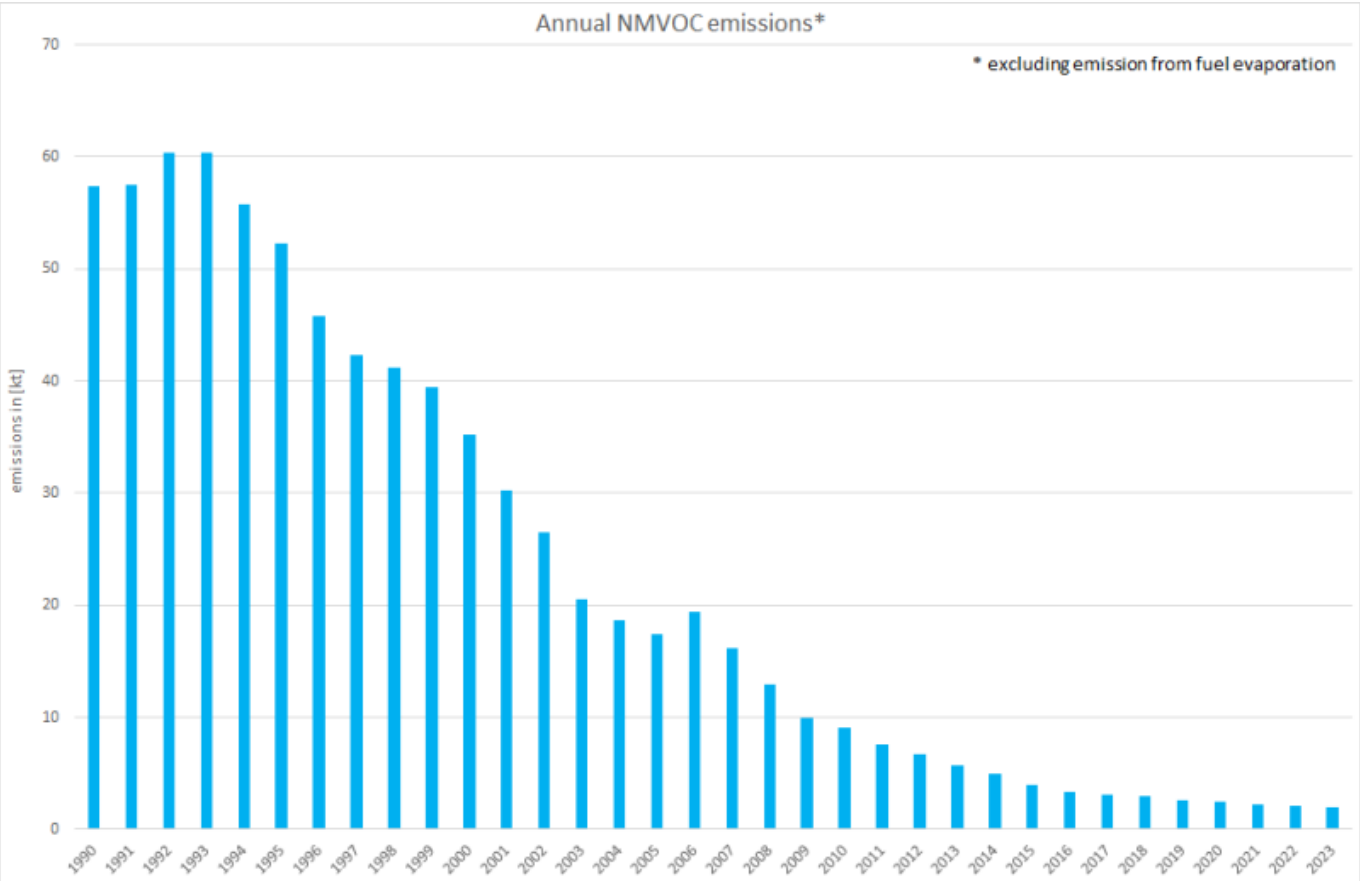


Non-methane volatile organic compounds (NMVOC) and carbon monoxide

Since 1990, exhaust emissions of **NMVOC** and **carbon monoxide** have decreased sharply due to catalytic-converter use and engine improvements resulting from ongoing tightening of emissions laws and improved fuel quality.

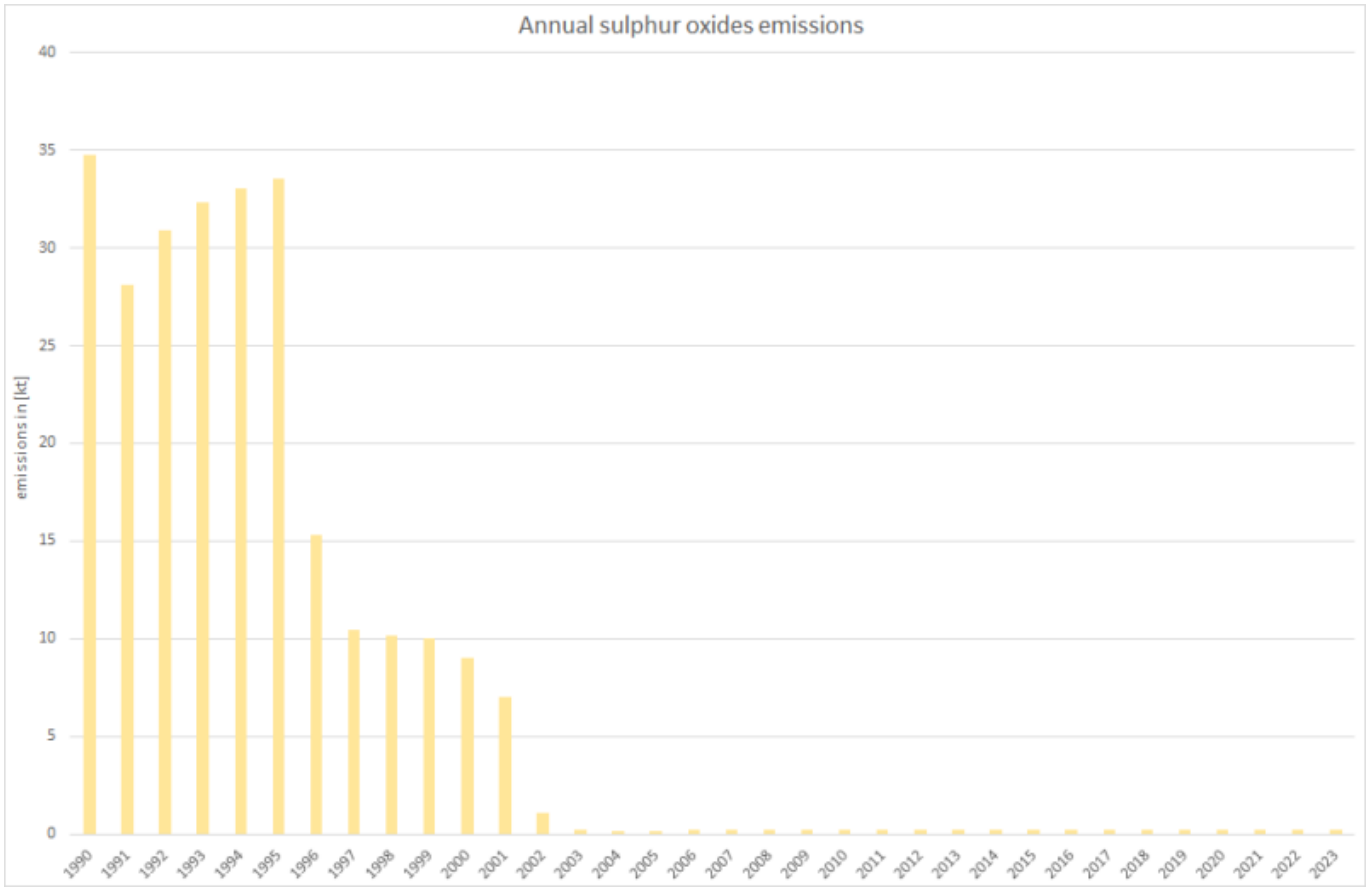
Table 6: EURO norms and their effect on limit values of CO emissions from diesel heavy-duty vehicles, in [g/kWh]

pre-Euro	Euro I	Euro II	Euro III	Euro IV	Euro V	Euro VI[10)]
11.2	4.5 / 4.9	4	2.1	1.5	1.5	1.5



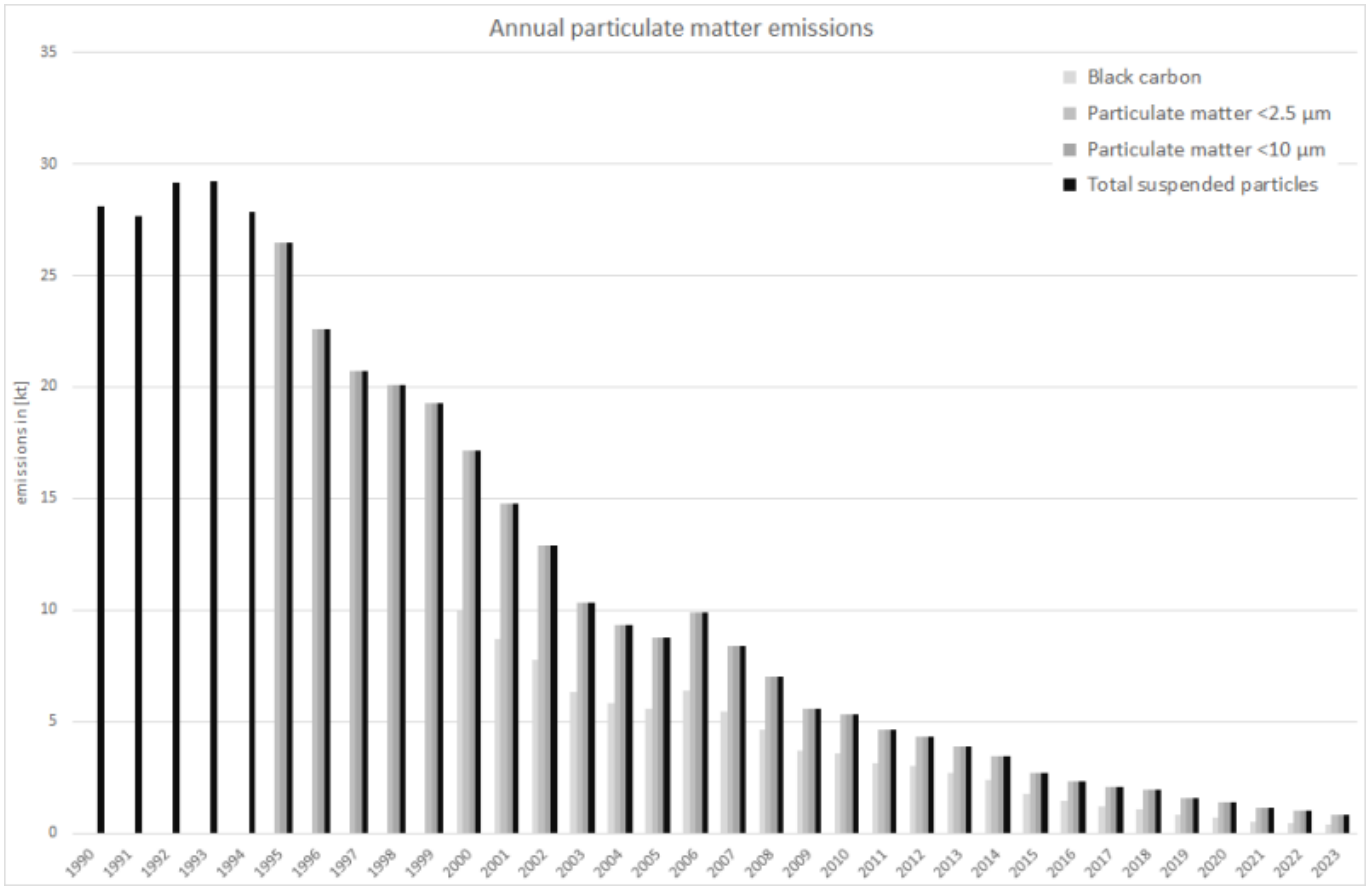
Ammonia and sulphur dioxide

As for the entire road transport sector, the trends for **sulphur dioxide** (SO_2) and **ammonia** (NH_3) exhaust emissions from heavy duty vehicles show charcteristics different from those shown above: Here, the strong dependence on increasing fuel qualities (sulphur content) leads to an cascaded downward trend of SO_2 emissions , influenced only slightly by increases in fuel consumption and mileage. For **ammonia** emissions the increasing use of catalytic converters in gasoline driven cars in the 1990s lead to a steep increase whereas both the technical development of the converters and the ongoing shift from gasoline to diesel cars resulted in decreasing emissions in the following years.



Particulate matter & Black carbon

As for all reported exhaust PM emissions from mobile diesel vehicles the Party assumes that nearly all particles emitted are within the $PM_{2.5}$ range, resulting in similar emission values for $PM_{2.5}$, PM_{10}, and TSP.



Recalculations

Compared to submission 2024, recalculations in **activity data** result mainly from a revision of the underlying National Energy Balance (NEB) for 2022 as well as the underlying model for 2022 and 2023.

Table 7: Revised fuel consumption data, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL OIL													
current Submission	436,779	553,405	636,362	453,716	537,434	539,210	544,857	575,273	626,967	595,144	599,097	559,214	537,439
previous Submission	436,779	553,405	636,362	453,716	537,434	539,210	544,857	575,273	626,967	595,144	599,097	556,904	532,565
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,310	4,874
relative change	0.00%	0.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.41%	0.92%
BIODIESEL													
current Submission		863	7,050	31,633	42,037	29,953	29,532	31,357	35,376	33,759	49,002	39,215	37,283
previous Submission		863	7,050	31,633	42,037	29,953	29,532	31,357	35,376	33,759	49,002	39,053	37,009
absolute change		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	162	275
relative change		0.00%	0.00%	0.0%	0.00%	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%	0.41%	0.74%
NATURAL GAS (CNG & LNG)													
current Submission				1,144	2,060	1,162	982	632	763	760	1,454	4,607	5,468
previous Submission				1,144	2,060	1,162	982	632	763	760	1,454	2,379	2,198
absolute change				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,228	3,269
relative change				0.00%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	93.6%	149%
BIOMETHANE													
current Submission					65	314	334	385	337	760	1,606	2,240	2,696
previous Submission					65	314	334	385	337	760	1,606	2,252	2,693
absolute change					0.00	0.00	0.00	0.00	0.00	0.00	0.00	-11.7	2.84
relative change					0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.52%	0.11%
NFR 1.A.3.b iii TOTAL													
current Submission	436,779	554,878	643,825	486,493	581,597	570,639	575,706	607,647	663,443	630,423	651,159	605,275	582,886
previous Submission	436,779	554,878	643,825	486,493	581,597	570,639	575,706	607,647	663,443	630,423	651,159	600,587	574,465
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,688	8,420
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.78%	1.47%

Due to the variety of highly specific tier3 **emission factors** applied, it is not possible to display any changes in these data sets in a comprehendible way.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter

9.1 - Recalculations.

Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

[1), 2), 5)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2024.

[3)] Keller et al. (2019): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8_HBEFA41_Development_Report.pdf - Dokumentation, Bern, 2019.

[4)] Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf - Dokumentation, Bern, 2022.

[6)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/@@download/file; Table 3-82: Heavy metal emission factors for all vehicle categories in ppm/wt fuel; Copenhagen, 2023.

[7)] Rentz et al. (2008): Otto Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung, Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte 01/2008, http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer; Dessau-Roßlau, 2008

[8)] EU (2009): REGULATION (EC) No 595/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information and amending Regulation (EC) No 715/2007 and Directive 2007/46/EC and repealing Directives 80/1269/EEC, 2005/55/EC and 2005/78/EC - https://data.europa.eu/eli/reg/2009/595/oj; Brussels, 18 June 2009.

[9)] EU (2011): REGULATIONS COMMISSION REGULATION (EU) No 582/2011 implementing and amending Regulation (EC) No 595/2009 of the European Parliament and of the Council with respect to emissions from heavy duty vehicles (Euro VI) and amending Annexes I and III to Directive 2007/46/EC of the European Parliament and of the Council; https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0582&qid=1744032326229; http://data.europa.eu/eli/reg/2011/582/oj; Brussels, 25 May 2011

[5)]

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.A.3.b iv - Road Transport: Mopeds & Motorcycles

Short description

In sub-categories *1.A.3.b iv - Road Transport: Mopeds & Motorcycles* emissions from fuel combustion in motorised two-wheelers are reported.



Category Code	Method	AD	EF
1.A.3.b iv	T1, T3	NS, M	CS, M, D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

Specific consumption data for mopeds and motorcycles is generated within the TREMOD model (Knörr, 2024a) [1)].

The following table provides an overview of annual amounts of gasoline fuels consumed by motorized two-wheelers in Germany.

Table 1: Annual fuel consumption of mopeds and motorcycles, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
MOPEDS														
Gasoline	5,143	3,206	3,223	3,092	3,305	3,438	3,413	3,285	3,245	3,306	3,387	2,993	3,262	2,882
Biogasoline				21	128	139	139	134	140	136	152	141	151	136
Σ Mopeds	**5,143**	**3,206**	**3,223**	**3,113**	**3,434**	**3,576**	**3,552**	**3,419**	**3,385**	**3,442**	**3,538**	**3,134**	**3,413**	**3,018**
MOTORCYCLES														
Gasoline	17,206	16,634	20,995	19,868	15,672	15,734	15,860	15,727	15,079	15,301	15,192	13,516	14,569	12,964
Biogasoline				138	609	635	647	642	653	630	681	637	675	612
Σ Motorcycles	**17,206**	**16,634**	**20,995**	**20,006**	**16,281**	**16,369**	**16,507**	**16,369**	**15,732**	**15,931**	**15,873**	**14,153**	**15,244**	**13,576**
MOTORIZED 2-WHEELERS: Mopeds & Motorcycles														
Gasoline	22,350	19,840	24,218	22,960	18,978	19,171	19,273	19,012	18,324	18,606	18,579	16,509	17,831	15,845
Biogasoline				159	737	774	787	776	793	767	833	778	826	748
Σ 1.A.3.b iv	**22,350**	**19,840**	**24,218**	**23,119**	**19,715**	**19,945**	**20,060**	**19,788**	**19,117**	**19,373**	**19,412**	**17,287**	**18,657**	**16,594**

source: TREMOD [2)]

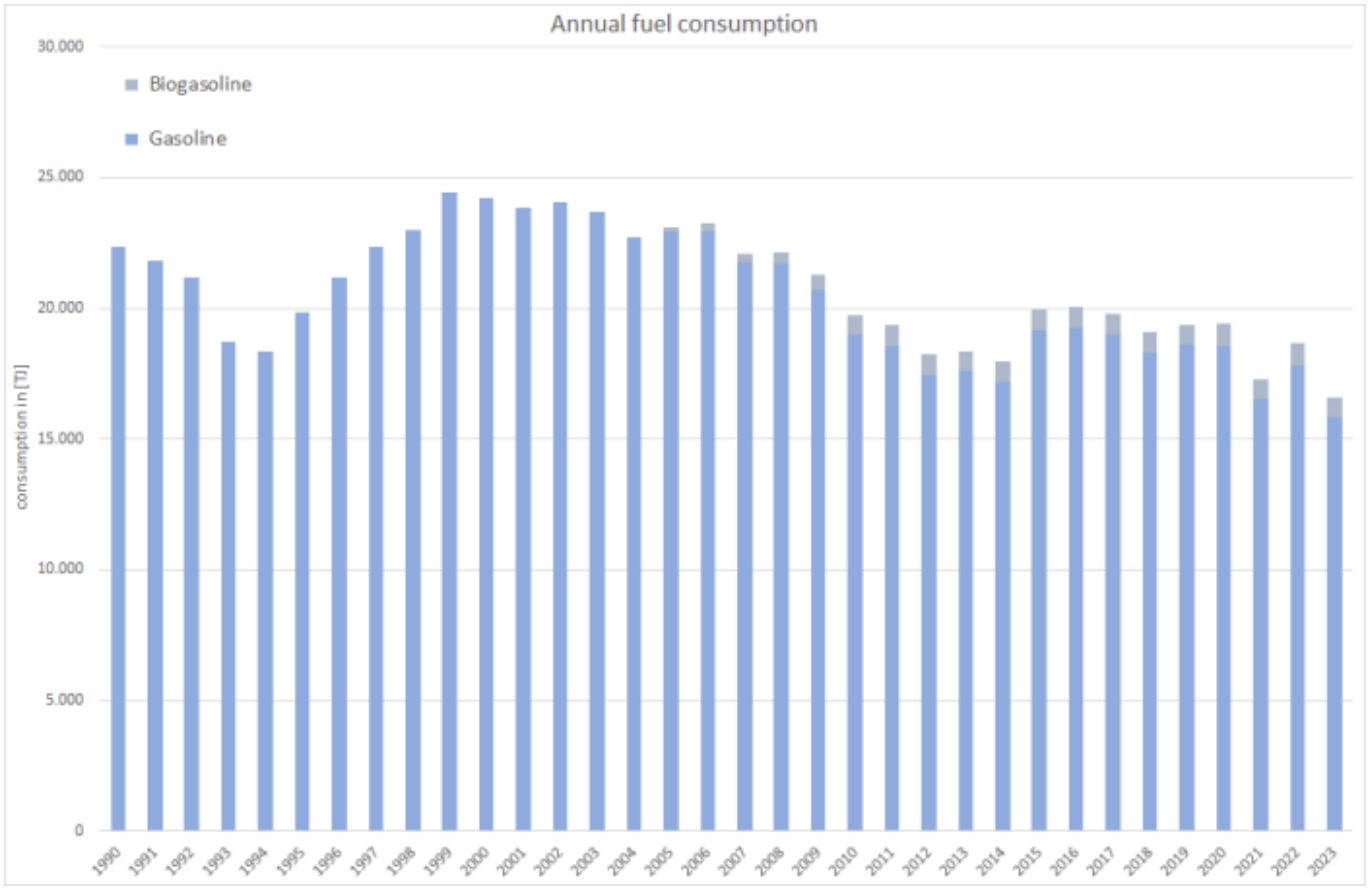
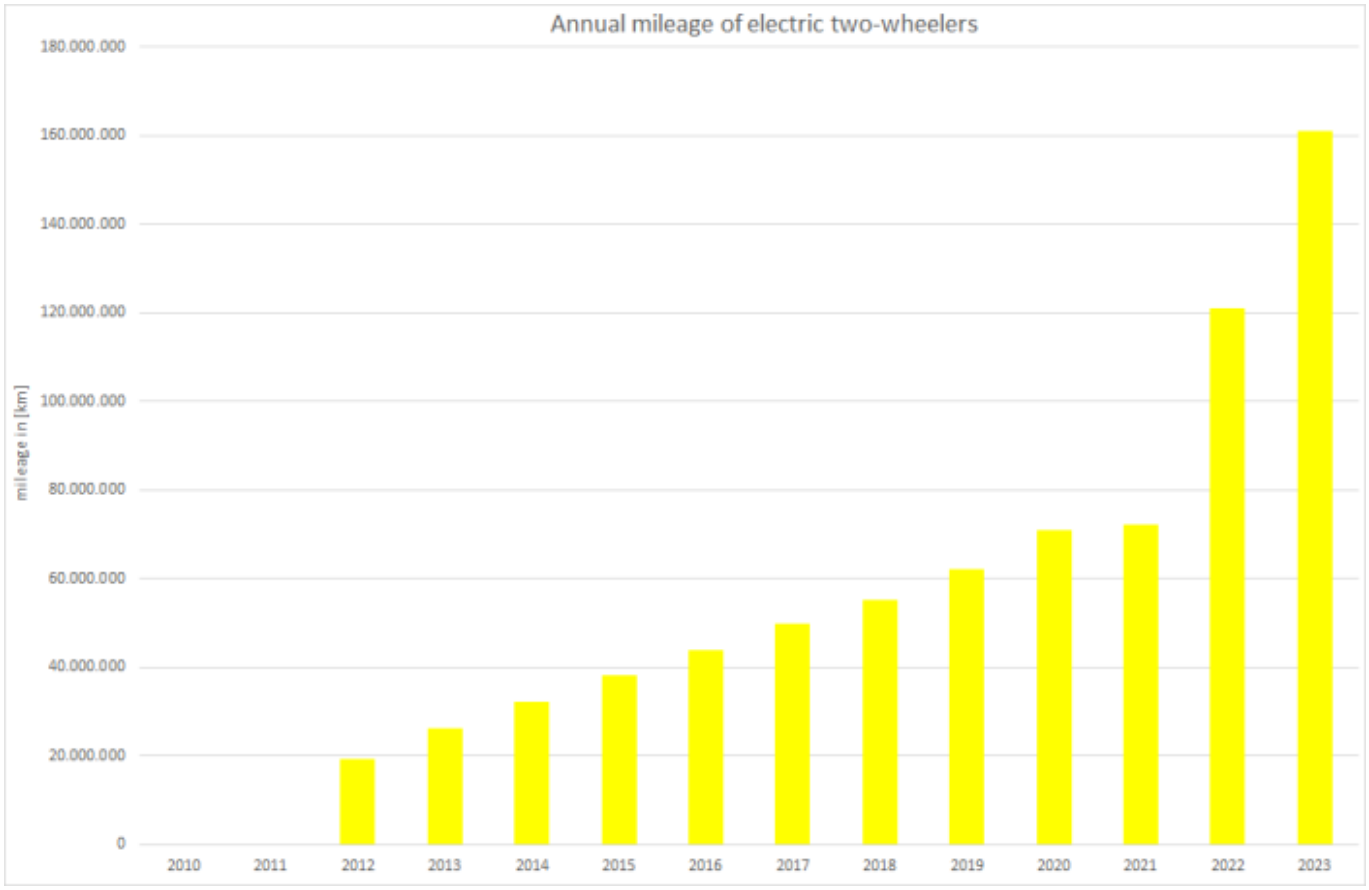


Table 2: Annual mileage of electric mopeds and motorcycles, as of 2012, in [km]

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
e-mopeds	4,893,858	7,081,254	8,286,339	9,349,275	10,473,058	11,684,376	12,603,833	14,405,436	17,202,225	18,705,389	46,436,326
e-motorcycles	14,288,683	19,091,180	23,913,479	28,696,175	33,478,875	38,107,442	42,529,340	47,620,933	53,621,255	53,399,717	78,383,254



For further information on mileage as well as abrasion-related emissions, please refer to sub-chapters on emissions from tyre & brake wear and road abrasion.

Emission factors

The majority of emission factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, versions 4.1 and 4.2) [3),4)], where they are provided on a tier3 level mostly and processed within TREMOD [5)].

However, it is not possible to present these highly specific tier3 values in a comprehendible way here.

With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [6)]

For heavy-metal (other then lead from leaded gasoline) and PAH exhaust-emissions, default emission factors from the 2023 EMEP/EEA Guidebook (EMEP/EEA, 2023), Table 3-86 have been applied [6)] (see super-ordinate chapter here).

Regarding PCDD/F, tier1 EF from (Rentz et al., 2008) [7)] are used instead.

The following table provides an overview of the EF. Please note, that the values for heavy-metal (in [g/TJ]) and PAH (in [mg/TJ]) exhaust-emissions have been estimated from the EMEP/EEA defaults provided in [ppm/wt].

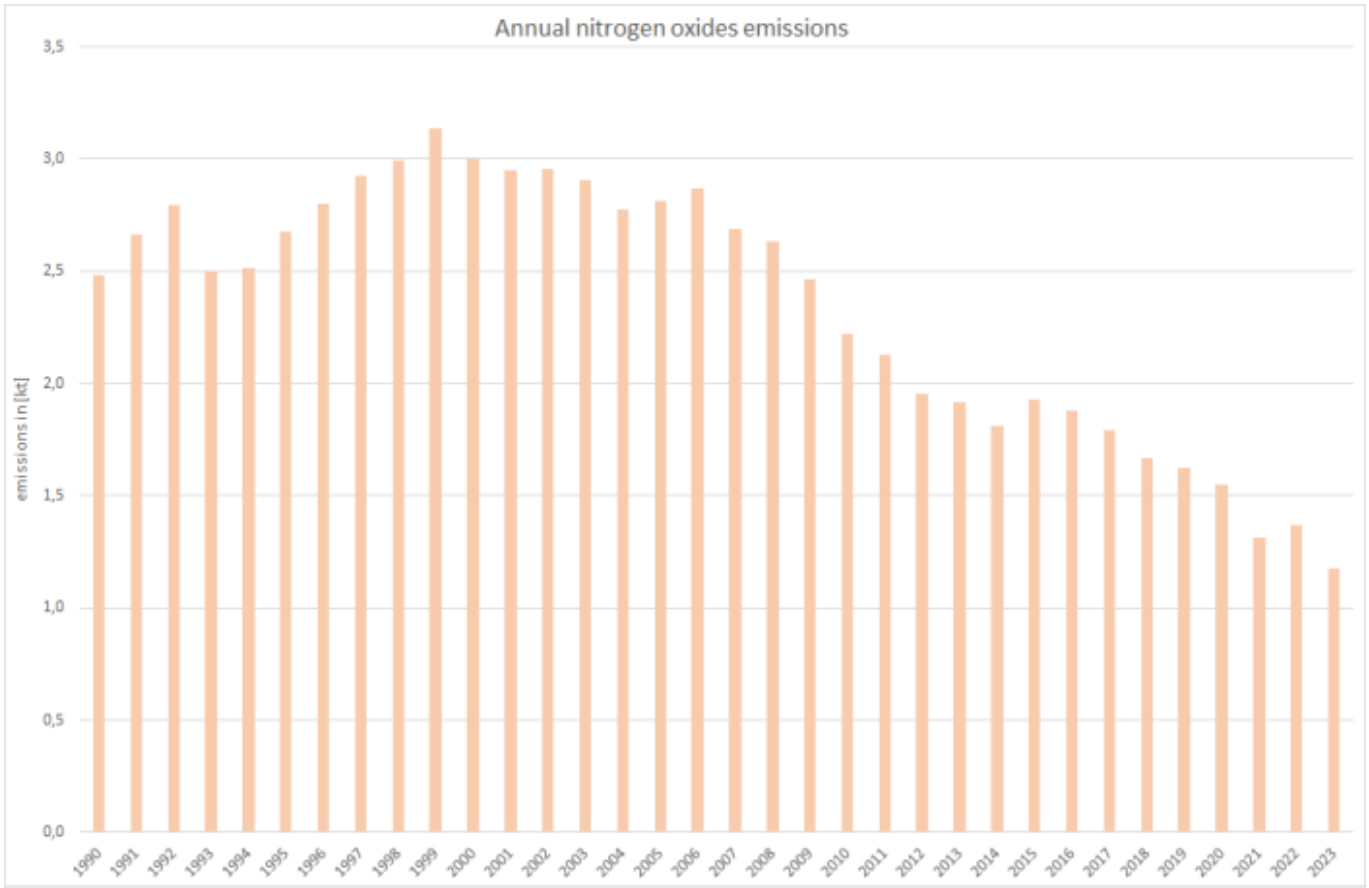
Table 3: Overview of tier1 EF applied for heavy metals and POPs exhaust-emissions

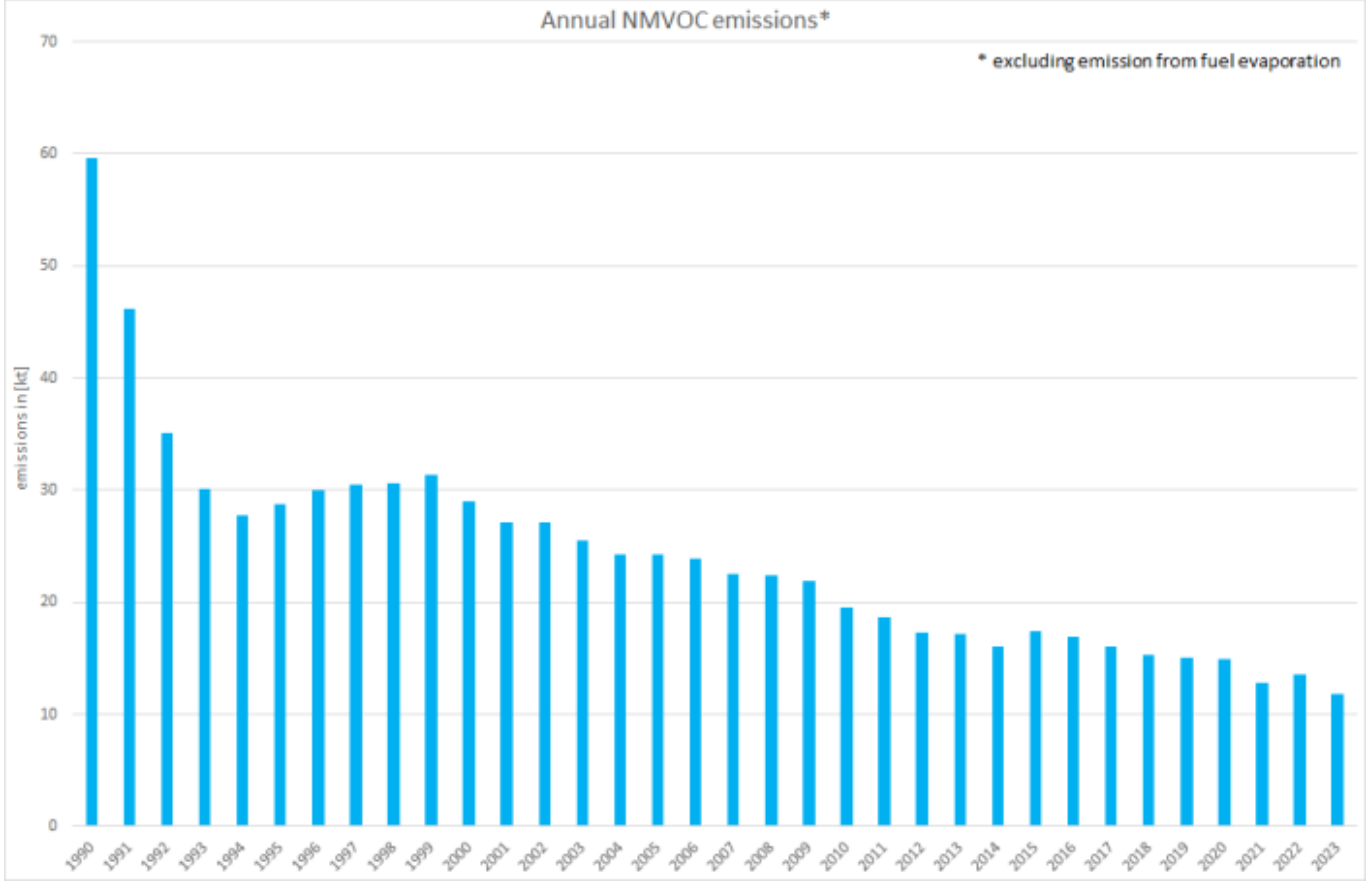
As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	PCDD/F	B[a]P	B[b]F	B[k]F	I[...]P	PAH 1-4
[g/TJ]									[µg/km]	[mg/TJ]				
0.007	0.005	0.145	0.103	0.200	0.053	0.037	0.005	0.758	0.0000027	192.91	215.88	156.17	234.25	799.21

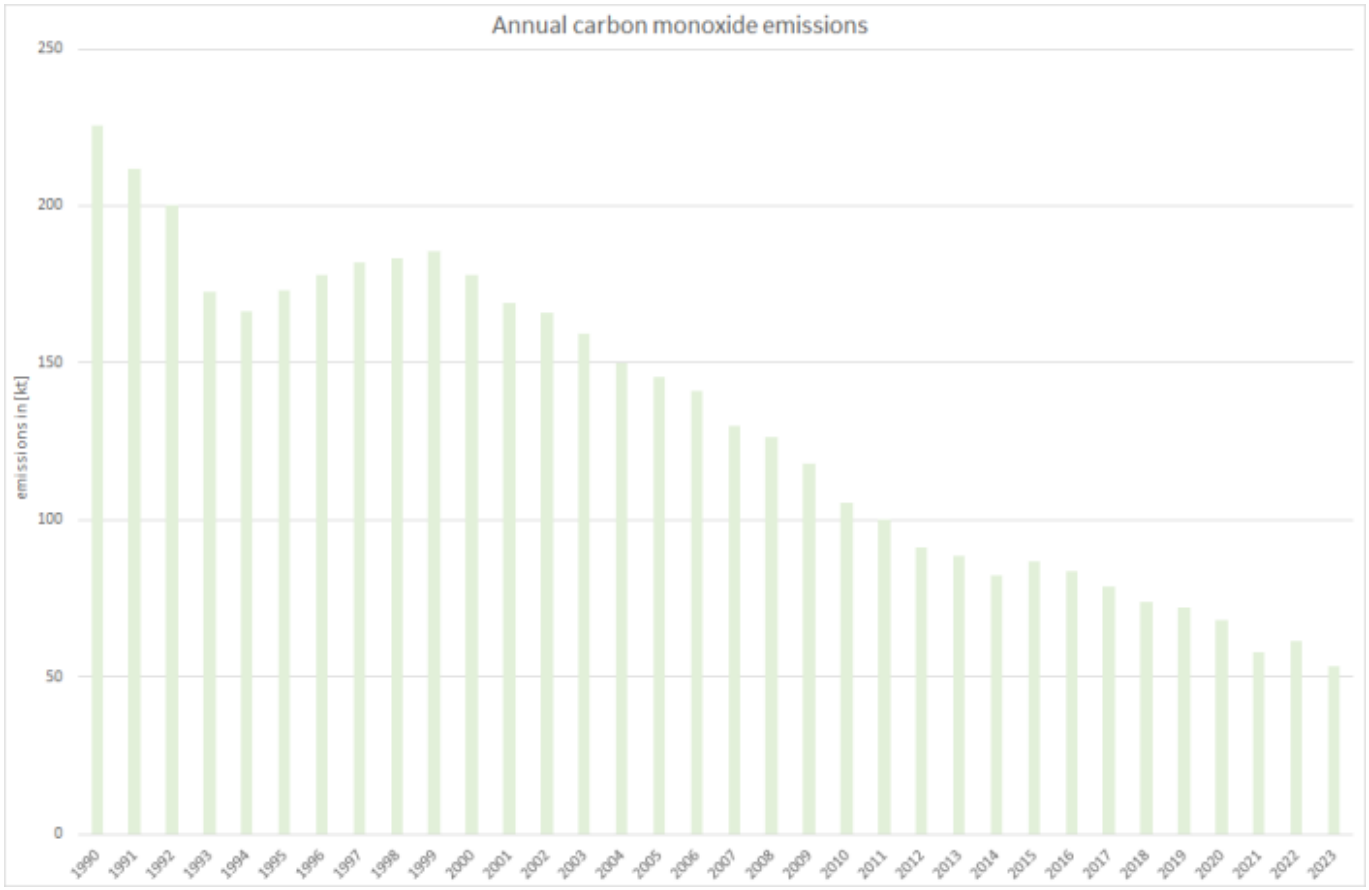
Discussion of emission trends

NFR 1.A.3.b iv is no key category.

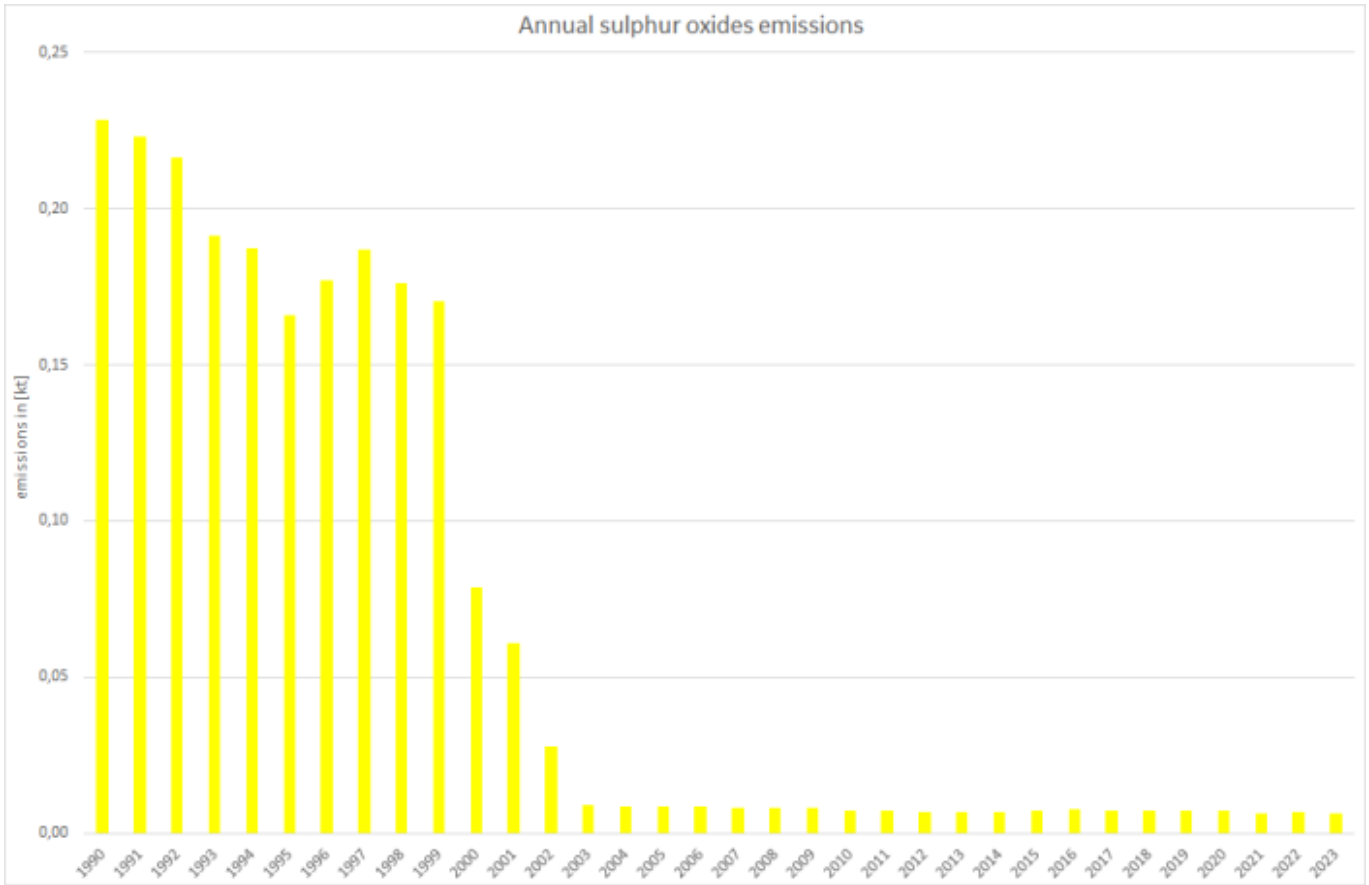
Since 1990, exhaust emissions of NO_x, NMVOC, and CO have decreased due to technical improvements.


Annual nitrogen oxides emissions
emissions in [kt]
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

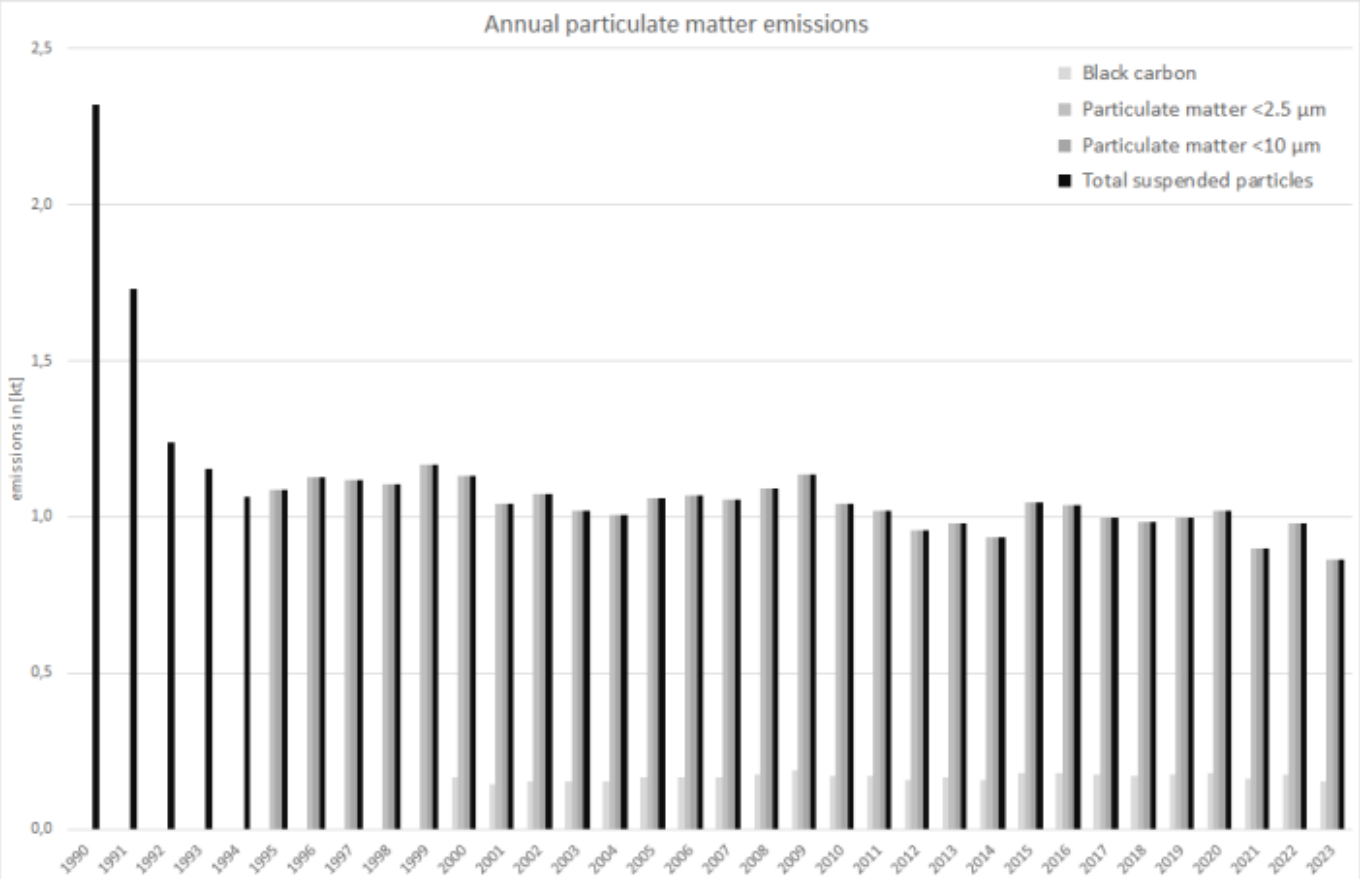

Annual NMVOC emissions*
* excluding emission from fuel evaporation
emissions in [kt]
70
60
50
40
30
20
10
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023



As for the entire road transport sector, the trends for **sulphur dioxide** exhaust emissions from two-wheelers shows charcteristics very different from those shown above: Here, the strong dependence on increasing fuel qualities (sulphur content) leads to an cascaded downward trend of emissions , influenced only slightly by increases in fuel consumption and mileage.



Particle emissions result from the comusbtion of gasoline and bioethanol. Here, due to the assumption that nearly all TSP emitted is formed by particles in the $PM_{2.5}$ range, similar estimates are provided for all three fractions. (Exception: Until 1997, additional TSP emissions from use of leaded gasoline are included.)



Recalculations

Compared to submission 2024, recalculations ....

Table 4: Revised fuel consumption data, in terajoules [TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
GASOLINE													
current submission	22,350	19,840	24,218	22,960	18,978	19,171	19,273	19,012	18,324	18,606	18,579	16,509	17,831
previous submission	22,350	19,840	24,218	22,960	18,978	19,171	19,273	19,012	18,324	18,606	18,579	16,802	18,300
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-293	-470
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-1.74%	-2.57%
BIOGASOLINE													
current submission				159	737	774	787	776	793	767	833	778	826
previous submission				159	737	774	787	776	793	767	833	792	848
absolute change				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-13.8	-21.8
relative change				0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-1.74%	-2.57%
TOTAL FUEL CONSUMPTION													
current submission	22,350	19,840	24,218	23,119	19,715	19,945	20,060	19,788	19,117	19,373	19,412	17,287	18,657
previous submission	22,350	19,840	24,218	23,119	19,715	19,945	20,060	19,788	19,117	19,373	19,412	17,594	19,148
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-307	-491
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-1.74%	-2.57%

Due to the variety of tier3 **emission factors** applied, it is not possible to display any changes in these data sets in a comprehendible way.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

[1), 5)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2024.

[3)] Keller et al. (2019): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8_HBEFA41_Development_Report.pdf - Dokumentation, Bern, 2019.

[4)] Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf - Dokumentation, Bern, 2022.

[6)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/@@download/file; Table 3-82: Heavy metal emission factors for all vehicle categories in ppm/wt fuel; Copenhagen, 2023.

[7)] Rentz et al. (2008): Otto Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung, Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte 01/2008, http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer; Dessau-Roßlau, 200 [(EU2013> EU (2013): Verordnung (EU) Nr. 168/2013 des Europäischen Parlaments und des Rates vom 15. Januar 2013 über die Genehmigung und Marktüberwachung von zwei- oder dreirädrigen und vierrädrigen Fahrzeugen; http://data.europa.eu/eli/reg/2013/168/oj; 15. Januar 2013, Straßburg

[6)]
During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.A.3.b v - Gasoline Evaporation

Short description

In category *1.A.3.b v - Road Transport: Gasoline evaporation* fugitive emissions from the evaporation of gasoline from road vehicles are reported.

NFR Code	Method	AD	EF
1.A.3.b v	T2	NS, M	CS, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

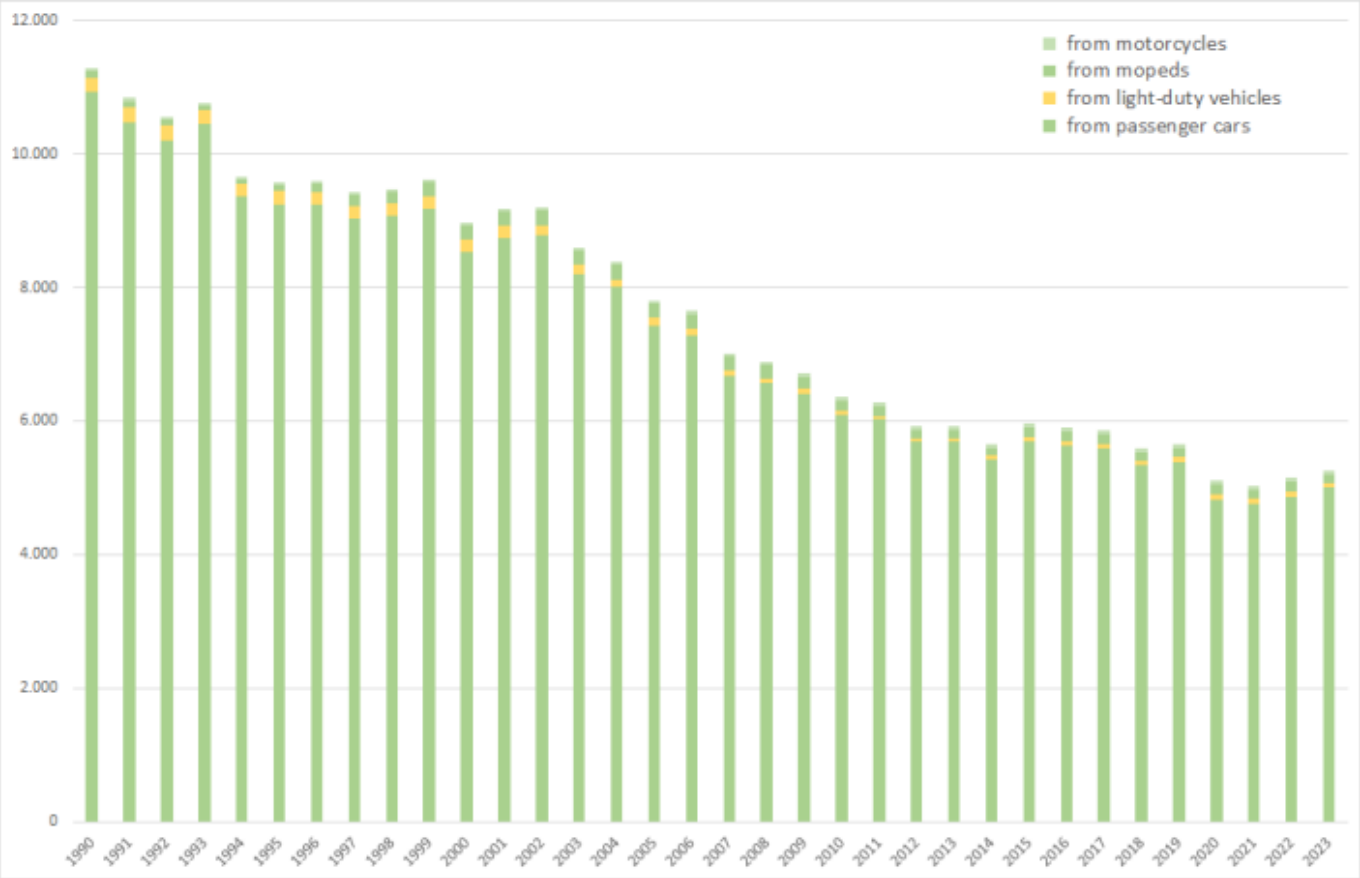
Activity data

Specific data for gasoline evaporation from road vehicles are generated within TREMOD [1)]. - The following table provides an overview of annual amounts of gasoline evaported from road vehicles in Germany.

Table 1: Annual amount of gasoline evaporated from road vehicles, in kilotonnes

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
PCs	10,926	9,239	8,537	7,434	6,091	5,700	5,643	5,588	5,331	5,383	4,827	4,758	4,871	5,001
LDVs	213	203	182	112	61.2	55.0	59.1	63.9	69.6	77.4	76.2	73.0	75.1	75.3
Mopeds	105	97.0	204	218	154	142	143	143	136	140	142	133	142	125
Motorcycles	50.2	42.2	43.9	47.5	58.3	61.8	61.2	58.6	58.4	59.6	61.3	54.5	59.3	52.4
Σ 1.A.3.b v	**11,283**	**9,581**	**8,967**	**7,812**	**6,364**	**5,959**	**5,907**	**5,853**	**5,595**	**5,661**	**5,107**	**5,018**	**5,147**	**5,253**

source: TREMOD



(Implied) Emission factors

Tier3 emission factors representing the effect of mitigation technologies are derived from TREMOD.

Table 2: Overview of implied emission factors per vehcile type, in kg/t

	Mitigation	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
PCs	Euro_1_I	0.18	1.25	1.82	2.30	2.85	3.39	3.45	3.48	3.61	3.69	3.97	4.30	4.41	4.32
	Euro_2_II		1.47	1.95	2.42	2.99	4.02	4.23	4.42	4.73	4.98	5.45	5.91	6.23	6.25
	Euro_3_III			1.93	2.41	2.85	3.64	3.80	3.94	4.19	4.39	4.84	5.27	5.59	5.68
	Euro_4_IV			1.67	1.91	2.11	2.77	2.89	2.99	3.17	3.31	3.66	4.00	4.22	4.29
	Euro_5_V					1.81	2.25	2.38	2.50	2.69	2.83	3.18	3.50	3.70	3.76
	Euro_6ab_VI									3.22	1.57	1.96	2.21	2.36	2.38
	Euro_6c_VI								1.58	1.59	1.63	1.88	2.15	2.30	2.37
	Euro_6d_temp_VI					1.99	1.79	1.84	1.88	1.98	2.10	2.42	2.73	2.92	2.98
	Euro_6d_VI						1.91	1.88	1.86	1.65	1.71	1.97	2.25	2.41	2.48
	pre-Euro	23.6	30.5	33.9	33.5	34.9	36.8	36.9	36.8	37.4	37.6	38.8	32.2	32.9	33.0

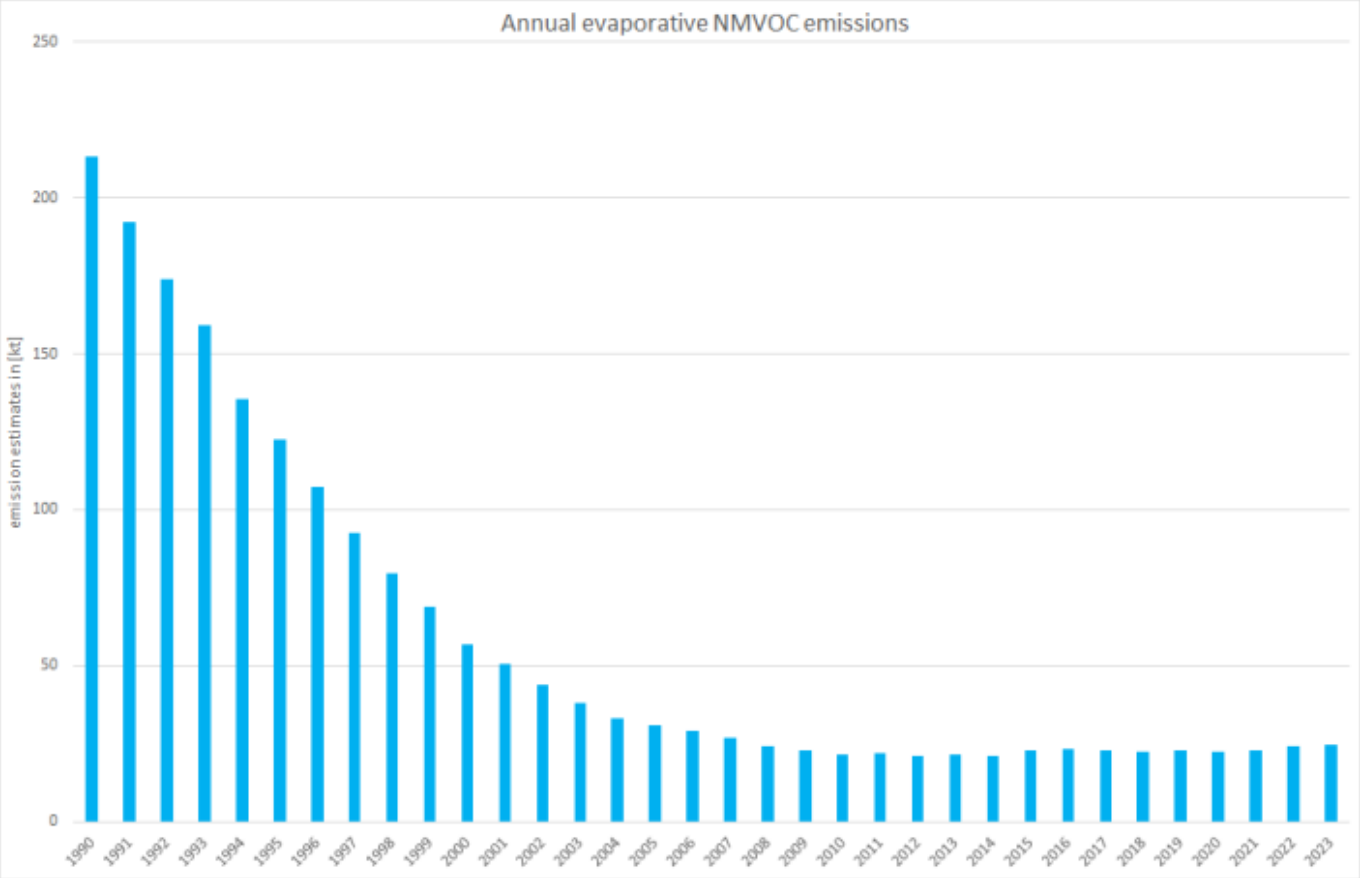
	Mitigation	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
LDVs	Euro_1_I						0.14	0.13	0.13	0.57	0.62	0.67	0.81	0.94	1.06
	Euro_2_II						0.75	0.73	0.71	0.69	0.71	0.80	0.99	1.12	1.23
	Euro_3_III									0.50	0.53	0.60	0.74	0.84	0.95
	Euro_4_IV						13.8	14.0	13.8	13.4	12.9	2.70	1.43	1.27	1.27
	Euro_5_V					0.97	1.09	1.11	1.16	1.23	1.32	1.51	1.82	2.05	2.27
	Euro_6ab_VI			0.75	1.13	1.96	2.72	2.67	2.60	2.55	2.55	2.68	3.01	3.16	3.27
	Euro_6c_VI		0.68	0.96	1.42	2.26	2.88	2.78	2.66	2.56	2.50	2.57	2.81	2.86	2.86
	Euro_6d_temp_VI				0.69	1.17	1.93	1.96	2.00	2.05	2.14	2.37	2.81	3.12	3.42
	Euro_6d_VI				0.87	1.62	2.32	2.31	2.30	2.31	2.36	2.56	2.95	3.19	3.39
	pre-Euro	20.5	17.1	17.1	17.6	20.3	21.7	20.4	19.3	18.5	18.0	18.2	17.0	17.2	17.2
Mopeds	Euro_1_I			0	11.0	15.3	21.3	22.2	22.7	23.7	23.9	24.6	27.2	28.0	32.6
	Euro_2_II			14.2	14.0	18.8	25.7	26.7	27.2	28.3	28.3	29.0	31.6	31.5	36.1
	Euro_4_IV				10.7	11.0	14.3	14.6	14.8	15.6	15.7	16.3	18.1	18.5	21.7
	Euro_5_V												17.6	17.3	19.8
	pre-Euro						14.0	14.6	15.2	15.8	15.7	16.2	17.8	18.0	21.1
Motorcycles	Euro_1_I	23.3	24.8	16.6	17.6	23.4	31.0	31.9	32.1	33.0	32.6	32.9	35.3	34.6	39.1
	Euro_2_II				13.2	11.6	11.3	11.3	11.5	11.5	11.7	11.8	13.3	13.2	14.9
	Euro_3_III			16.6	15.0	14.6	16.0	16.4	17.0	17.1	17.3	17.3	19.5	19.0	21.3
	Euro_4_IV												9.7	9.4	10.4
	Euro_5_V									9.3	9.3	9.2	10.2	10.1	11.3
	pre-Euro	37.4	19.2	19.9	18.0	17.4	18.1	18.3	18.8	18.8	18.8	18.7	20.8	20.1	22.3

Discussion of emission trends

Table 3: Outcome of Key Category Analysis

for:	**NMVOC**
by:	Level & Trend

NFR 1.A.3.b v is key source for emissions of Non-Methane Volatile Organic Compounds - NMVOC. *(fugitive emissions only; no NMVOC emissions from fuel combustion included)*



Since its maximum level of over 11,000 kilotonnes in 1990, the amount of evaporated gasoline is decreasing - and so are the related NMVOC emissions. The amounts of evaporated gasoline are connected directly with those of gasoline consumed. Here, the decrease becomes sharper from 2000 onwards following a growing switch from gasoline to diesel oil especially in passenger cars. Here, the annual amounts of NMVOC emissions from evaporation not only depend directly on the amount of evaporated gasoline but also on the number of vehicles equipped with mitigation technologies. Thus, the decrease is sharpest straight after 1990 and since then slowing down.

Recalculations

Activity data have been revised for all years.

Table 4: Revised annual amounts of evaporated gasoline, in kilotonnes

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
current submission	11,294	9,581	8,967	7,812	6,364	5,959	5,907	5,853	5,595	5,661	5,107	5,018	5,147
previous submission	11,294	9,581	8,967	7,812	6,364	5,959	5,907	5,853	5,595	5,661	5,107	4,973	5,166
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.3	-18.7
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.91%	-0.36%

In addition, the NMVOC **emission factors** applied were revised for several years.

As a result, NMVOC emissions from gasoline evaporation were re-estimated as follows:

Table 5: Re-estimated NMVOC emissions, in kilotonnes

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
current submission	213	123	56.7	30.8	21.7	23.0	23.1	23.0	22.5	23.0	22.4	22.8	24.3
previous submission	213	123	56.7	30.8	21.7	23.0	23.1	23.0	22.5	23.0	22.4	23.1	24.2
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.34	0.05
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-1.45%	0.19%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 8.1 - Recalculations.

Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

[1)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg & Berlin, 2024.

1.A.3.b vi-vii - Road Transport: Automobile Tyre and Brake Wear and Road Abrasion

This overview chapter provides information on emissions from automobile tyre and brake wear & road abrasion are reported reported in NFR sub-categories 1.A.3.b vi and 1.A.3.b vii. These sub-categories are important sources for a) particle emissions and b) emissions of heavy metals, POPs etc. included in these particles.

NFR-Code	Name of Category
1.A.3.b vi	Automobile Tyre and Brake Wear
1.A.3.b vii	Automobile Road Abrasion

Methodology

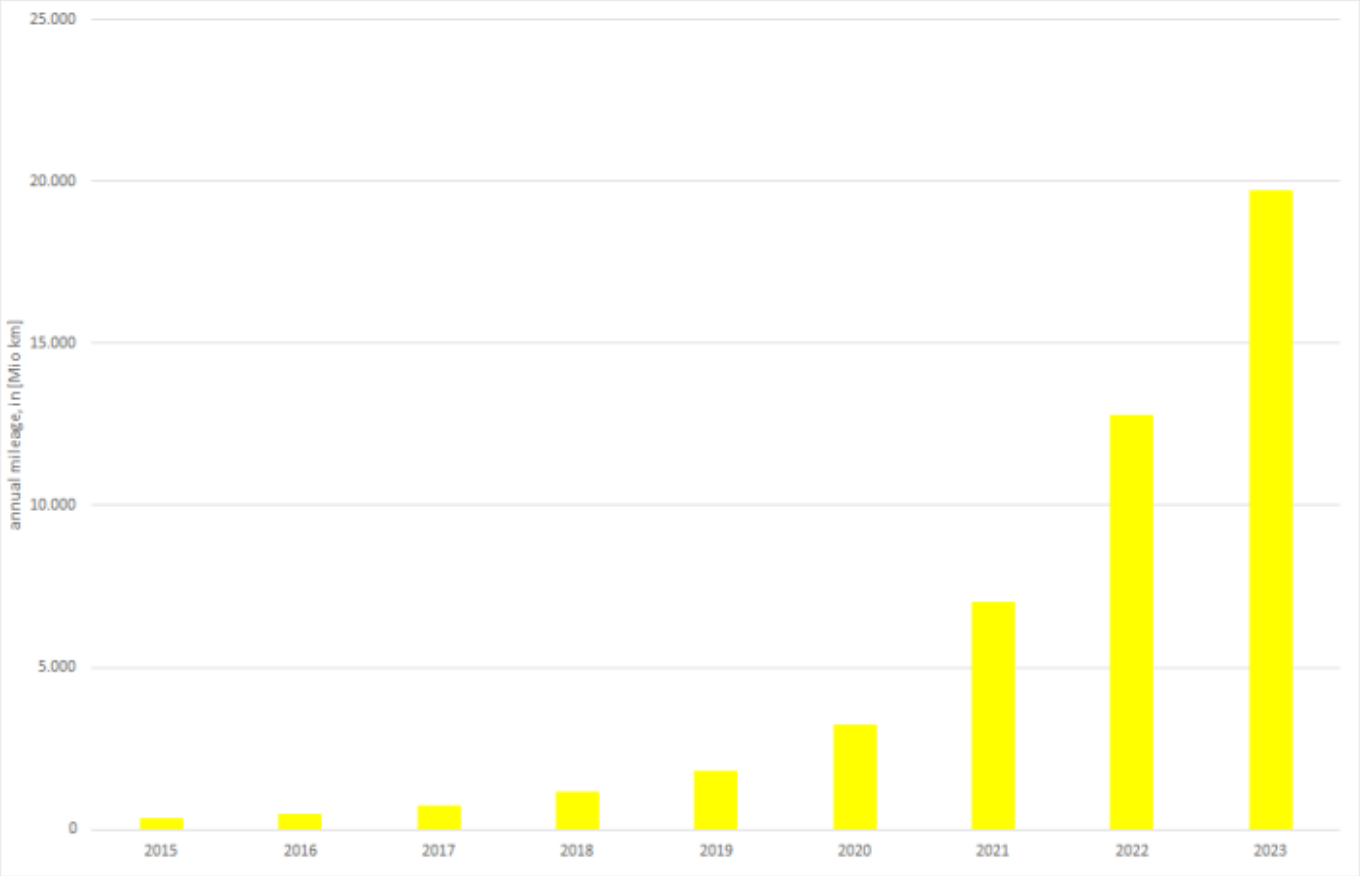
Activity data

Specific mileage data for all different types of road vehicles are generated within TREMOD (Knörr et al., 2024a) [1)]. The following table provides an overview of annual mileages.

Table 1: Mileage data for road vehicles 1990-2022, in 10^6 kilometers

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Passenger Cars	492,280	535,524	565,345	580,076	596,532	630,995	638,156	643,711	643,198	645,829	548,971	546,127	564,042	645,874
Light Duty Vehicles	14,259	23,294	31,541	35,938	39,226	45,330	47,457	49,698	51,918	53,657	50,983	54,572	56,132	55,467
Heavy Duty Vehicles	40,827	54,025	62,478	60,932	61,970	66,463	68,460	69,264	70,650	70,052	67,072	69,046	68,516	64,547
thereof: Lorries & Trucks	36,657	50,109	58,440	56,788	57,728	61,548	63,061	64,704	66,084	65,435	64,128	65,876	64,744	60,190
thereof: Buses	4,170	3,916	4,038	4,144	4,243	4,915	5,399	4,560	4,566	4,617	2,944	3,171	3,773	4,357
Two-wheelers	15,734	12,303	15,161	15,621	15,298	14,508	14,519	14,503	14,625	14,842	14,985	13,407	14,492	13,836
thereof: Mopeds	5,917	3,830	4,047	4,191	4,990	4,870	4,831	4,730	4,849	4,922	5,039	4,479	4,856	3,916
thereof: Motorcycles	9,817	8,473	11,113	11,429	10,308	9,638	9,687	9,773	9,776	9,920	9,946	8,928	9,636	9,920
TOTAL MILEAGE	**563,099**	**625,145**	**674,524**	**692,567**	**713,026**	**757,295**	**768,591**	**777,176**	**780,391**	**784,380**	**682,010**	**683,152**	**703,182**	**779,723**

The following chart illustrates the increase in annual mileage of electric road vehicles in 10^6 kilometers. Despite the exponential growth, only about 2.5 per cent of annual mileage was “electric” in 2023.



Discussion of emission trends

Please see sub-category chapters 1.A.3.b vi - Automobile Tyre and Brake Wear and 1.A.3.b vii - Automobile Road Abrasion .

Recalculations

With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

[1)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg & Berlin, 2024.

1.A.3.b vi - Road Transport: Automobile Tyre and Brake Wear

Short description

In sub-categories *1.A.3.b vi - Road transport: Automobile tyre and brake wear* emissions from automobile tyre and brake wear in RT are reported. Therefore, these sub-category is an important source for a) particle emissions and b) emissions of heavy metals, POPs etc. included in these particles.

Category Code	Method	AD	EF
1.A.3.b vi	T1, T3	NS, M	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	CO	**Pb**	**Cd**	Hg	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	PCDD/F	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAH1-4**	HCB	PCBs
NA	NA	NA	NA	**L/-**	**L/-**	**L/-**	**L/-**	NA	L/-	-/-	NA	**L/-**	**L/-**	**L/T**	-/-	**L/-**	**L/T**	NA	-/-	-/-	NE	-/-	-/-	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

Abrasive emissions from tyre and brake wear are estimated based on vehicle-type specific mileage data.

For detailed mileage data, please see superordinate chapter on abrasive emissions from road vehicles.

Emission factors

Table 1: Emission factors applied

		Tyre Wear						Brake Wear					
		PCs	**LDVs**	**HDVs**	**Buses**	**Mopeds**	**Motorcycles**	**PCs**	**LDVs**	**HDVs**	**Buses**	**Mopeds**	**Motorcycles**
BC	[mg/km]	1.07	1.69	4.50	4.50	0.55	0.55	0.75	1.17	3.27	3.27	0.44	0.44
$PM_{2.5}$		4.49	7.10	18.9	18.9	1.93	1.93	2.93	4.56	12.7	12.7	1.44	1.44
PM_{10}		6.40	10.1	27.0	24.3	2.80	2.80	7.35	11.5	32.0	28.8	3.63	3.63
TSP		10.7	16.9	45.0	45.0	4.60	4.60	7.50	11.7	32.7	32.7	3.70	3.7
Pb	[µg/km]	1.88	2.97	4.26	3.10	0.81	0.81	45.5	71.0	199	199	22.5	22.5
Hg		NA											
Cd		0.05	0.08	0.11	0.08	0.02	0.02	0.17	0.26	0.73	0.73	0.08	0.08
As		0.04	0.06	0.09	0.07	0.02	0.02	0.51	0.79	2.21	2.21	0.25	0.25
Cr		0.26	0.40	0.58	0.42	0.11	0.11	17.3	27.0	75.7	75.7	8.55	8.55
Cu		1.86	2.94	4.21	3.06	0.80	0.80	383	598	1674	1674	189	189
Ni		0.32	0.51	0.72	0.53	0.14	0.14	2.45	3.83	10.71	10.71	1.21	1.21
Se		0.21	0.34	0.48	0.35	0.09	0.09	0.15	0.23	0.66	0.66	0.07	0.07
Zn		79.5	126	180	131	34.2	34.2	65.1	102	284	284	32.1	32.1
B[a]P		0.032	0.049	0.134	0.120	0.013	0.013	NA					
B[b]F		0.038	0.063	0.161	0.144	0.019	0.019						
B[k]F		0	0	0	0	0	0						
I[..]P		0.019	0.028	0.082	0.072	0.006	0.006						
∑ PAHs 1-4		0.090	0.140	0.379	0.336	0.038	0.038						

Discussion of emission trends

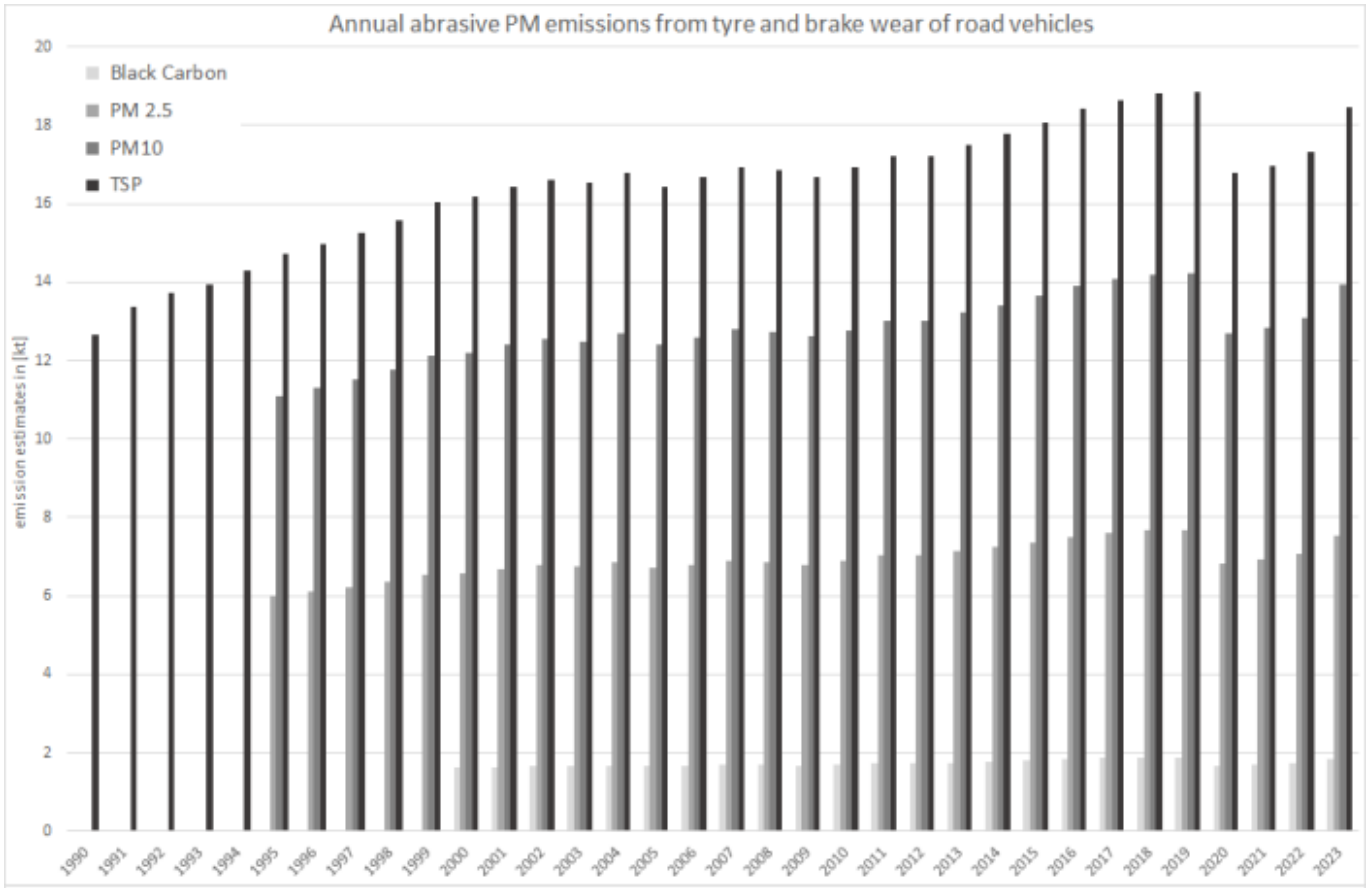
(emissions from wear/abrasion only; no fuel combustion included)

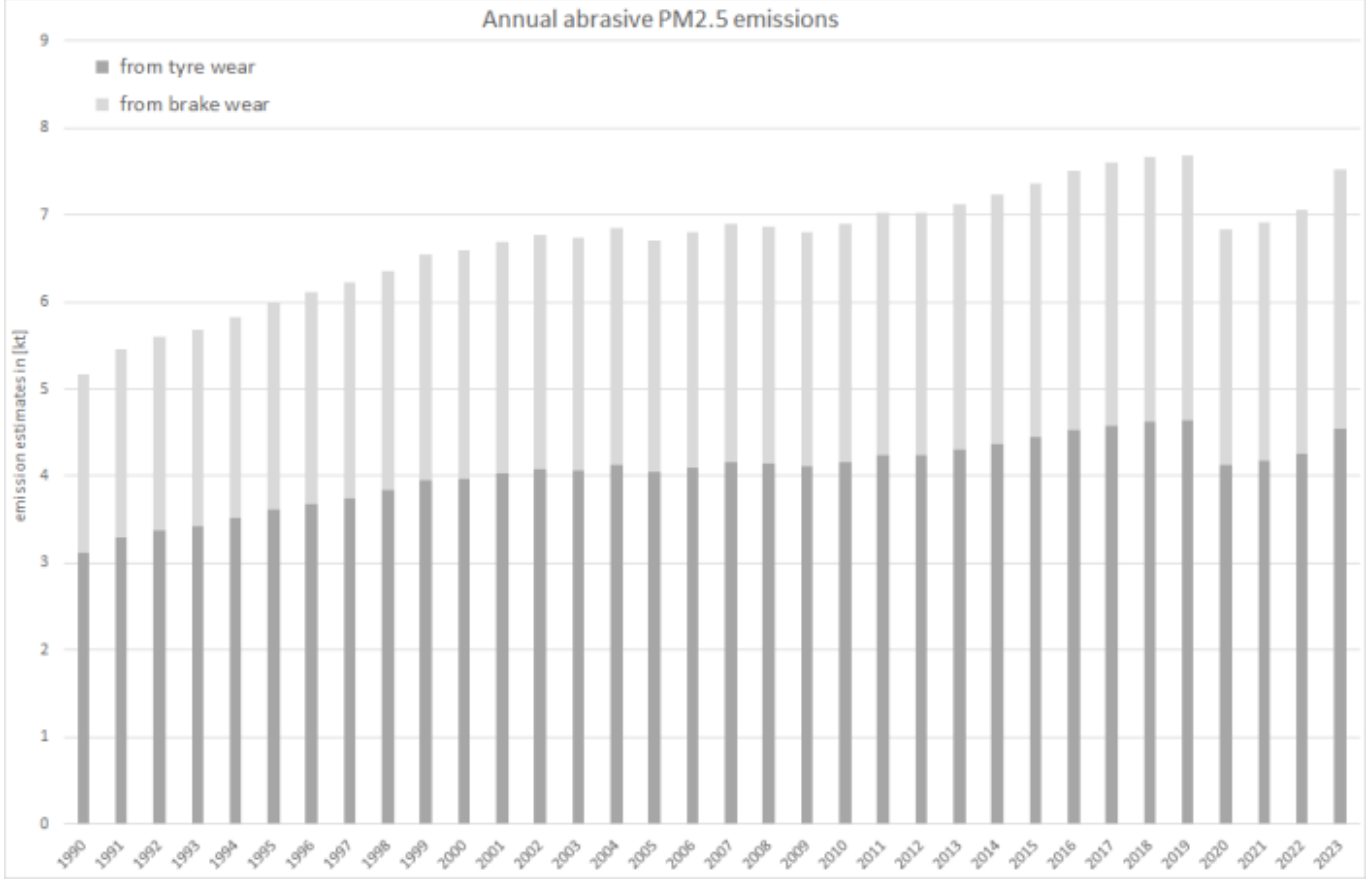
Table 2: Outcome of Key Category Analysis

for:	**BC**	**$PM_{2.5}$**	**PM_{10}**	**TSP**
by:	L/-	L/-	L/-	L/-

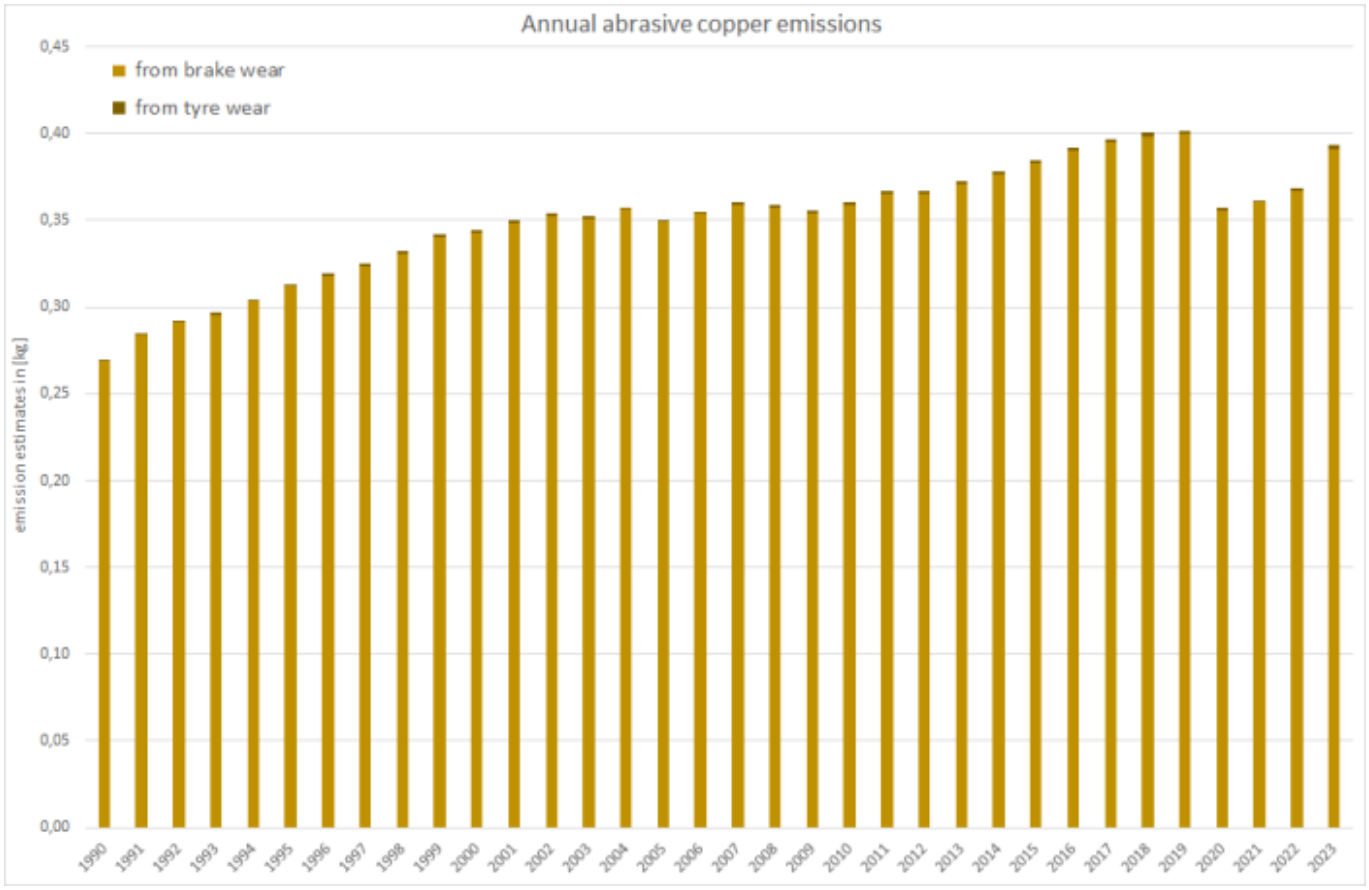
All reported emissions from tyre and brake wear are linked directly to the mileage driven by the road vehicles covered.

Here, after a moderate decrease during the Covid-19 pandemic, mileage related abrasive emissions show a slow recovery not yet reaching pre-pandemic levels again.

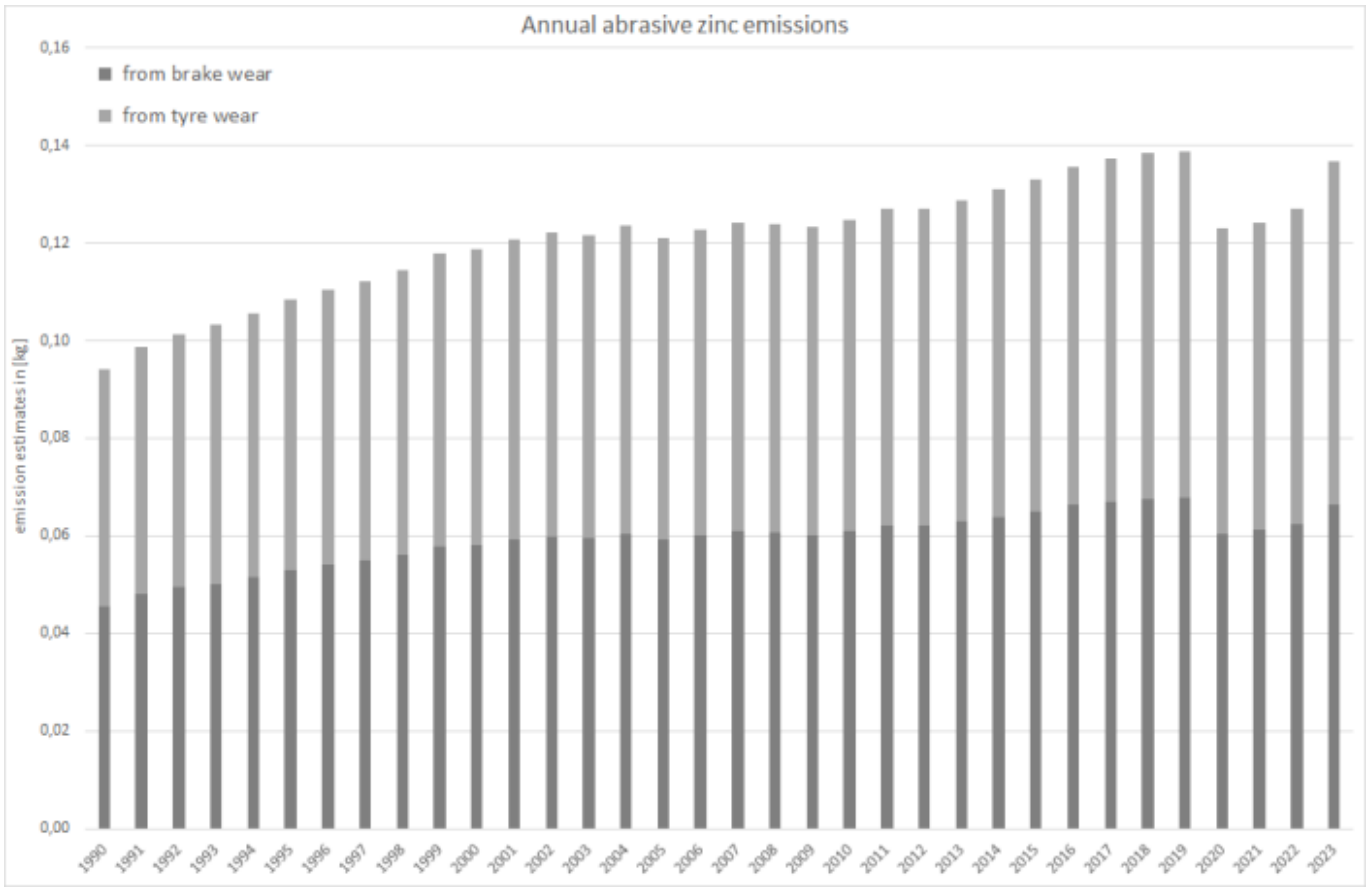




Whereas annual copper emissions result almost entirely from the wear of (disc) brakes...



...zinc emissions result from both tyre and brake wear with high amounts of zinc used in tyre rubber and drum brakes applied in trucks (heavy loads) and buses (stop-and-go).



Recalculations

With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

1.A.3.b vii - Road Transport: Automobile Road Abrasion

Short description

In sub-category *1.A.3.b vii - Road Transport: Automobile Road Abrasion* emissions from road abrasion in Road Transport are reported. Therefore, this sub-category is an important source for a) particle emissions and b) emissions of heavy metals, POPs etc. included in these particles.

Category Code	Method	AD	EF
1.A.3.b vii	T1, T3	NS, M	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	CO	**Pb**	**Cd**	Hg	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	POPs
NA	NA	NA	NA	**L/-**	**L/-**	**L/-**	NE	NA	-/-	-/-	NA	-/-	-/-	-/-	-/-	NE	-/-	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

Abrasive emissions from tyre and brake wear are estimated based on vehicle-type specific mileage data. For detailed mileage data, please see superordinate chapter on abrasive emissions from road vehicles.

Emission factors

Table 1: Emission factors applied

		PCs	LDVs	HDVs	Buses	Mopeds	Motorcycles
BC	[mg/km]	NA					
$PM_{2.5}$		4.05	4.05	20.5	20.5	1.62	1.62
PM_{10}		7.50	7.50	38.0	34.2	3.00	3.00
TSP		15.0	15.0	76.0	76.0	6.00	6.00
Pb	[µg/km]	0.00006	0.00006	0.00031	0.00006	0.00002	0.00002
Hg		NA					
Cd		0.000003	0.000003	0.000016	0.000003	0.000001	0.000001
As		0.00004	0.00004	0.00020	0.00004	0.00002	0.00002
Cr		0.00108	0.00108	0.00547	0.00108	0.00043	0.00043
Cu		0.00004	0.00004	0.00019	0.00004	0.00001	0.00001
Ni		0.00057	0.00057	0.00289	0.00057	0.00023	0.00023
Se		NA					
Zn		0.00129	0.00129	0.00654	0.00129	0.00052	0.00052

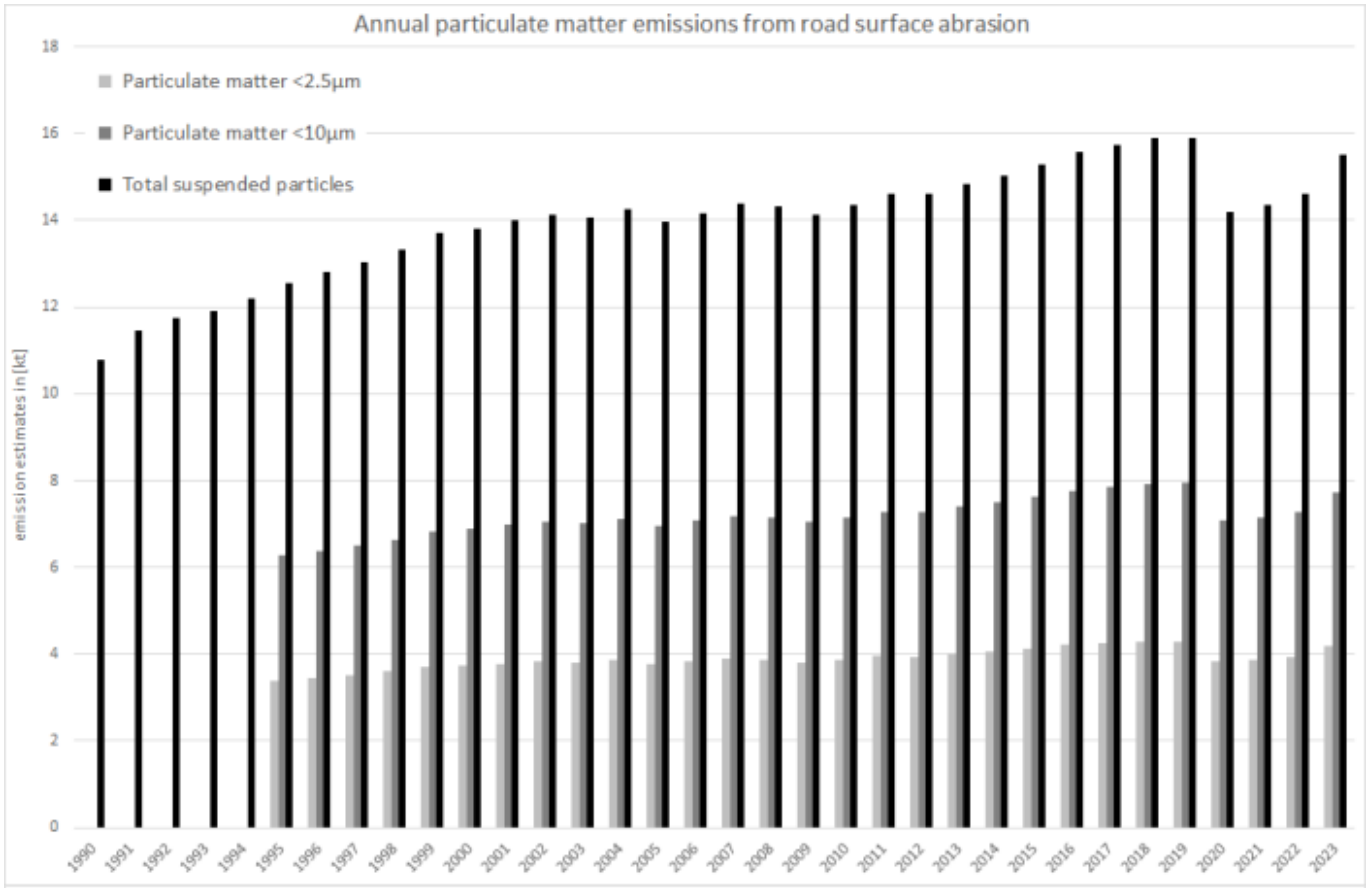
Discussion of emission trends

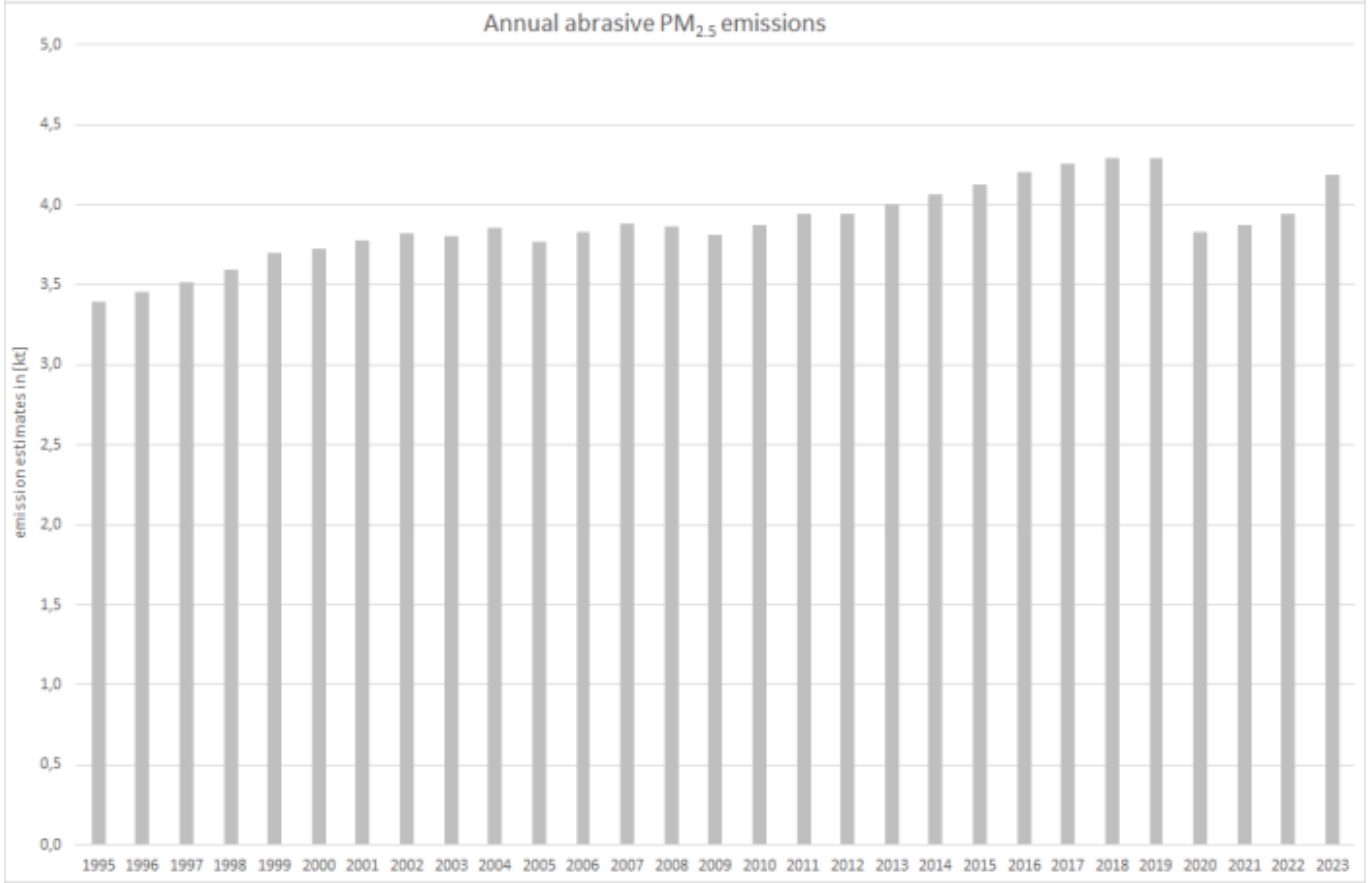
Table 2: Outcome of Key Category Analysis

for:	**TSP**	**PM_{10}**	**$PM_{2.5}$**
by:	Level	Level	Level

Emissions from road abrasion are directly linked to driven mileage. Thus, the overall trend of emissions from road abrasion is similar to the trend for total driven mileage.

Here, as described for tyre and brake wear, after a moderate decrease during the Covid-19 pandemic, mileage related abrasive emissions show a steady recovery not yet reaching pre-pandemic levels.





Recalculations

With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

1.A.3.c - Transport: Railways

NFR-specific inventory data

Short description

In category *1.A.3.c - Railways*, emissions from fuel combustion in German railways and from the related abrasion and wear of contact line, braking systems and tyres on rails are reported.

Category Code	Method	AD	EF
1.A.3.c	T1, T2	NS, M	CS, D, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	-/-	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	**L/-**	**L/-**	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Germany's railway sector is undergoing a long-term modernisation process aimed at making electricity the main energy source for rail transports. Use of electricity, instead of diesel fuel, to power locomotives has been continually increased, and electricity now provides over 80% of all railway traction power. Railways' power stations for generation of traction current

are allocated to the stationary component of the energy sector (1.A.1.a) and are not included in the following. In energy input for trains of German railways, diesel fuel is the only energy source that plays a significant role apart from electric power.

Methodology

Activity Data

Generally, total inland deliveries of *diesel oil* are available from the National Energy Balances (NEBs) (AGEB, 2024) [1)]. This data is based upon sales data of the Association of the German Petroleum Industry (MWV) [2)]. As a revision of this MWV data for the years 2005 to 2009 was not adopted to the respective National Energy Balances, the original MWV data are applied for this five years.

Data on the consumption of biodiesel in railways is provided in the NEBs as well, from 2004 onward. However, the data applied in the emissions inventory are based on the average annual shares of biodiesel added to the fossil diesel oil.

In addition, rather small quantities of *solid fuels* are used for historical steam engines vehicles operated mostly for tourism and exhibition purposes. Official fuel delivery data are available for lignite, through 2002, and for hard coal, through 2000 only. Therefore, in order to complete these time series, operator surveys were carried out in 2012 [3)], 2016 [4)] and 2021 [5)]. During these surveys, questionnaires were provided to any known operator of historical steam engines in Germany. Here, due to limited data archiving, nearly complete data could only be gained for years as of 2005 and for the main operators only. For earlier years and a variety of smaller operators, conservative gap filling was applied.

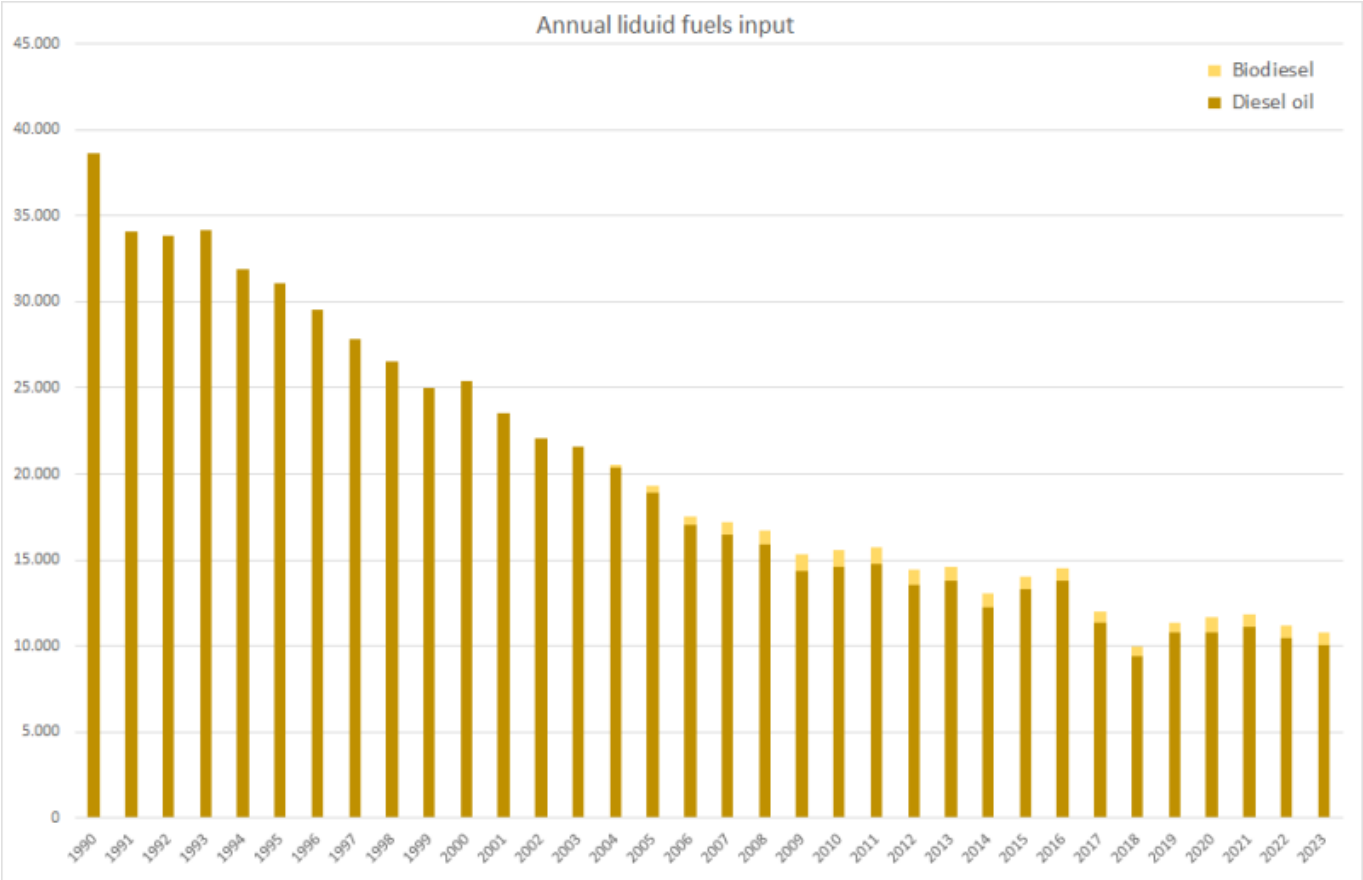
Table 1: Overview of activity-data sources for domestic fuel sales to railway operators

Activity	**data source / quality of activity data**
combustion of:	
Diesel oil	1990-2004: NEB lines 74 & 61: 'Schienenverkehr' / 2005-2009: MWV annual report, table: 'Sektoraler Verbrauch von Dieselkraftstoff' / from 2010: NEB line 61
Biodiesel	calculated from official blending rates
Hard coal	1990-1994: NEB line 74; 1995-2004: interpolation; 2005, 2010, 2015, 2019 and 2020: survey data; as of 2021: extrapolation
Hard coal coke	1990-1997: NEB lines 74 & 61; 1998-2004: interpolation; 2005, 2010, 2015, 2019 and 2020: survey data; as of 2021: extrapolation
Raw lignite	from 1990: NEB lines 74 & 61
Lignite briquettes	from 1990: NEB lines 74 & 61
abrasion and wear of contact line, braking systems and tyres on rails:	
transport performance data	in Mio ptkm (performance-ton-kilometers) derived from the TREMOD model

Table 2: Annual fuel consumption in German railways, in terajoules

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Diesel Oil	38,605	31,054	25,410	18,877	14,626	13,321	13,775	11,344	9,425	10,747	10,782	11,072	10,482	10,039
Biodiesel	0	0	0	434	976	738	745	618	532	610	882	776	727	744
Liquids TOTAL	**38,605**	**31,054**	**25,410**	**19,311**	**15,602**	**14,059**	**14,520**	**11,962**	**9,957**	**11,357**	**11,664**	**11,848**	**11,210**	**10,783**
Lignite Briquettes	200	86	1.33	0.79	0.79	0.66	0.63	0.46	0.46	0.43	0.22	0.35	0.35	0.35
Hard Coal	576	232	223	267	324	351	361	367	365	362	306	325	325	325
Hard Coal Coke	2,000	1,309	431	14.6	7.32	0.02	1.19	1.21	1.20	1.20	1.12	1.15	1.15	1.15
Solids TOTAL	**2,776**	**1,627**	**655**	**283**	**332**	**352**	**363**	**368**	**367**	**363**	**308**	**327**	**327**	**327**
Σ 1.A.3.c	**41,381**	**32,681**	**26,065**	**19,594**	**15,934**	**14,411**	**14,883**	**12,331**	**10,324**	**11,720**	**11,972**	**12,175**	**11,536**	**11,110**

The use of other fuels – such as vegetable oils or gas – in private narrow-gauge railway vehicles has not been included to date and may still be considered negligible.



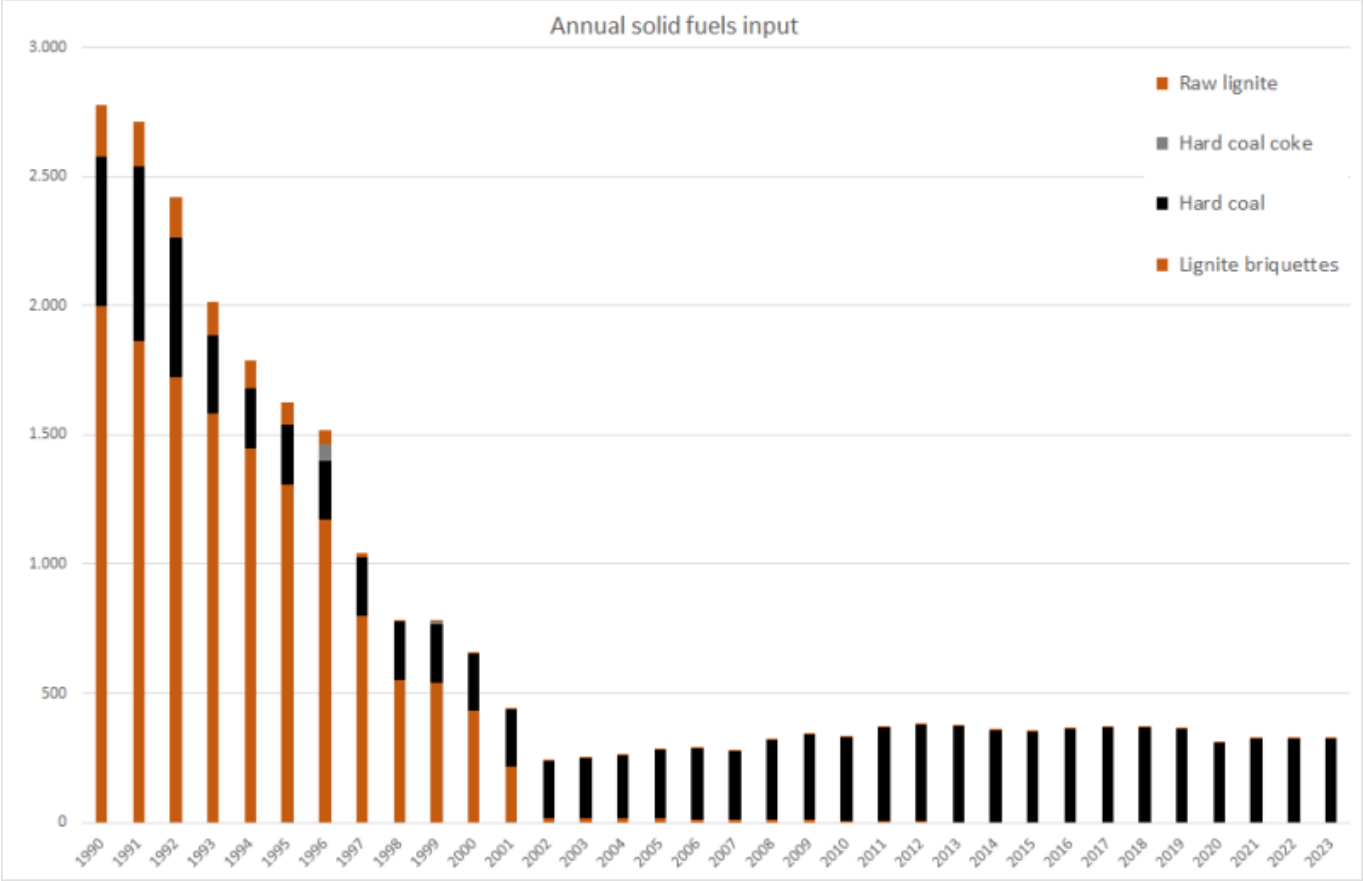
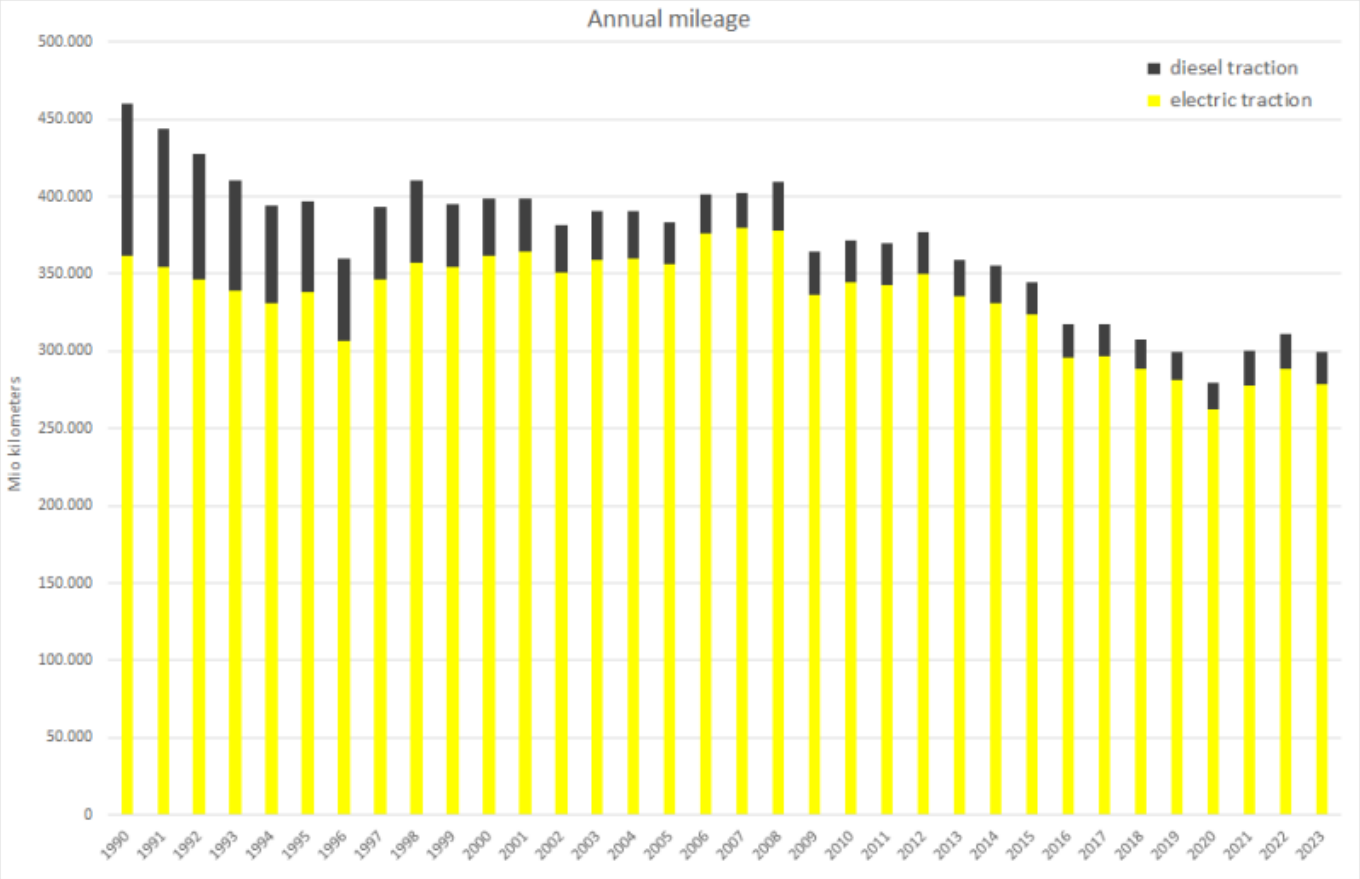


Table 3: Annual transport performance by mode of traction, in Mio tkm (ton-kilometers)

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel	98,812	58,805	37,237	26,540	26,702	21,397	21,484	21,365	19,580	18,058	16,917	23,028	22,733	21,028
Electric	361,515	337,853	361,633	356,605	344,546	323,387	295,798	296,280	288,336	281,130	262,268	277,395	288,761	278,660

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Σ 1.A.3.c	**460,326**	**396,658**	**398,870**	**383,145**	**371,248**	**344,785**	**317,282**	**317,645**	**307,916**	**299,188**	**279,184**	**300,423**	**311,494**	**299,688**



Transport performance showed only a moderate pandemic-related decrease in 2020 and has fully recovered in 2021 and 2022.

Regarding particulate-matter and heavy-metal emissions from **abrasion and wear of contact line, braking systems, tyres on rails**, annual transport performances of railway vehicles with electrical and Diesel traction derived from Knörr et al. (2024a) [6)] are applied as activity data.

Emission factors

The (implied) emission factors used here for estimating **emissions from diesel fuel combustion** are of very different quality:

For the main pollutants, CO and PM, annual tier2 IEF computed within the TREMOD model are used, representing the development of German railway fleet, fuel quality and mitigation technologies [7)]. On the other hand, constant default values from (EMEP/EEA, 2019) [8)] are used for all reported PAHs and heavy metals and from Rentz et al. (2008) [9)] regarding PCDD/F. As no emission factors are available for HCB and PCBs, no such emissions have been calculated yet.

Regarding **emissions from solid fuels** used in historic steam engines, all emission factors displayed below have been adopted from small-scale stationary combustion.

Furthermore, regarding **emissions from abrasion and wear**, emission factors are calculated from PM_{10} emission estimates directly provided by the German railroad company Deutsche Bahn AG.

As these original emissions are only available as of 2013, implied EF($PM_{,10}$) were calculated from the emission estimates extrapolated backwards from 2013 to 1990 and the transport performance data available from TREMOD.

Regarding $PM_{2.5}$, and TSP, due to leck of better information, a fractional distribution of 0.5 : 1 : 1 ($PM_{2.5}$: PM_{10} : TSP) is assumed for now. Emission factors for emssions of copper, nickel and chrome are calculated via typical shares of the named metals in the contact line (copper) and in the braking systems (Ni and Cr). Other heavy metals contained in alloys used for

the contact line (silver, magnesium, tin) are not taken into account here. Furthermore, emissions from other wear parts (e.g. the current collector) are not estimated. However, these components are not supposed to contain any of the nine heavy metals to be reported here (current collectors are made of aluminium alloys and coal).

Table 3: Annual country-specific emission factors for diesel fuels[1], in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
NH_3	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
NMVOC	109	100	90.2	64.8	52.0	39.2	39.3	38.0	37.0	36.6	38.1	37.3	34.9	33.5
NO_x	1,170	1,207	1,225	1,111	970	826	803	776	750	708	742	745	697	679
SO_x	196	60.5	14.1	0.32	0.32	0.32	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
PM^2	28.8	28.3	23.8	15.2	11.5	8.67	8.54	8.05	7.71	7.44	7.95	7.97	7.30	6.95
BC^3	44.4	43.6	36.6	23.4	17.7	13.3	13.1	12.4	11.9	11.4	12.2	12.3	11.2	10.7
CO	287	292	255	162	121	95.8	95.1	94.0	91.4	90.3	90.9	90.5	87.7	86.5

[1] due to lack of better information: similar EF are applied for fossil diesel oil and biodiesel
[2] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: >99% of TSP consists of $PM_{2.5}$)
[3] EFs calculated via f-BCs as provided in [10)], Chapter: 1.A.3.c - Railways, Appendix A: tier1: diesel fuels: f-BC=0.56

Table 4: Emission factors applied for solid fuels, in kg/TJ

	NH_3	NMVOC	NO_x	SO_x	$PM_{2.5}$	PM_{10}	TSP	BC^1	CO
Hard coal	4.00	15.0	120	650	222	250	278	14.2	500
Hard coal coke	4.00	0.50	120	500	15.0	15.0	15.0	0.96	1,000

[1] EFs calculated via f-BCs as provided in [11)], Chapter: 1.A.4 - Small Combustion: Residential combustion (1.A.4.b): Table 3-3, Zhang et al., 2012): f-BC=0.064

Table 5: Country-specific emission factors for abrasive emissions, in [g/performance-tonnes km] and for 2022

	$PM_{2.5}$	PM_{10}	TSP	BC	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Contact line [1]	0.00018	0.00036	0.00036	NA	NA	NA	NA	NA	NA	0.00033	NA	NA	NA
Tyres on rails [2]	0.010	0.020	0.020	NA	NA								
Braking system [3]	0.004	0.008	0.008	NA	NA	NA	NA	NA	0.00008	NA	0.00016	NA	NA
Current collector [4]	NE	NE	NE	NE	NA								

[1] assumption: 100 per cent copper
[2] assumption: 100 per cent steel
[3] assumption: steel alloy containing Chromium and Nickel
[4] typically: aluminium alloy + coal contacts; no particulate matter emissions calculated yet

With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [7)]

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Discussion of emission trends

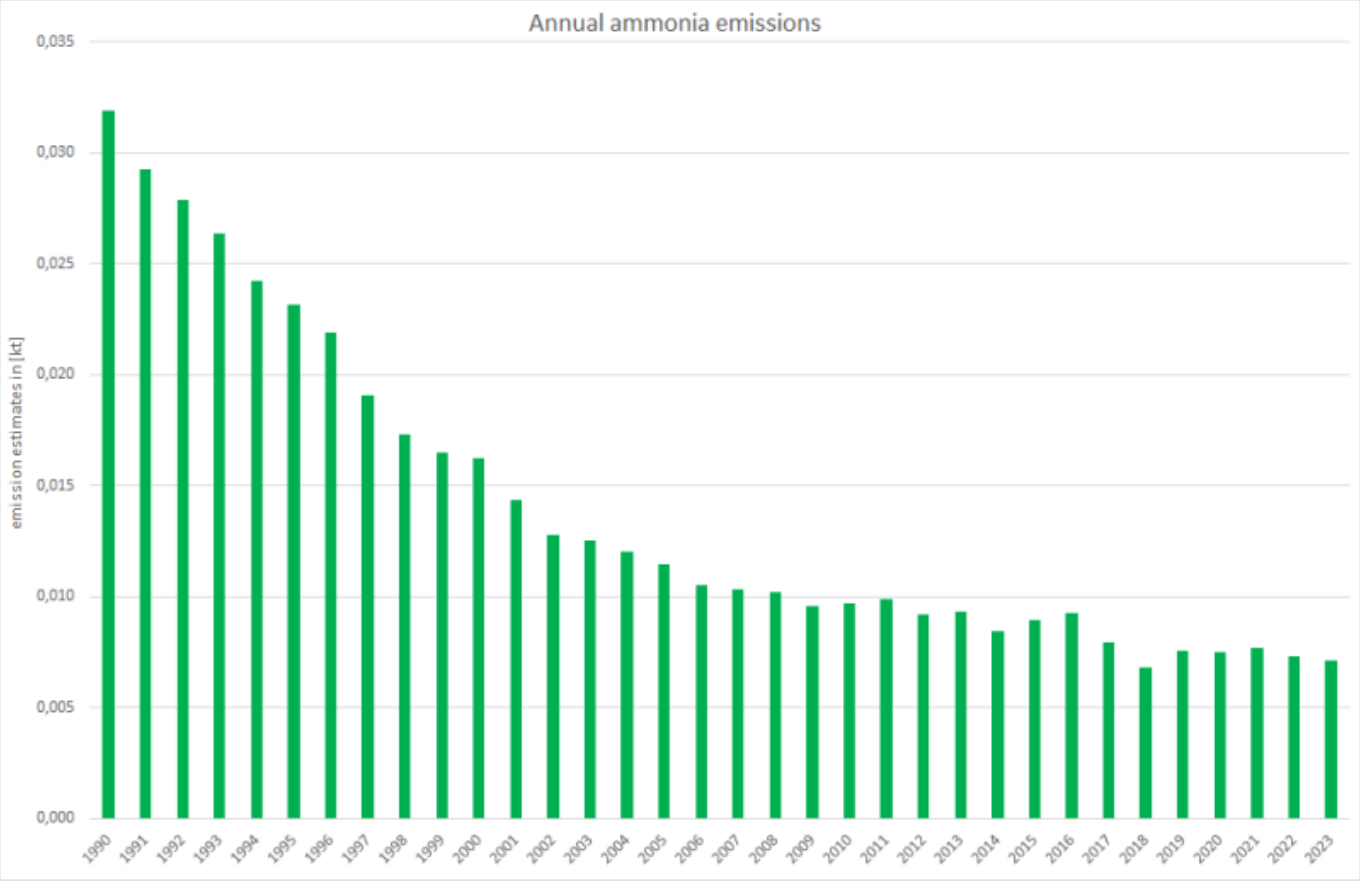
Table 6: Outcome of Key Category Analysis

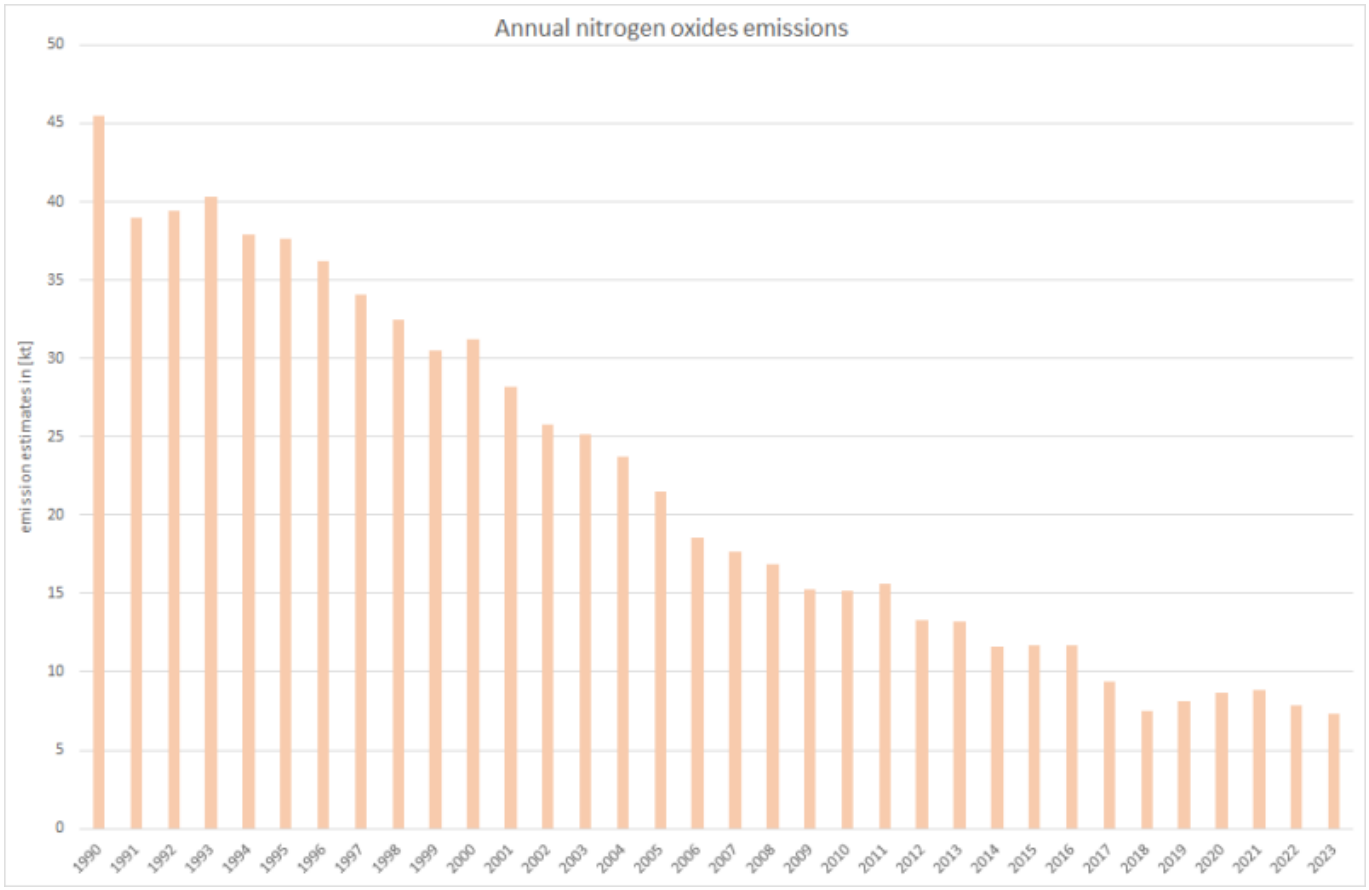
for:	TSP	PM_{10}	$PM_{2.5}$

by:	L/-	L/-	L/-

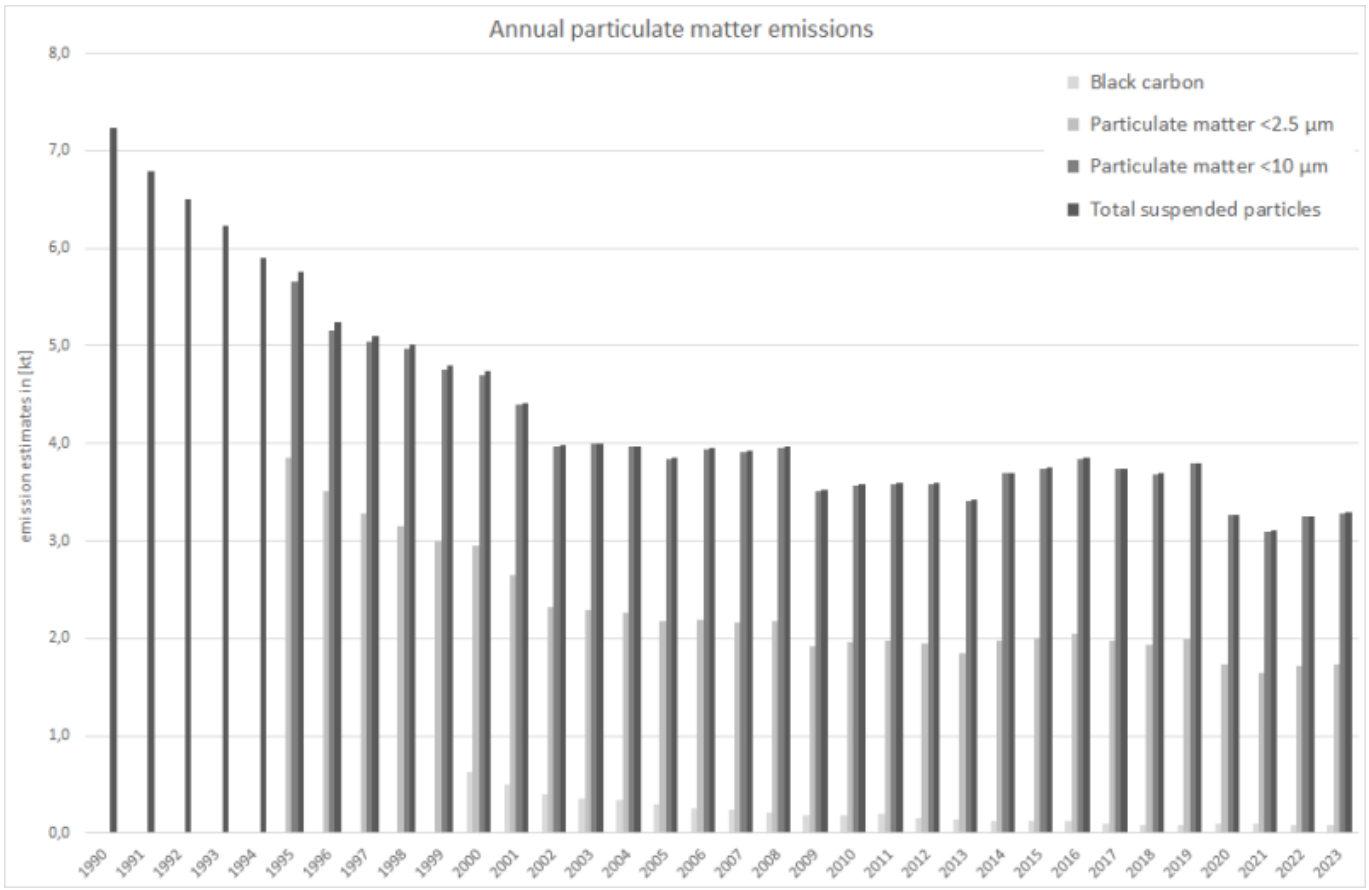
Basically, for all unregulated pollutants, emission trends directly follow the trend in over-all fuel consumption.

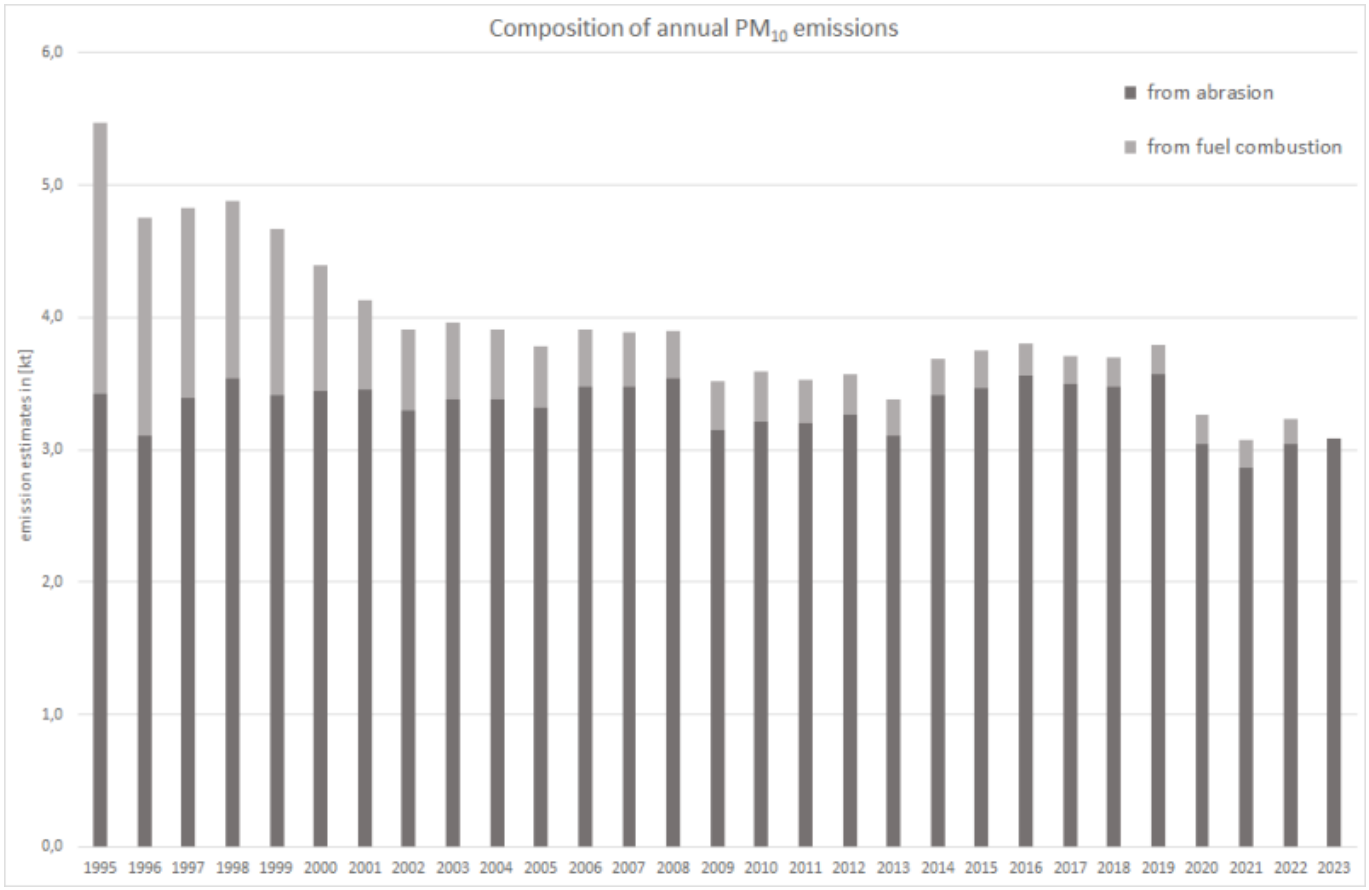
Here, as emission factors for solid fuels tend to be much higher than those for diesel oil, emission trends are disproportionately effected by the amount of solid fuels used. Therefore, for the **main pollutants**, **carbon monoxide**, **particulate matter** and **PAHs**, emission trends show remarkable jumps especially after 1995 that result from the significantly higher amounts of solid fuels used.



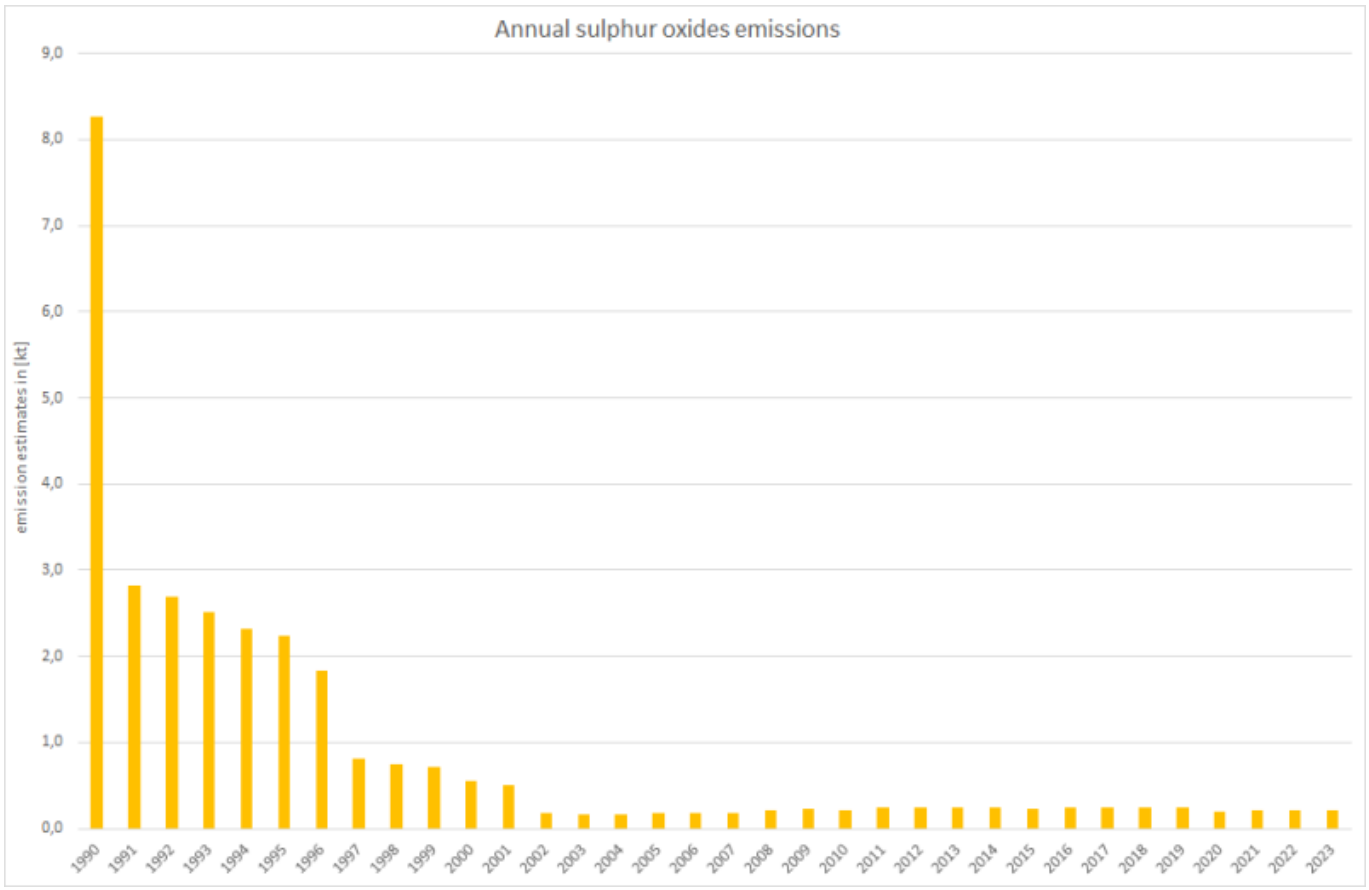


For all fractions of **particulate matter**, the majority of emissions generally result from abrasion and wear and the combustion of diesel fuels. Additional jumps in the over-all trend result from the use of lignite briquettes (1996-2001). Here, as the EF(BC) for fuel combustion are estimated via fractions provided in [12)], black carbon emissions follow the corresponding emissions of $PM_{2.5}$.

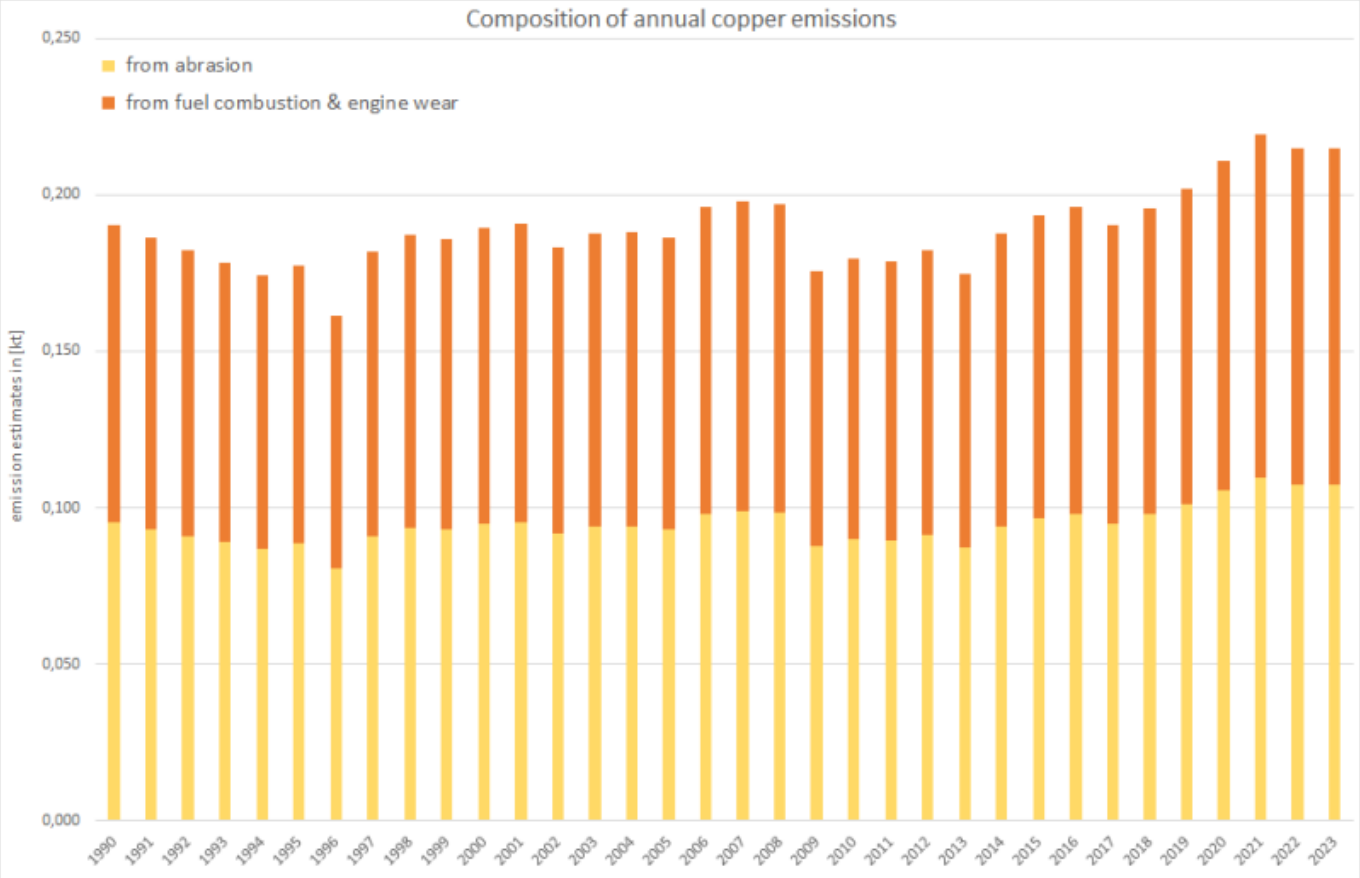




Due to fuel-sulphur legislation, the trend of **sulphur dioxide** emissions follows not only the trend in fuel consumption but also reflects the impact of regulated fuel-qualities. For the years as of 2005, sulphur emissions from diesel combustion have decreased so strongly, that the over-all trend shows a slight increase again due to the now dominating contribution of sulphur from the use of solid fuels.



Regarding **heavy metals**, emissions from combustion of diesel oil and from abrasion and wear are estimated from tier1 default emission factors. Therefore, the emission trends reflect the development of diesel use and - for copper, chromium and nickel emissions resulting from the abrasion & wear of contact line and braking systems - the annual transport performance (see description of activity data above).



Recalculations

Activity data have been recalculated only due to the finalization of the National Energy Balances 2022.

Table 5: Revised fuel consumption data 2022, in terajoule

	DIESEL OIL	BIODIESEL	RAW LIGNITE	LIGN. BRIQU.	COKE OVEN COKE	BITUMIN. COAL	TOTAL
current submission	10.482	727	0	1.15	0.35	325	**11,536**
previous submission	10.464	727	0	1.15	0.35	325	**11,518**
absolute change	18.2	0.01	0.00	0.00	0.00	0.00	**18.2**
relative change	0.17%	0.002%	0.00%	0.00%	0.00%	0.00%	**0.16%**

Furthermore, due to the routine revision of the TREMOD model [13)], tier2 **emission factors** changed for recent years.

In addition, abrasive PM_{10} emissions as derived from a model hosted at the DB AG have been revised. Here, especially the emission factors for PM_{10} emissions from the abrasion of tyre on rail and gray cast iron brakes were reduced significantly due to most recent results from a measurement campaign [14)] and for all years:

Table 6: Revised abrasive PM_{10} emissions, from DB AG, in [kt]

	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
current submission	5.66	4.70	3.84	3.57	3.74	3.84	3.73	3.69	3.79	3.26	3.09	3.25
previous submission	10.7	9.76	8.70	8.28	8.76	8.64	8.41	8.56	8.66	8.10	8.70	8.99

	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
absolute change	-5.03	-5.06	-4.86	-4.71	-5.01	-4.80	-4.67	-4.88	-4.87	-4.84	-5.61	-5.75
relative change	-47.1%	-51.8%	-55.8%	-56.9%	-57.3%	-55.5%	-55.6%	-56.9%	-56.2%	-59.8%	-64.4%	-63.9%

All abrasive particulate matter and heavy metal (Cu, Cr, Ni) emissions estimated based on these original PM_{10} emissions were revised accordingly.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023 (title: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland”) carried out by Knörr et al. (2009) [15)].

Planned improvements

Besides the scheduled **routine revision** of TREMOD, no further improvements are planned for the next annual submission.

FAQs

Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?

The EF provided in the 2019 EMEP/EEA Guidebook [16)] represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metals contained in the biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel.

[1)] AGEB, 2024: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

[2)] MWV (2021): Association of the German Petroleum Industry (Mineralölwirtschaftsverband, MWV): Annual Report 2018, page 65, Table 'Sektoraler Verbrauch von Dieselkraftstoff 2012-2019'; https://www.mwv.de/wp-content/uploads/2020/09/MWV_Mineraloelwirtschaftsverband-e.V.-Jahresbericht-2020-Webversion.pdf, Berlin, 2021.

[3)] Hedel, R., & Kunze, J. (2012): Recherche des jährlichen Kohleeinsatzes in historischen Schienenfahrzeugen seit 1990. Probst & Consorten Marketing-Beratung. Dresden, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2012.

[4)] Illichmann, S. (2016): Recherche des Festbrennstoffeinsatzes historischer Schienenfahrzeuge in Deutschland 2015, Probst & Consorten Marketing-Beratung, on behalf of the Umweltbundesamt, Dessau-Roßlau, unpublished, 2016.

[5)] Hasenbalg (2021): Recherche des Festbrennstoffeinsatzes historischer Schienenfahrzeuge in Deutschland 2019 & 2020, Probst & Consorten Marketing-Beratung, FKZ 363 01 392; un published; Dresden, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2021.

[6), 13)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2024.

[8), 12), 16)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-c-railways/view; Copenhagen, 2019.

[9)] Rentz et al. (2008): Otto Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung,

Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), FKZ 205 67 444, UBA Texte 01/2008, https://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008

[10)] (bibcite 6)

[11)] (bibcite 6)

[14)] DZSF (2025): Deutsches Zentrum für Schienenverkehrsforschung / German Centre for Rail Traffic Research) research project on “Size-specific and spatial distribution of traffic-related abrasion and particulate emissions” (Größenspezifische und räumliche Verteilung von verkehrsbedingten Abrieben und partikulären Emissionen); https://www.dzsf.bund.de/SharedDocs/Standardartikel/DZSF/Projekte/Projekt_44_Abriebe_Emissionen.html, 2025

[15)] Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

[7)]

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.A.3.d - Navigation

Short description

Category *1.A.3.d - Navigation* includes emissions from national and international inland and maritime navigation.

NFR-Code	Name of Category	Method	AD	EF	Key Category Analysis
1.A.3.d	**Navigation**	*see sub-category details*			
consisting of / including source categories					
1.A.3.d i (ii)	International Inland Waterways	*Germany does not report emissions from this sub-category.*			
1.A.3.d ii	National Navigation (Shipping)	*see sub-category details*			
1.A.3.d i (i)	International Maritime Navigation	*see sub-category details*			

Methodology

Activity Data

Primary fuel deliveries data for the entire navigation sector (maritime and inland waterways) is included in lines 6 ('International Maritime Bunkers') and 64 ('Coastal and Inland Navigation') of the National Energy Balance (NEB) (AGEB, 2024) [1)]. (For comparison, official mineral-oil data of the Federal Office of Economics and Export Control (BAFA, 2024) [2)] are applied, too.)

Data on the consumption of *biodiesel* is provided in NEB line 64 from 2004 onward. However, as this data appears to be rather inconsistent, the consumption of biofuels is calculated within TREMOD via the official annual blending rates.

Table 1: Primary fuel deliveries as listed in the National Energy Balance, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
NEB line 6 - Maritime Bunkers ('Hochseebunkerungen')														
Diesel	23,336	20,426	21,542	18,342	22,340	43,254	42,198	9,822						
Light fuel oil (Heating oil)	NO							26,958	31,266	30,087	22,684	30,118	31,498	26,939
Heavy fuel oil	80,230	64,382	69,578	86,272	93,886	57,386	75,445	58,277	39,248	26,813	32,431	28,106	29,651	26,871
LNG[1]	NO					22.0	64.4	58.8	197	153	276	293	513	382
NEB line 64 - Coastal and Inland Navigation ('Küsten- und Binnenschifffahrt')														
Diesel oil	27,716	23,562	11,864	19,842	18,370	15,894	14,529	14,907	14,813	14,660	14,029	12,003	9,275	9.887
LPG	*7.00*	*7.00*	*7.00*	7.02	7.08	7.10	7.25	7.06	7.13	7.16	7.40	7.51	7.55	7.61
Gasoline	*272*	*272*	*272*	274	261	265	265	266	262	265	269	273	275	276
Biogasoline[2]	NO			1.90	10.1	10.7	10.8	10.8	11.3	10.9	12.0	12.9	12.8	13.0
TOTAL inland fuel deliveries	**131,561**	**108,649**	**103,263**	**124,739**	**134,875**	**116,838**	**132,520**	**110,305**	**85,805**	**71,996**	**69,708**	**70,812**	**71,232**	**64,375**

data sources: fossil liquid fuels: NEB [3)]; [1]LNG (as not yet included in NEB): BSH model [4)], [2]biogasoline: TREMOD [5)]
italic numbers: extrapolated backwards as data provided in NEB only as of 2003

As the statistical allocation of fuels delivered to the navigation (shipping) sector follows tax aspects, NEB line 6 ('International Maritime Bunkers') includes all fuel deliveries to IMO-registered ship involved in both national and international maritime activities. On the other hand, NEB line 64 ('Coastal and Inland Navigation') includes all fuel deliveries to ship involved in inland and non-IMO maritime navigation.

Table 2: Allocation of for subsector-specfic fuel deliveries data in the NEB

NEB line	including fuel deliveries to navigation sub-sectors…
6 - 'International Maritime Bunkers'	…international maritime navigation / national maritime navigation (IMO) / national fishing (IMO) / military navigation (IMO)

64 - 'Coastal and Inland Navigation'	...national inland navigation / national maritime navigation (non-IMO) / national fishing (non-IMO) / military navigation (non-IMO)

Therefore, the amounts of fuels listed in NEB lines 6 and 64 are broken down on several sub-sectors.

Regarding all national maritime activities, taking place in National Maritime Navigation, national fishing, and military navigation, a country-specific approach allows for estimating tier3 fuel consumption data based on ship movement information (AIS signal) for IMO- and non-IMO ships.

In contrast to this bottom-up approach, fuel consumption in both *international maritime navigation* and *national inland navigation* are calculated as tier1 estimates. The following equations and charts try to illustrate the way of deducing these tier1 activity data:

Estimating the tier1 activity data for International maritime navigation:

$AD_{1.A.3.d\ i} = PAD_{NEB\ line\ 6} - AD_{1.A.3.d\ ii\ (a)\ -\ IMO} - AD_{1.A.4.c\ iii\ -\ IMO} - AD_{1.A.5.b\ iii\ -\ IMO}$	with * $AD_{1.A.3.d\ i}$ - tier1 activity data for International maritime navigation * $PAD_{NEB\ line\ 6}$ - primary over-all fuel deliveries data from NEB line 6 - 'International Maritime Bunkers' * $AD_{1.A.3.d\ ii\ (a)\ -\ IMO}$ - tier3 activity data for IMO-registered ships involved in national maritime navigation * $AD_{1.A.4.c\ iii\ -\ IMO}$ - tier3 activity data for IMO-registered ships involved in national fishing * $AD_{1.A.5.b\ iii\ -\ IMO}$ - tier3 activity data for IMO-registered ships involved in military navigation

Estimating the tier1 activity data for National inland navigation:

$AD_{1.A.3.d\ ii\ (b)} = PAD_{NEB\ line\ 64} - AD_{1.A.3.d\ ii\ (a)\ -\ non\text{-}IMO} - AD_{1.A.4.c\ iii\ -\ non\text{-}IMO} - AD_{1.A.5.b\ iii\ -\ non\text{-}IMO}$	with * $AD_{1.A.3.d\ ii\ (b)}$ - tier1 activity data for National inland navigation * $PAD_{NEB\ line\ 64}$ - primary over-all fuel deliveries data from NEB line 64 - 'Coastal and Inland Navigation' * $AD_{1.A.3.d\ ii\ (a)\ -\ non\text{-}IMO}$ - tier3 activity data for non-IMO ships involved in national maritime navigation * $AD_{1.A.4.c\ iii\ -non\text{-}IMO}$ - tier3 activity data for for non-IMO ships involved in national fishing * $AD_{1.A.5.b\ iii\ -\ non\text{-}IMO}$ - tier3 activity data for for non-IMO ships involved in military navigation

Table 3: Resulting breakdown of primary fuel deliveries onto the different navigation sub-sectors, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
TOTAL	**131,561**	**108,649**	**103,263**	**124,739**	**134,875**	**116,838**	**132,520**	**110,305**	**85,805**	**71,996**	**69,708**	**70,812**	**71,232**	**64,375**
1.A.3.d i - International maritime navigation														
Diesel oil	13,162	13,096	13,709	11,546	16,273	33,836	32,424	27,370	16,000	NO				
Light fuel oil	NO								5,333	20,104	13,606	21,260	23,267	18,657
Heavy fuel oil	76,942	62,066	67,080	84,127	91,992	57,278	75,408	58,196	38,986	26,418	32,053	27,713	29,414	26,633
1.A.3.d ii (a) - National maritime navigation														
Diesel oil	9,484	6,828	7,367	6,399	5,690	8,980	9,335	8,960	7,084	NO				
Light fuel oil	NO								2,361	9,497	8,329	8,475	7,879	7,922
Heavy fuel oil	3,103	2,186	2,382	2,054	1,810	108	37,0	81,1	262	394	378	392	237	237
LNG	NO					22.0	64.4	58.8	197	153	276	293	513	382
1.A.3.d ii (b) - National inland navigation														
Diesel oil	27,716	23,562	11,864	19,842	18,370	15,894	14,529	14,907	14,813	14,660	14,029	12,003	9,275	9,887
Gasoline	272	272	272	274	261	265	265	266	262	265	269	273	275	276
Biogasoline				1.90	10.1	10.7	10.8	10.8	11.3	10.9	12.0	12.9	12.8	13.0
LPG	7.00	7.00	7.00	7.02	7.08	7.10	7.25	7.06	7.13	7.16	7.40	7.51	7.55	7.61
1.A.4.c iii - National Fishing														
Diesel oil	305	240	238	226	227	284	298	293	267	NO				
Light fuel oil	NO								88.9	322	359	265	221	225

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
TOTAL	**131,561**	**108,649**	**103,263**	**124,739**	**134,875**	**116,838**	**132,520**	**110,305**	**85,805**	**71,996**	**69,708**	**70,812**	**71,232**	**64,375**
Heavy fuel oil	33.3	26.0	26.0	24.4	24.5	NO								
1.A.5.b iii - Military Navigation														
Diesel oil	380	263	228	171	150	154	141	156	99.5	NO				
Light fuel oil	NO								33.2	164	390	118	131	135
Heavy fuel oil	152	104	90.4	67.4	59.0	NO								

Emission factors

Annual country-specific emission factors have been developed within the underlying models maintained at the ifeu Institute for Energy and Environmental Research (Knörr et al. (2024a): TREMOD) [6)] and the Federal Maritime and Hydrographic Agency (Deichnik (2024): BSH model) [7)].

For information on these country-specific emission factors, please refer to the sub-chapters linked above.

Impact of fuel-sulphur regulation on sulphur dioxide

Table 4: Development of fuel-sulfur limits for maritime fuels in SECAs, in [% m/m]

mid-2006 to mid-2010	1.50	
mid-2010 to 2015	1.00	LSFO[2]
as of 2015	0.10	ULSFO[3]

[1]: SECA = Sulphur Emission Control Area [8)], [9)] [2]: Low sulphur Fuel Oil [3]: Ultra low sulphur Fuel Oil

These fuel-sulfur limits listed are used for the derivation of emission factors especially for heavy fuel oil used in the German inventory. Here, until 2006, a global average of 2.70 % m/m is applied.

Table 5: Development of global fuel-sulfur limits for maritime fuels, in [% m/m]

until 2012	4.50
2012 to 2020	3.50
as of 2020	0.50

Heavy metals and POPs

For heavy metal and POP emissions, tier1 EF have been derived from the EMEP/EEA Guidebook 2019 mainly [10)].

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Table 4 shows the tier1 emission factors for exhaust emissions of **heavy-metals** and **POPs** as applied to all navigation sub-categories in 1.A.3.d as well as NFRs 1.A.4.c iii and 1.A.5.b iii. The listed values have been derived from default values provided in the EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2019) [11)] and (Rentz et al., 2008) [12)].

Here, as the guidebook does not provide source-specific values for **PAHs**, respective values provided for diesel in railways and heavy duty road vehicles have been applied as a gap-filling proxy.

Table 6: Tier1 emission factors for heavy-metal and POP exhaust emissions

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	B[a]P	B[b]F	B[k]F	I[...]p	PAH 1-4	PCBs	HCB	PCDD/F

	[g/TJ]									[mg/TJ]							
Diesel oil & Light fuel oil	3.03 [2]	0.233 [2]	0.698 [2]	0.93 [2]	1.16 [2]	20.5 [2]	23.3 [2]	2.33 [2]	27.9 [2]	698 [5]	1,164 [5]	801 [6]	184 [6]	2,847 [4]	0.885 [2]	1.86 [2]	93.0 [7]
Heavy fuel oil	4.46 [3]	0.496 [3]	0.496 [3]	16.9 [3]	17.8 [3]	31.0 [3]	793 [3]	5.20 [3]	29.7 [3]	741 [5]	1,235 [5]	849 [6]	195 [6]	3,020 [4]	14.1 [3]	3.46 [3]	98.7 [7]

[2] tier1 defaults from [13)], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Table 3-2
[3] tier1 defaults from [14)], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Table 3-1
[4] sum of tier1 default values applied for B[a]P, B[b]F, B[k]F, and I[1,2,3-c,d]P
[5] tier1 defaults from [15)], Chapter: 1.A.3.c Railways: Diesel, Table 3-1
[6] tier1 defaults from [16)], Chapter: 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv - Road transport, Table 3-8: HDV, Diesel
[7] tier1 value derived from [17)]

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1), 3) AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

2) BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.

5), 6) Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2024.

7) Deichnik (2024): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs. from Bundesamts für Seeschifffahrt und Hydrographie (BSH - Federal Maritime and Hydrographic Agency); on behalf of the Umweltbundesamt, Hamburg / Dessau-Roßlau, 2024.

8) Wikipedia, 2023: https://en.wikipedia.org/wiki/Emission_control_area

9) IMO, 2014: https://arquivo.pt/wayback/20141223211746/http:/www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-(SOx)-%e2%80%93-Regulation-14.aspx

10), 11), 13), 14), 15), 16) EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019.

12), 17) Rentz et al., 2008: Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, https://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008.

1.A.3.d ii - National Navigation

Short description

Under category *1.A.3.d ii - National Navigation* emissions from national navigation (both inland and maritime) are reported.

Category Code	Method	AD	EF
1.A.3.d ii	T1, T2, T3	NS, M	CS, D, M
covering emissions in:			
Domestic maritime navigation	T1, T2, T3	NS, M	CS, D, M
Domestic inland navigation	T1, T2, T3	NS, M	CS, D, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/F**	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAH1-4**	**HCB**	**PCBs**
L/-	-/-	-/-	-/-	**L/T**	**-/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

As described for the over-all sector 1.A.3.d and all other navigational activities in the superordinate chapter, specific fuel consumption data for NFR 1.A.3.d ii is included in the primary fuel deliveries data provided in NEB lines 6 ('International

Maritime Bunkers') and 64 ('Coastal and Inland Navigation') [1)].

Here, the annual fuel consumption for domestic *maritime* navigation are modelled within [2)] based on AIS data and deduced from NEB lines 6 and 64 respectively, depending on whether or not a certain ship is registered by the International Maritime Organization (IMO). Here, fuels consumed by large, IMO-registered and sea-going ships and vessels are included in NEB line 6 whereas fuels consumed by smaller ships without IMO-registration are included in NEB line 64. After these deductions, the amounts of fuels remaining in NEB 64 are allocated to domestic *inland* navigation.

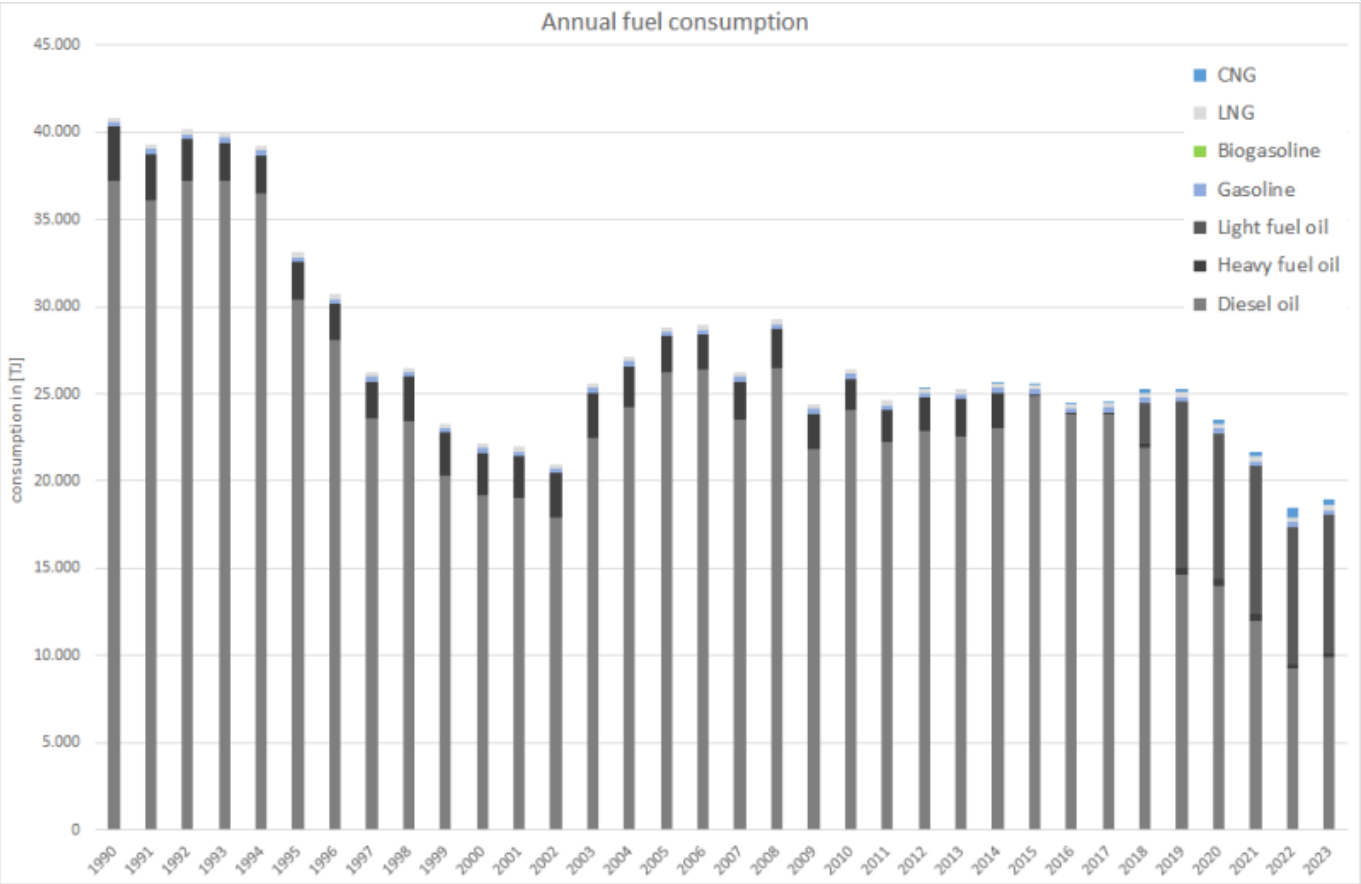
The small amounts of LNG used almost entirely in ferries are not yet included in the NEB but are estimated directly in the BSH model.

Table 1: Annual over-all fuel consumption for domestic navigation, in terajoule

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel Oil	37,199	30,389	19,231	26,241	24,060	24,874	23,863	23,866	21,897	14,660	14,029	12,003	9,275	9,887
Light Fuel Oil									2,361	9,497	8,329	8,475	7,879	7,922
Heavy fuel oil	3,103	2,186	2,382	2,054	1,810	108	37.0	81.1	262	394	378	392	237	237
LNG						22.0	64.4	58.8	197	153	276	293	513	382
Gasoline	272	272	272	274	261	265	265	266	262	265	269	273	275	276
Biogasoline				1.90	10.1	10.7	10.8	10.8	11.3	10.9	12.0	12.9	12.8	13.0
LPG	7.00	7.00	7.00	7.02	7.08	7.10	7.25	7.06	7.13	7.16	7.40	7.51	7.55	7.61
Σ 1.A.3.d ii	**40,582**	**32,854**	**21,892**	**28,577**	**26,149**	**25,286**	**24,248**	**24,290**	**24,997**	**24,988**	**23,299**	**21,456**	**18,199**	**18,724**

Table 2: Specific fuel consumption data for domestic maritime and inland navigation, in terajoule

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
NATIONAL MARITIME NAVIGATION														
Diesel Oil	9,484	6,828	7,367	6,399	5,690	8,980	9,335	8,960	7,084					
Light Fuel Oil									2,361	9,497	8,329	8,475	7,879	7,922
Heavy fuel oil	3,103	2,186	2,382	2,054	1,810	108	37.0	81.1	262	394	378	392	237	237
LNG						22.0	64.4	58.8	197	153	276	293	513	382
NATIONAL INLAND NAVIGATION														
Diesel Oil	27,716	23,562	11,864	19,842	18,370	15,894	14,529	14,907	14,813	14,660	14,029	12,003	9,275	9,887
Gasoline	272	272	272	274	261	265	265	266	262	265	269	273	275	276
Biogasoline				1.90	10.1	10.7	10.8	10.8	11.3	10.9	12.0	12.9	12.8	13.0
LPG	7.00	7.00	7.00	7.02	7.08	7.10	7.25	7.06	7.13	7.16	7.40	7.51	7.55	7.61
Σ 1.A.3.d ii	**40,582**	**32,854**	**21,892**	**28,577**	**26,149**	**25,286**	**24,248**	**24,290**	**24,997**	**24,988**	**23,299**	**21,456**	**18,199**	**18,724**



Emission factors

The emission factors applied for **national maritime navigation** are derived from different sources and therefore are of very different quality.

For the main pollutants, country-specific implied values are used, that are based on tier3 EF included in the BSH model [3)] which mainly relate on values from the EMEP/EEA guidebook 2023 [4)]. These modelled IEFs take into account the ship specific information derived from AIS data as well as the mix of fuel-qualities applied depending on the type of ship and the current state of activity.

Here, for **sulphur dioxide** and **particulate matter**, annual values are available representing the impact of fuel sulphur legislation. In addition, regarding $_2$, the increasing operation of so-called scrubbers in order to fullfil emission limits especially within SECA areas is reflected for heavy fuel oil.

Table 3: Country-specific emission factors applied for fuels used in domestic maritime navigation, in [kg/TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
DIESEL OIL & LIGHT FUEL OIL[1]														
NH_3	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
NMVOC	71.9	72.1	72.0	72.0	72.1	81.5	82.7	83.2	75.0	80.3	78.2	81.4	79.8	77.4
NO_x	1,199	1,198	1,199	1,199	1,198	1,115	1,111	1,115	1,095	1,106	1,090	1,098	1,098	1,095
SO_2	466	419	233	186	69.8	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
BC[2]	110	99.1	55.0	44.0	16.5	17.4	17.7	17.7	17.3	17.5	16.8	16.9	17.1	16.9
$PM_{2.5}$	354	320	177	142	53.3	56.2	57.1	57.1	55.9	56.5	54.2	54.6	55.2	54.6
PM_{10}	378	342	190	152	57.1	60.1	61.1	61.1	59.8	60.4	58.0	58.5	59.0	58.4
TSP[3]	378	342	190	152	57.1	60.1	61.1	61.1	59.8	60.4	58.0	58.5	59.0	58.4
CO	128	128	128	128	128	140	142	141	139	140	138	140	140	142
HEAVY FUEL OIL														
NH_3	0.33	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.35	0.34
NMVOC	96.6	96.5	96.5	96.5	96.5	104	117	131	156	172	168	156	165	166

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
NO_x	1,604	1,602	1,603	1,603	1,602	1,216	1,572	1,300	1,332	1,242	1,368	1,385	1,439	1,408
SO_x	1,319	1,332	1,323	1.336	496	48.6	49.2	48.1	45.9	46.5	48.1	47.0	47.6	47.2
BC[2]	70.8	71.2	70.8	71.6	26.5	14.2	18.0	20.1	19.1	18.9	21.4	21.3	23.2	23.4
$PM_{2.5}$	590	594	590	596	221	118	150	168	159	158	179	178	194	195
PM_{10}	649	653	649	656	243	130	165	184	175	173	197	195	213	214
TSP[3]	649	653	649	656	243	130	165	184	175	173	197	195	213	214
CO	179	179	179	179	179	144	162	157	156	150	151	147	144	142
LIQUEFIED NATURAL GAS (LNG)														
NH_3	NA					NE								
NMVOC	NA					49.3	48.5	44.4	43.3	58.5	53.7	48.9	56.2	53.2
NO_x	NA					112	112	112	112	112	112	112	112	112
SO_x	NA					NE								
BC[2]	NA					NE								
$PM_{2.5}$,PM_{10},TSP	NA					2.41	2.41	2.41	2.41	2.41	1.51	1.51	1.51	1.48
CO	NA					157	157	157	157	157	156	154	154	145

[1] identical EF applied for diesel oil and light fuel oil
[2] estimated from f-BCs as provided in [5)]: f-BC (HFO) = 0.12, f-BC (MDO/MGO) = 0.31 as provided in [6)], chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Tables 3-1 & 3-2
[3] ratio of $PM_{2.5}$: PM_{10} : TSP derived from the tier1 default EF as provided in [7)], chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Tables 3-1 & 3-2

For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

For main pollutants and particulate matter from **national inland navigation**, modelled emission factors are available from TREMOD (Knörr et al. (2024a)) [8)]. Here, for *SO_2*, and *PM*, annual values reflect the impact of fuel-sulphur legislation.

Table 4: Country-specific emission factors for diesel fuels used in domestic inland navigation, in [kg/TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
DIESEL OIL														
NH_3	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
NMVOC	96.4	87.9	77.7	72.3	66.6	61.2	60.3	59.4	58.5	58.0	57.1	56.4	55.4	54.5
NO_x	1,327	1,331	1,336	1,289	1,231	1,175	1,164	1,152	1,141	1,135	1,124	1,115	1,093	1,070
SO_x	85.2	60.5	60.5	60.5	60.5	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[1]	17.5	16.0	14.1	11.8	9.17	8.14	7.99	7.83	7.67	7.58	7.44	7.31	7.12	6.95
PM[2]	56.5	51.7	45.6	38.1	29.6	26.3	25.8	25.2	24.7	24.4	24.0	23.6	23.0	22.4
CO	417	387	337	299	256	229	225	221	216	213	209	206	203	200
GASOLINE														
NH_3	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
NMVOC (exh.)	952	1036	1269	1373	1196	897	853	813	779	753	734	722	714	710
NMVOC (evap.)	28.8	55.3	131	164	196	186	185	185	184	184	184	185	187	188
NO_x	383	375	353	345	338	341	325	299	276	256	238	223	210	199
SO_x	10.1	8.27	3.22	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[1]	2.33	2.33	2.33	2.33	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32
PM[2]	7.50	7.50	7.50	7.50	7.50	7.49	7.49	7.49	7.49	7.49	7.49	7.49	7.49	7.49
CO	30,204	30,817	32,595	33,248	26,105	18,536	17,387	16,286	15,336	14,583	13,995	13,565	13,241	12,996
LPG														
NH_3	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
NMVOC	147	147	145	145	145	145	145	145	145	144	141	134	126	116
NO_x	1,346	1,342	1,325	1,325	1,325	1,325	1,325	1,325	1,325	1,316	1,284	1,225	1,144	1,056
SO_x	0.42	0.42	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
BC[1]	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
PM[2]	0.85	0.85	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
CO	114	114	112	112	112	112	112	112	112	112	112	112	112	112

[1] calculated from f-BC as provided in [9], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii, Table 3-2: f-BC (MDO/MGO) = 0.31
[2] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP from diesel oil combustion consists of $PM_{2.5}$)

With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [8]

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Discussion of emission trends

Table 5: Outcome of Key Category Analysis

for:	**NO_x**	**PM_{10}**	**$PM_{2.5}$**
by:	L/-	-/T	L/T

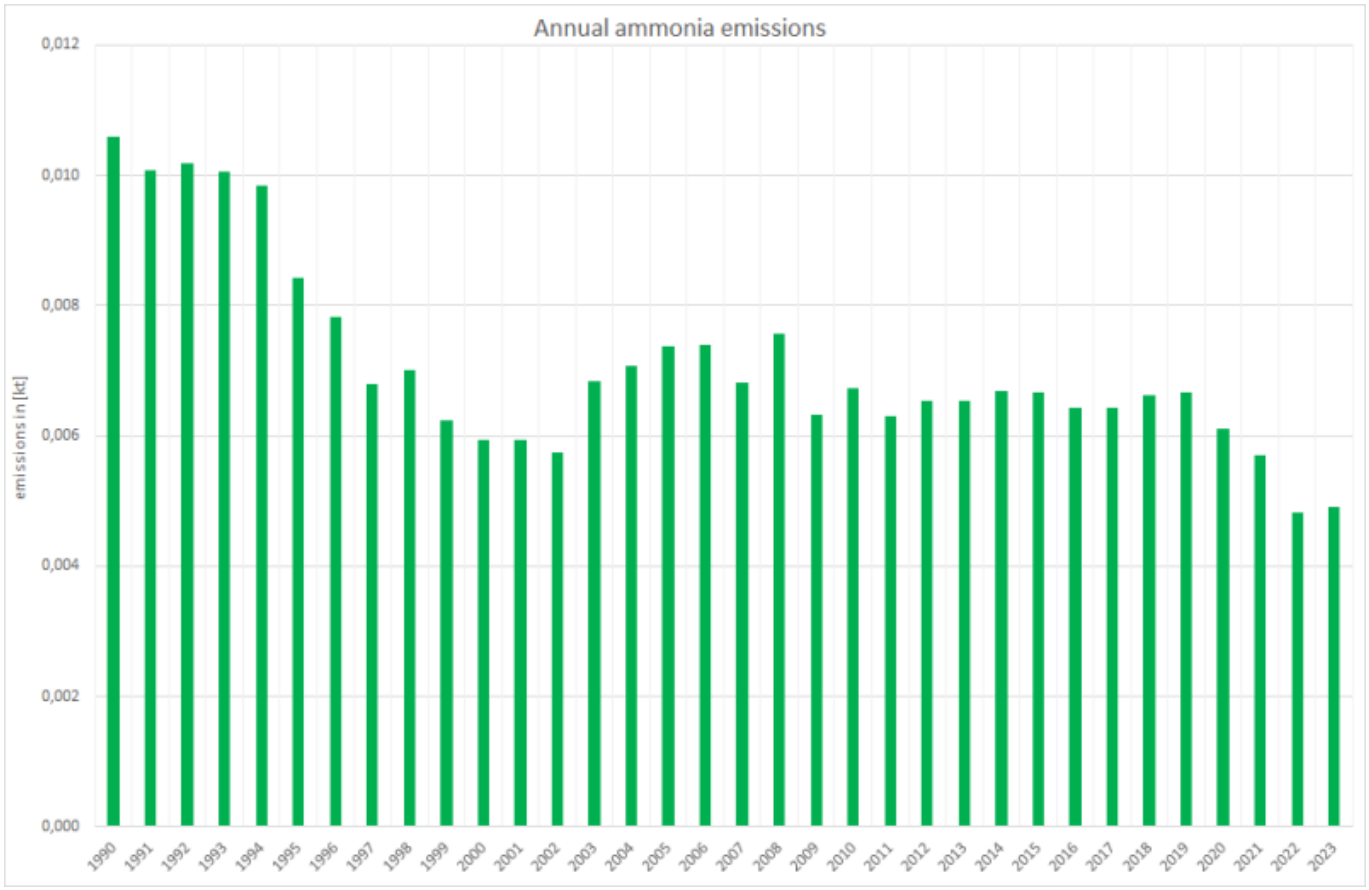
The following tale includes emission limits according to Directive 2004/26/EC [10] for inland vessels.

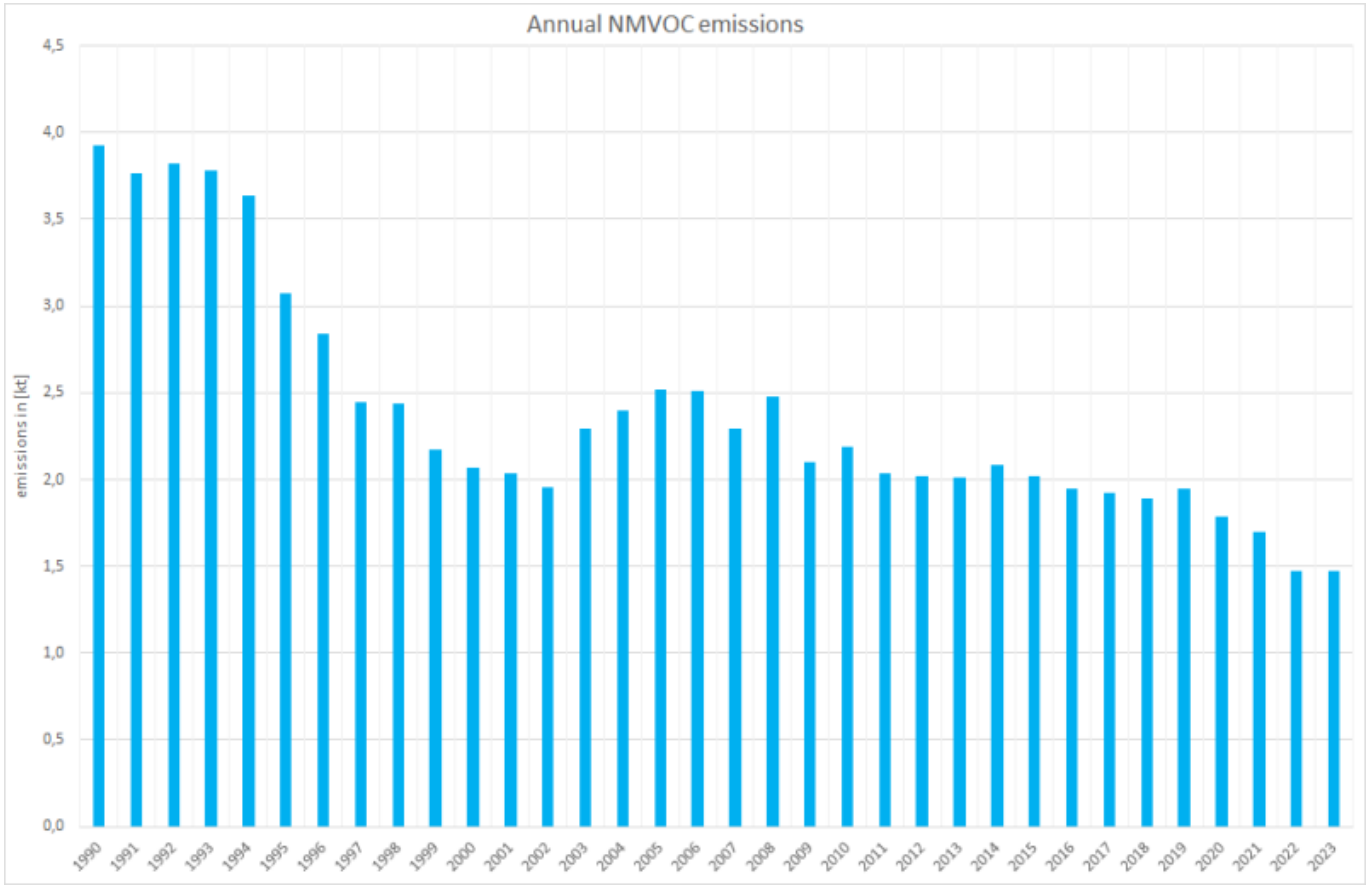
Table 6: Overview of emission limits, in [g/kWh]

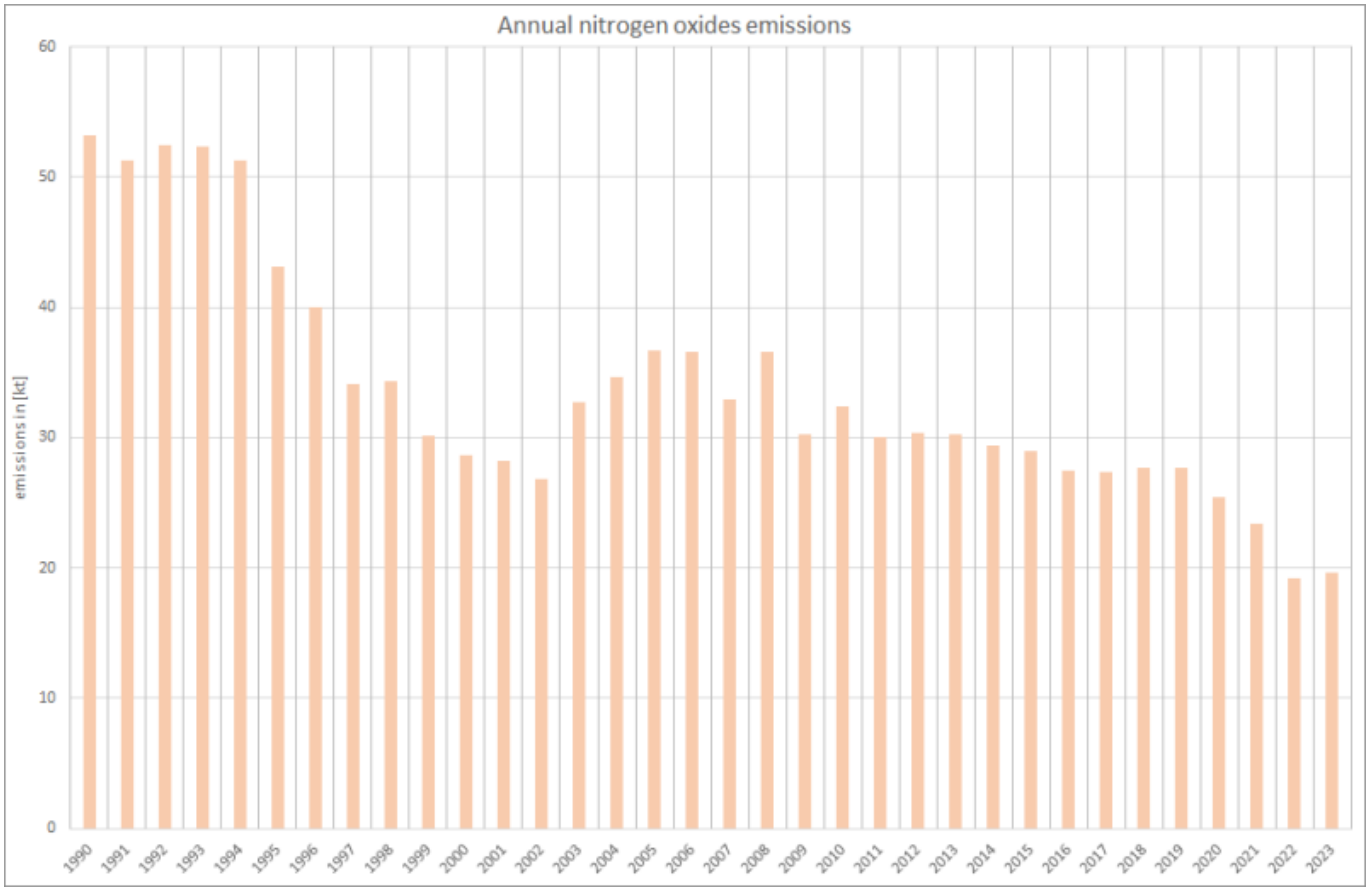
Category: swept volume/net power (SV/P)	**Carbon monoxide**	**∑ Hydrocarbons + Nitrogen oxides**	**Particulates**
(litres per cylinder/kW)	(CO)	($HC+NO_x$)	(PT)
V1:1; SV < 0,9; P ≥ 37 kW	5.0	7.5	0.40
V1:2; 0.9 ≤ SV < 1.2	5.0	7.2	0.30
V1:3 1.2 ≤ SV < 2.5	5.0	7.2	0.20
V1:4; 2.5 ≤ SV < 5	5.0	7.2	0.20
V2:1; 5 ≤ SV < 15	5.0	7.8	0.27
V2:2; 15 ≤ SV < 20; P < 3300 kW	5.0	8.7	0.50
V2:3; 15 ≤ SV < 20; P ≥ 3300 kW	5.0	9.8	0.50
V2:4; 20 ≤ SV < 25	5.0	9.8	0.50
V2:5; 25 ≤ SV < 30	5.0	11.0	0.50

However, Directive 2004/26/EC has been replaced by Regulation (EU) 2016/1628 in 2016 [11].

For **ammonia**, **NMVOC**, and **nitrogen oxides** as well as **carbon monoxide**, emission trends more or less represent the trend in over-all fuel consumption.

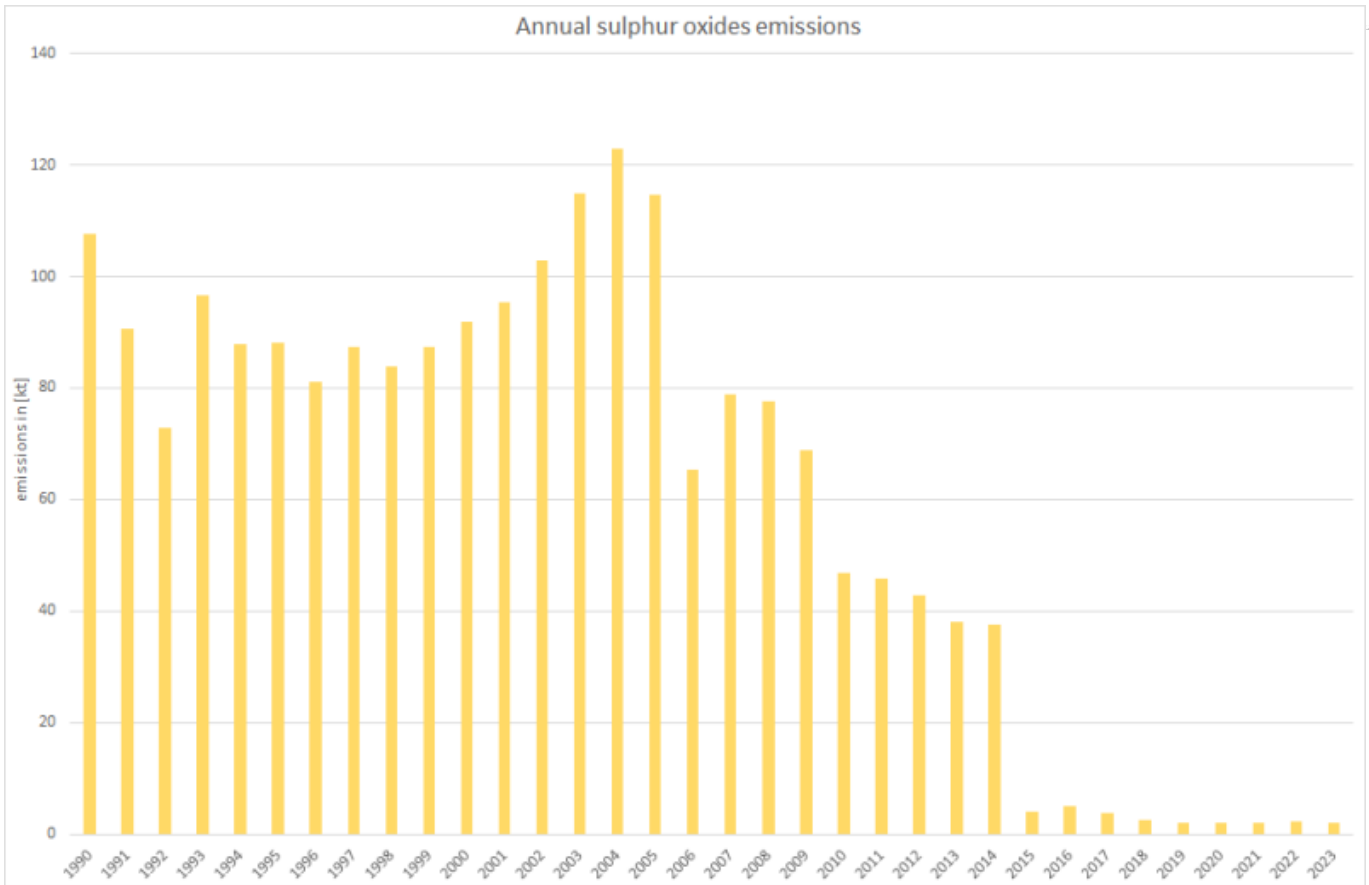

Annual ammonia emissions
emissions in [kt]
0,012
0,010
0,008
0,006
0,004
0,002
0,000
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023


Annual NMVOC emissions
emissions in [kt]
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023



Nonetheless, for these pollutants, annual emission factors from BSH [12)] and TREMOD [13)] have been applied for national *maritime* and *inland* navigation, respectively, reflecting the technical development of the German inland navigation fleet.

Here, the trends in **sulphur dioxide** and **particulate matter** emissions reflect the impact of ongoing fuel-sulphur legislation especially in maritime navigation.



Recalculations

Compared to the previous submission, **activity data** remain unaltered for **national maritime navigation**, whereas fuel consumption data allocated to **inland navigation** has been revised within TREMOD taking into account the finalisation of the National Energy Balance for 2022.

Table 7: Revised over-all fuel consumption data for national navigation, in terajoules

	sea vessels only:			inland vessels only:				
	LIGHT FUEL OIL	**HEAVY FUEL OIL**	**LNG**	**DIESEL OIL**	**GASOLINE**	**BIOETHANOL**	**LPG**	**TOTAL**
current submission	7.879	237	513	9.275	275	12,8	7,55	**18.199**
previous submission	7.879	237	513	9.819	275	12,8	7,58	**18.744**
absolute change	0,00	0,00	0,00	-545	-0,18	-0,01	-0,02	**-545**
relative change	0,00%	0,00%	0,00%	-5,55%	-0,06%	-0,06%	-0,30%	**-2,91%**

In addition, several emission factors have been reviesed. Tho following table provides the most important revisions occurimg for NMOVOC and NO_x in national maritime navigation.

Table 8: Revised emission factors, in kg/TJ

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
NATIONAL MARITIME NAVIGATION: DIESEL OIL & LIGHT FUEL OIL													
NMVOC													
current submission	71.9	72.1	72.0	72.0	72.1	81.5	82.7	83.2	75.0	80.3	78.2	81.4	79.8
previous submission	48.5	48.4	48.4	48.4	48.4	44.4	43.9	44.2	43.8	44.0	44.0	42.1	43.0
absolute change	23.5	23.7	23.6	23.6	23.7	37.1	38.8	38.9	31.3	36.2	34.2	39.3	36.8
relative change	48.4%	48.8%	48.7%	48.6%	48.9%	83.6%	88.5%	88.1%	71.4%	82.3%	77.8%	93.3%	85.7%
NO_x													
current submission	1,199	1,198	1,199	1,199	1,198	1,115	1,111	1,115	1,095	1,106	1,090	1,098	1,098
previous submission	1,101	1,101	1,101	1,101	1,101	1,184	1,183	1,189	1,200	1,199	1,169	1,194	1,181
absolute change	97.8	97.3	97.4	97.5	97.3	-68.6	-71.1	-73.8	-105.8	-92.7	-79.1	-96.1	-83.1
relative change	8.88%	8.84%	8.85%	8.86%	8.83%	-5.79%	-6.01%	-6.20%	-8.82%	-7.73%	-6.77%	-8.05%	-7.03%
NATIONAL MARITIME NAVIGATION: HEAVY FUEL OIL													
NMVOC													
current submission	96.6	96.5	96.5	96.5	96.5	104	117	131	156	172	168	156	165
previous submission	43.0	42.8	42.9	42.9	42.8	26.1	30.2	33.7	32.5	32.7	37.4	37.5	40.7
absolute change	53.6	53.6	53.6	53.6	53.7	77.5	87.2	97.5	123	139	130	118	125
relative change	125%	125%	125%	125%	125%	297%	288%	289%	379%	427%	348%	316%	306%
NO_x													
current submission	1,604	1,602	1,603	1,603	1,602	1,216	1,572	1,300	1,332	1,242	1,368	1,385	1,439
previous submission	1,368	1,368	1,368	1,368	1,368	1,487	1,440	1,479	1,480	1,507	1,509	1,526	1,556
absolute change	236	235	235	235	235	-271	132	-179	-148	-265	-141	-141	-117
relative change	17.2%	17.2%	17.2%	17.2%	17.2%	-18.2%	9.18%	-12.1%	-10.0%	-17.6%	-9.36%	-9.24%	-7.52%



For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by Knörr et al. (2009) [14)].

Planned improvements

Besides the **routine revisions of the models** used for maritime and inland navigation, the percental BC-fractions (f-BC) applied for maritime navigation will be updated in accordance with the information provided in Chapter 1.A.3.d Navigation (shipping) 2023 of the EMEP/EEA GB 2023.

[1)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

[2), 3), 12)] Deichnik (2024): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs. from Bundesamts für Seeschifffahrt und Hydrographie (BSH - Federal Maritime and Hydrographic Agency); Hamburg, 2024.

[4)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook – 2023; Chapter 1.A.3.d Navigation (shipping) 2023; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-d-navigation/@@download/file; Copenhagen, 2023.

[5), 6), 7), 9)] EMEP/EEA (2016): EMEP/EEA air pollutant emission inventory guidebook – 2019; Chapter 1.A.3.d Navigation (shipping) 2016; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-d-navigation/@@download/file; Copenhagen, 2016.

[8), 13)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2024.

[10)] EU (2004): Directive 2004/ 26/EC of the European Parliament and of the Council of 21 April 2004 amending Directive 97/68/EC on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery; http://data.europa.eu/eli/dir/2004/26/oj; Strasbourg, 2004

[11)] EU (2016): Regulation (EU) 2016/1628 of the European Parliament and of the Council of 14 September 2016 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery, amending Regulations (EU) No 1024/2012 and (EU) No 167/2013, and amending and repealing Directive 97/68/EC; http://data.europa.eu/eli/reg/2016/1628/oj; Strasbourg, 14 September 2016

[14)] Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; URL: https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf, FKZ 360 16 023, Heidelberg & Zürich, 2009.

[8)] During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.A.3.d i (i) - International maritime navigation

Short description

Under NFR category **1.A.3.d i (i)**, emissions from international maritime navigation fuelling in and starting form German harbours are reported.

Category Code	Method	AD	EF
1.A.3.d i (i)	T1, T2, T3	NS, M	CS, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
not included in key category analysis																									

Methodology

Activity data

Primary fuel delivery data (primary activity data, PAD) for *international maritime navigation* is included in line 6 - 'International Deep-Sea Bunkers' of the National Energy Balances (NEB) (AGEB, 2024) [1)] together with respective data for IMO-registered ships used in *national maritime transport* (see 1.A.3.d ii (a)), *fishing* (see NFR 1.A.4.c iii) and *military navigation* (see NFR 1.A.5.b iii).

The AD applied for *international maritime navigation* therefore represents the remains of primary fuel delivery data from NEB line 6 minus the modelled consumption data estimated for non-IMO ships in *1.A.3.d ii (a)*, *1.A.4.c iii* and *1.A.5.b iii*:

$AD_{1.A.3.d\ i} = PAD_{NEB\ line\ 6} - AD_{1.A.3.d\ ii\ (a)\ -\ IMO} - AD_{1.A.4.c\ iii\ -\ IMO} - AD_{1.A.5.b\ iii\ -\ IMO}$	with * $AD_{1.A.3.d\ i}$ - tier1 activity data for International maritime navigation * $PAD_{NEB\ line\ 6}$ - primary over-all fuel deliveries data from NEB line 6 - 'International Maritime Bunkers' * $AD_{1.A.3.d\ ii\ (a)\ -\ IMO}$ - tier3 activity data for IMO-registered ships involved in national maritime navigation * $AD_{1.A.4.c\ iii\ -\ IMO}$ - tier3 activity data for IMO-registered ships involved in national fishing * $AD_{1.A.5.b\ iii\ -\ IMO}$ - tier3 activity data for IMO-registered ships involved in military navigation

As a result, activity data can fluctuate strongly from year to year.

However, this effect can be explained with the fact that large ocean-going ships do not need to bunker fuels on every single harbour but can go on for weeks without any additional fuel uptake.

This can be further increased with increasing differences in fuel prices.

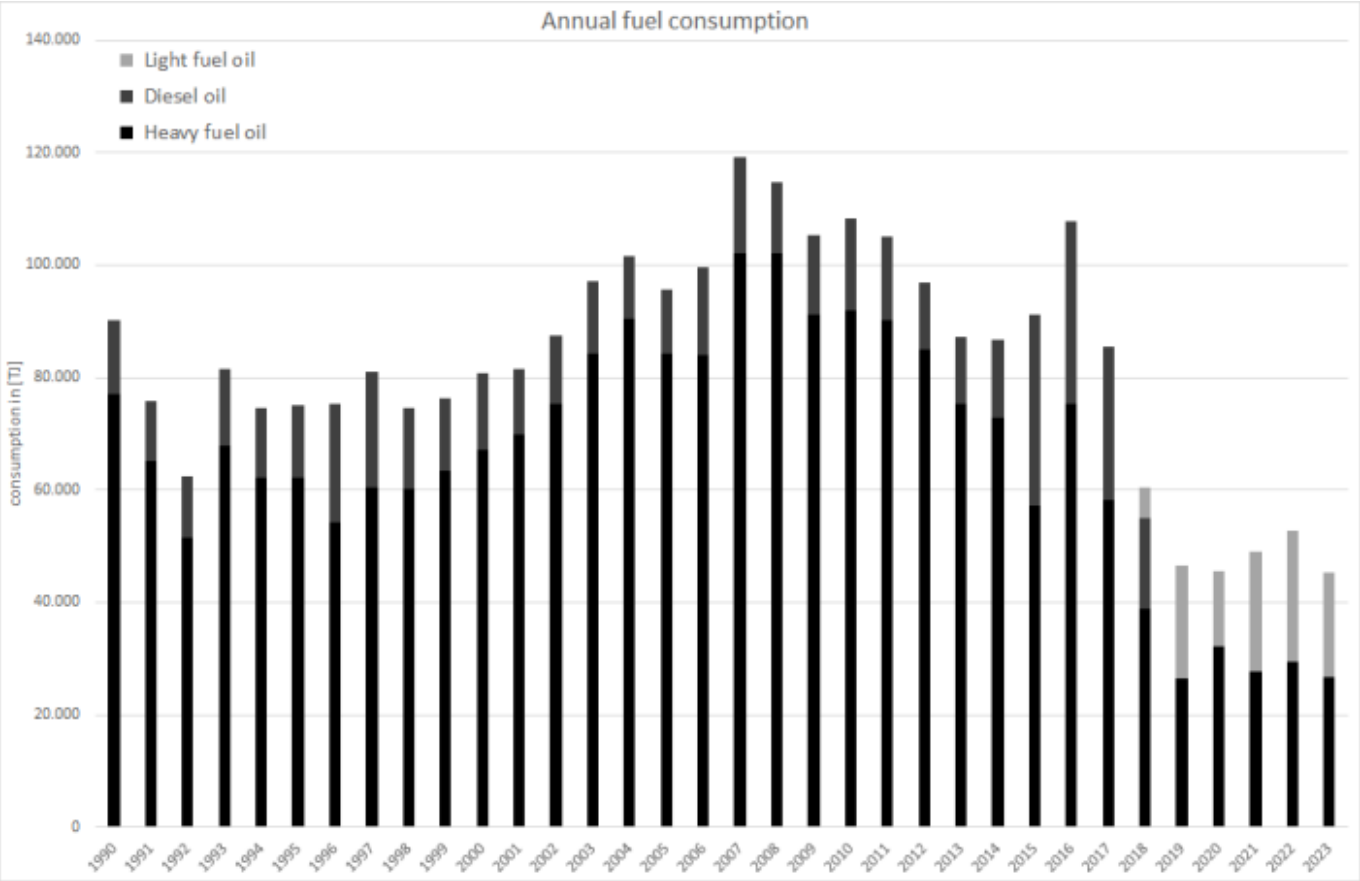
Table 1: Annual fuel consumption, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel Oil	13,162	13,096	13,709	11,546	16,273	33,836	32,424	27,370	16,000					
Light Heating Oil									5,333	20,104	13,606	21,260	23,267	18,657
Heavy fuel oil	76,942	62,066	67,080	84,127	91,992	57,278	75,408	58,196	38,986	26,418	32,053	27,713	29,414	26,633
Σ 1.A.3.d i	**90,104**	**75,162**	**80,789**	**95,672**	**108,266**	**91,114**	**107,832**	**85,566**	**60,319**	**46,522**	**45,660**	**48,973**	**52,681**	**45,290**

source: own estimates based on underlying BSH model (Deichnik, K. (2024)) [2)]

Consumption of heavy oil has been increasing since 1984 as a result of high petroleum prices, global increases in transports and increasing maritime use of diesel engines that can run on heavy oil. The emissions fluctuations that occurred in the navigation sector in 1992 and 1996 were caused by trade and oil crises.

Furthermore, after 2014, with ever stricter legislation espacially regarding fuel sulphur content, an ongoing shift from heavy fuel oil to maritime diesel oil can be observed.



Emission factors

For **main pollutants** and **particulate matter**, modelled emission factors are available from (Deichnik, K. (2024)).

Here, for **sulphur dioxide** and **particulate matter**, annual values are available representing the impact of fuel sulphur legislation. In addition, regarding SO_2, the increasing operation of so-called scrubbers in order to fullfil emission limits especially within SECA areas is reflected for heavy fuel oil.

Table 2: Annual country-specific emission factors, in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
DIESEL OIL & LIGHT FUEL OIL														
NH_3	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
NMVOC	71.9	72.1	72.0	72.0	72.1	81.5	82.7	83.2	75.0	80.3	78.2	81.4	79.8	77.4
NO_x	1,199	1,198	1,199	1,199	1,198	1,115	1,111	1,115	1,095	1,106	1,090	1,098	1,098	1,095
SO_x	466	419	233	186	69.8	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
BC[1]	110	99.1	55.0	44.0	16.5	17.4	17.7	17.7	17.3	17.5	16.8	16.9	17.1	16.9
$PM_{2.5}$	354	320	177	142	53.3	56.2	57.1	57.1	55.9	56.5	54.2	54.6	55.2	54.6
PM_{10}	378	342	190	152	57.1	60.1	61.1	61.1	59.8	60.4	58.0	58.5	59.0	58.4
TSP[2]	378	342	190	152	57.1	60.1	61.1	61.1	59.8	60.4	58.0	58.5	59.0	58.4
CO	128	128	128	128	128	140	142	141	139	140	138	140	140	142
HEAVY FUEL OIL														
NH_3	0.33	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.35	0.34
NMVOC	96.6	96.5	96.5	96.5	96.5	103.6	117.4	131.2	155.6	172.2	167.6	155.9	165.3	165.6
NO_x	1,604	1,602	1,603	1,603	1,602	1,216	1,572	1,300	1,332	1,242	1,368	1,385	1,439	1,408
SO_x	1,319	1,332	1,323	1,336	496	48.6	49.2	48.1	45.9	46.5	48.1	47.0	47.6	47.2
BC[1]	70.8	71.2	70.8	71.6	26.5	14.2	18.0	20.1	19.1	18.9	21.4	21.3	23.2	23.4
$PM_{2.5}$	590	594	590	596	221	118	150	168	159	158	179	178	194	195
PM_{10}	649	653	649	656	243	130	165	184	175	173	197	195	213	214
TSP[2]	649	653	649	656	243	130	165	184	175	173	197	195	213	214
CO	179	179	179	179	179	144	162	157	156	150	151	147	144	142

[1] estimated from f-BCs as provided in [3)]: f-BC (HFO) = 0.12, f-BC (MDO/MGO) = 0.31 as provided in [4)], chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Tables 3-1 & 3-2

[2] ratios $PM_{2.5}$: PM_{10} : TSP derived from the tier1 default EF as provided in [5)], chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Tables 3-1 & 3-2



For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

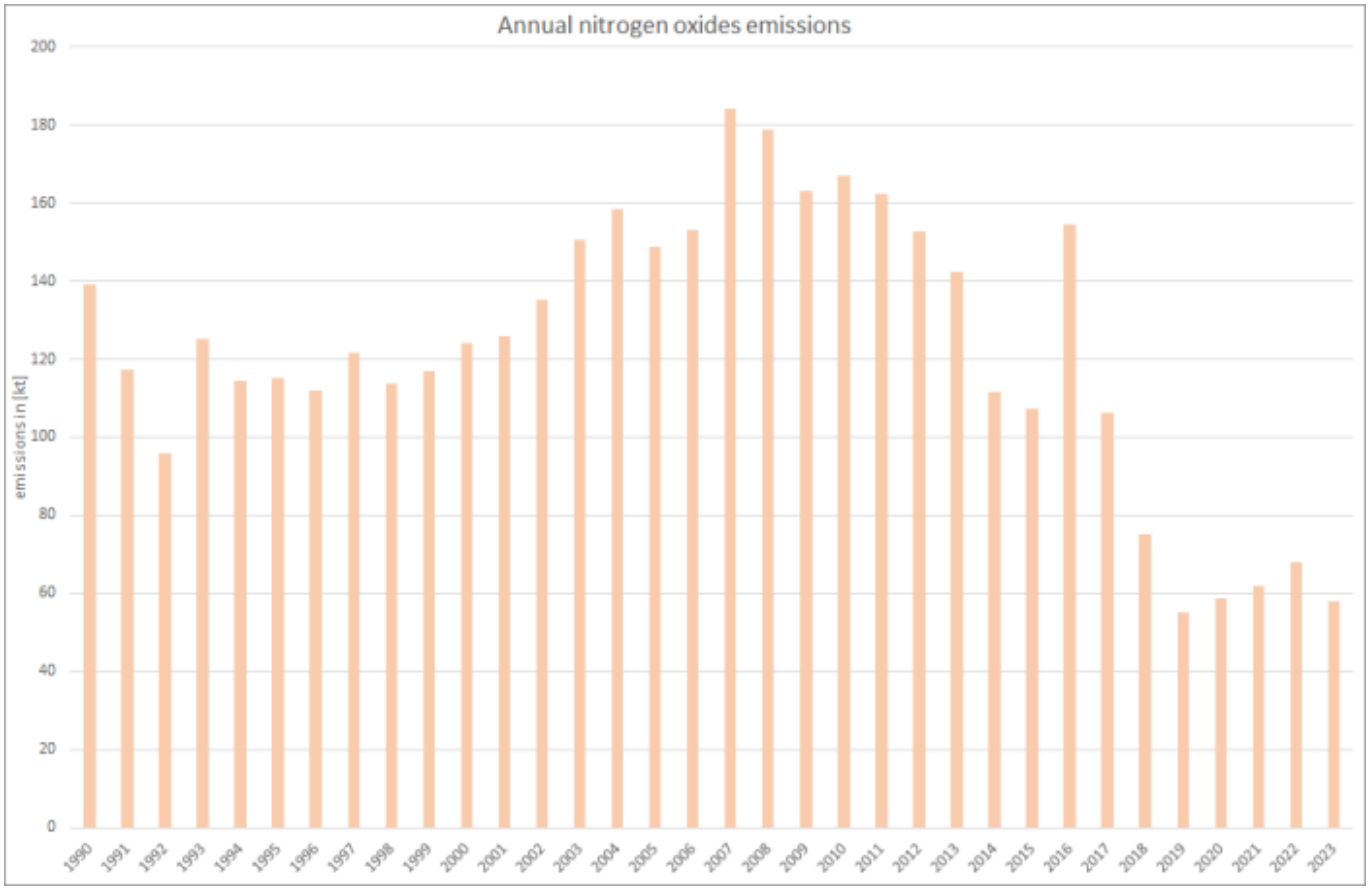
Discussion of emission trends

NFR 1.A.3.d i is **not considered in the key category analysis**.

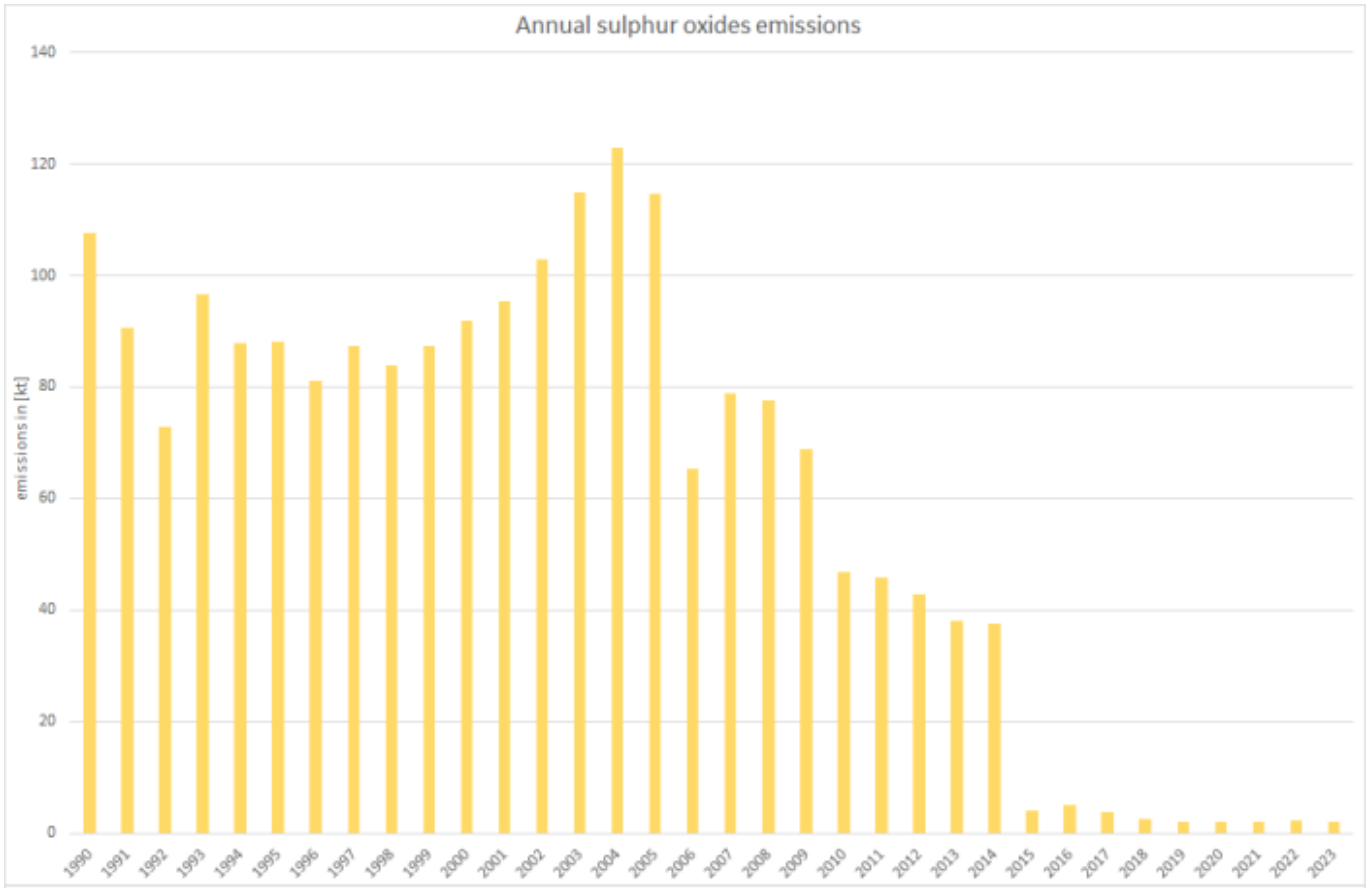
Basically, with no significant technical improvements with respect to mitigation technologies, trends in emissions depend more or less directly the amounts of fuels bunkered in German harbours and the contributions of diesel oil/light heating oil and heavy fuel oil to the over-all fuel input.

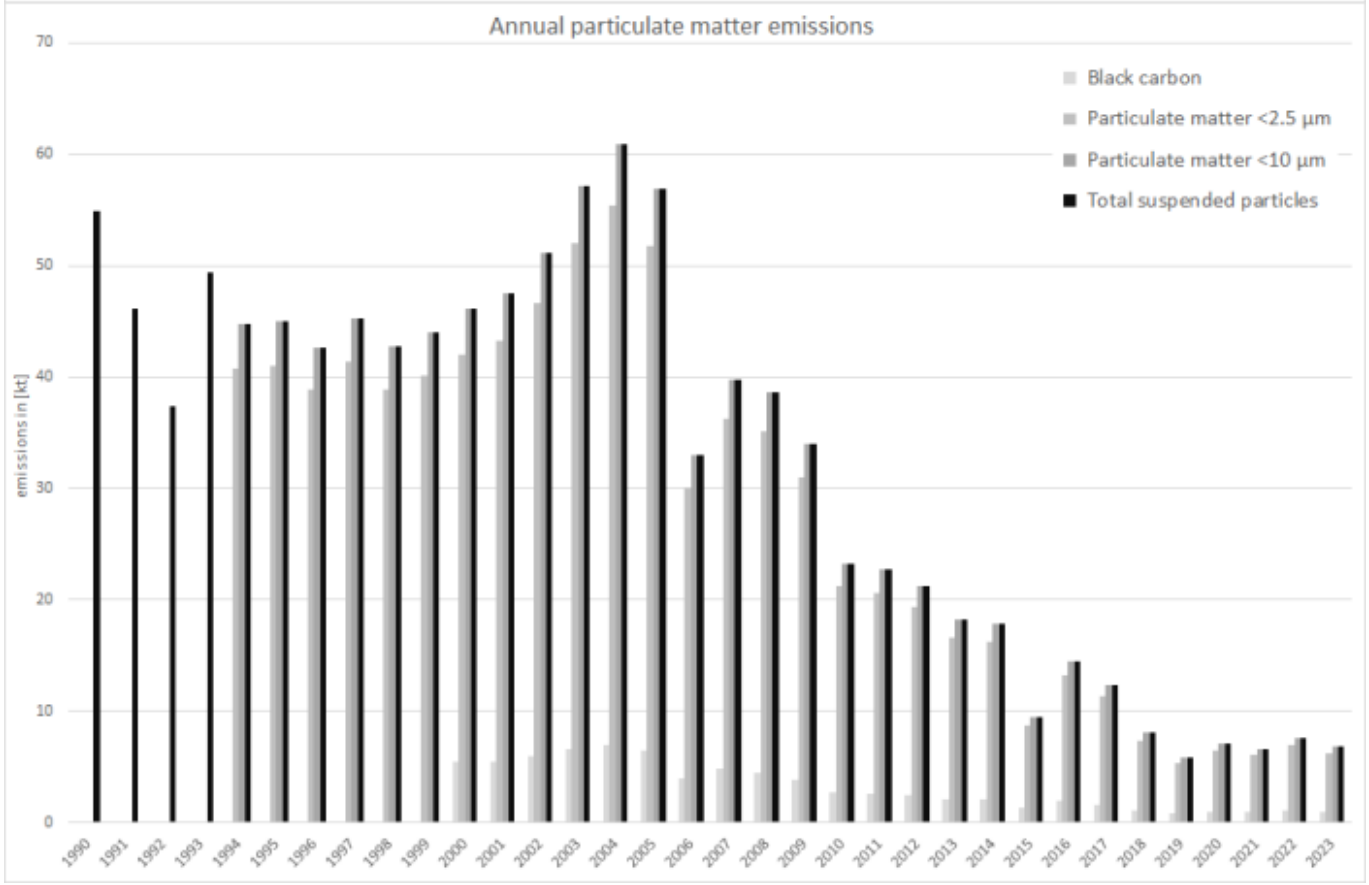
Here, as the amounts of fuels allocated to international maritime navigation represent the remains of annual over-all inland fuel deliveries minus fuel consumption in domestic shipping, activity data and, hence, emissions, fluctuate strongly from year to year (see also information on activity data as stated above).

Therefore, especially emission trends for unregulated pollutants (such as **NH_3**, **NO_x**, **NMVOC** and **CO**, all **HM** and **POPs**) with only slight changes in the annual over-all IEFs applied, follow the trends in fuel consumption and the shares of diesel and heavy fuel oil:



In contrast, emission trends for **SO_x** and **PM**, both depending on the fuel's sulphur content, follow not only the trends in fuel consumption but do also reflect fuel-sulphur legislation:





Recalculations

Activity data have been recalculated widely due to the revision of the National Energy Balances (NEB) 2003 to 2021.

Table 3: Revised activity data 2003-2021, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL OIL													
current submission	13,162	13,096	13,709	11,546	16,273	33,836	32,424	27,370	16,000	NO			
previous submission	13,162	13,096	13,709	11,546	16,273	33,836	32,424	27,370	16,000	NO			
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA			
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	NA			
LIGHT FUEL OIL													
current submission	NO								5,333	20,104	13,606	21,260	23,267
previous submission	NO								5,333	20,104	13,606	21,260	23,321
absolute change	NA								0.00	0.00	0.00	0.00	-53.40
relative change	NA								0.00%	0.00%	0.00%	0.00%	-0.23%
HEAVY FUEL OIL													
current submission	76,942	62,066	67,080	84,127	91,992	57,278	75,408	58,196	38,986	26,418	32,053	27,713	29,414
previous submission	76,942	62,066	67,080	84,127	91,992	57,278	75,408	58,196	38,986	26,418	32,053	27,713	29,297
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	117
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.40%
NFR 1.A.3.d i (i) TOTAL													
current submission	90,104	75,162	80,789	95,672	108,266	91,114	107,832	85,566	60,319	46,522	45,660	48,973	52,681
previous submission	90,104	75,162	80,789	95,672	108,266	91,114	107,832	85,566	60,319	46,522	45,660	48,973	52,618
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0,01	0.00	63.6
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0,00%	0.00%	0.12%

In contrast, all implied **emission factors** derived from the underlying BSH model [6)] remain unaltered.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by Knörr et al. (2009) [7)].

Planned improvements

Besides routine maintenance and further development of the BSH model, no improvements are planned.

FAQs

[1)] AGEB, 2024: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

[2), 6)] Deichnik (2024): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs. from Bundesamts für Seeschifffahrt und Hydrographie (BSH - Federal Maritime and Hydrographic Agency); Hamburg, 2024.

[3), 4), 5)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, URL: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019; Copenhagen, 2019.

[7)] Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; URL: https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf, FKZ 360 16 023, Heidelberg &

Zürich, 2009.

At the moment, Germany does not report any emissions from this sub-category.

Primary fuel deliveries data available from the National Energy Balance (NEB), from the BAFA Official Mineral Oil Data or other statistiocs does not allow a differentiation into national and international inland navigation on German inland waterways. Therefore, for the time beeing, all activity data is allocated to 1.A.3.d ii - National Navigation and here to the sub-sector of *1.A.3.d ii (b) - National Inland Navigation*.

1.A.3.e - Other Transport

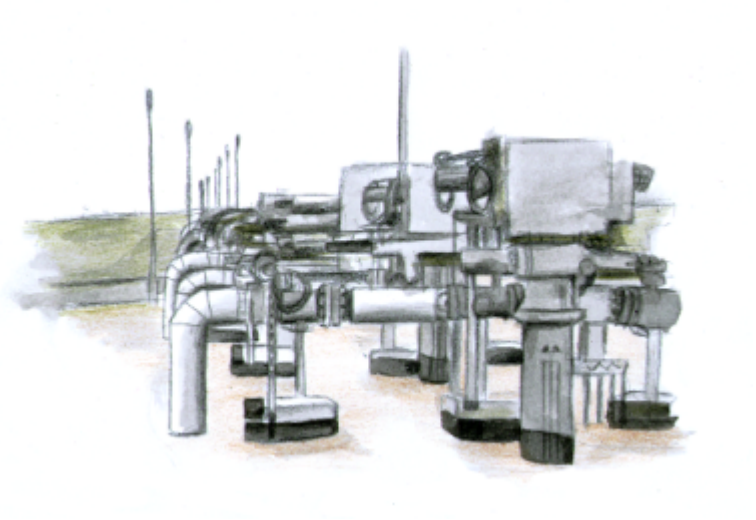
NFR category *1.A.3.e - Other Transportation* comprises of the two sub-categories *1.A.3.e i - Pipeline Transport* and *1.A.3.e ii - Other Transport: Other*.

At the moment, only emissions from compressors in pipeline transport of natural gas are reported, whereas no further emission sources are allocated in NFR 1.A.3.e ii.

NFR-Code	Name of Category	Method	AD	EF	Key Category Analysis
1.A.3.e	Other Transportation	*see sub-category details*			
consisting of / including source categories					
1.A.3.e i	Other Transport: Pipeline Transport	*see sub-category details*			
1.A.3.e ii	Other Transport: Other	*no activities reported in this sub-catgeory.*			

1.A.3.e i - Other Transport: Pipeline Transport

Short description



Under category 1.A.3.e i - Pipeline Compressors emissions from compressors in pipeline transport of natural gas are reported.

NFR Code	Method	AD	EF
1.A.3.e i	T2	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	Pb	Cd	**Hg**	As	Cr	Cu	Ni	Se	Zn	POPs
-/-	-/-	-/-	NA	-/-	-/-	-/-	NE	-/-	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

Methodology

Activity data

In past years, statistical fuel consumption data from the National Energy Balances for Germany was used (AGEB, 2024)[1)]. But a comparison with data from German ETS (available as of 2005) exposed several inconsistencies within these statistics.

Therefore, as the fuel consumption of a compressor station depends strongly on the amount of transferred natural gas, a conversion factor was derived reflecting the relation between the fuel consumption of all compressor stations and the primary energy consumption of natural gas within Germany. Using this conversion factor, the insufficient statistical data could be replaced by much more solid estimates for the years 1990 to 2004 whereas from 2005 on the abovementioned ETS data is used.

Table 1: Consumption of natural gas in compressor stations, in [tJ]

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
19,449	23,740	25,324	26,501	21,021	22,026	18,737	22,422	23,856	21,417	13,748	14,990	23,623	16,620

Emission factors

The emission factors for pipeline compressors have been taken from the research project “Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010” (Rentz et al., 2002)[2)]. A detailed description of the procedure is presented in Chapter: 1.A.1.a - Public Electricity And Heat Production. In 2018 and 2019 emission factors were revised by using emission data from large combustion plants (UBA, 2019) [3)].

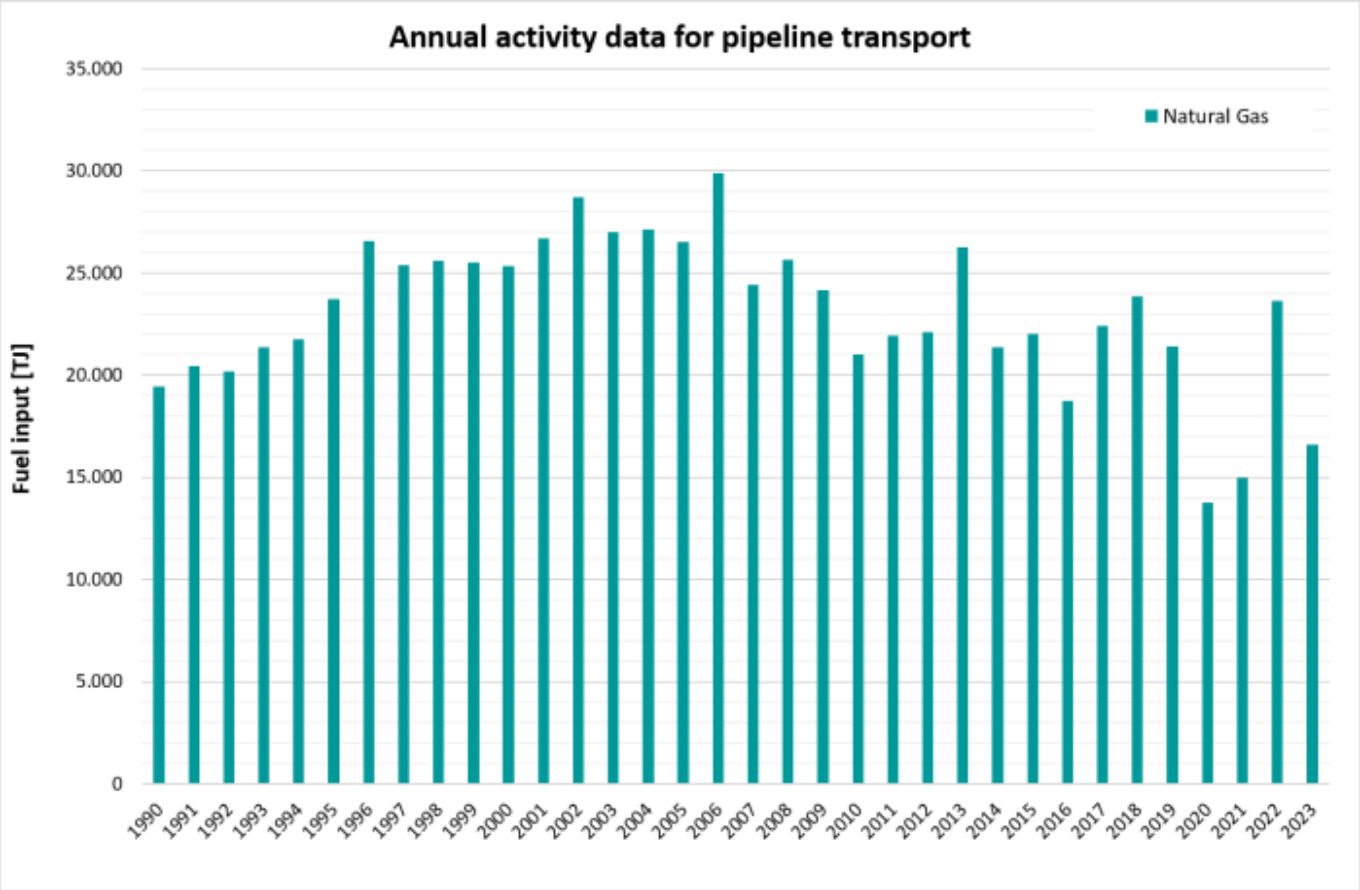
Compressor stations, in Germany mostly gas turbines, are responsible for maintaining a constant pressure in the pipeline. Basically they work discontinuously which causes relatively high specific emissions. In order to reflect this point the German law allows exemptions for installations with a low level of utilization.

Table 2: Emission factors used for pipeline transport, in kg/TJ

SOx	NOx	TSP	CO
0.14	62.18	0.4	35

Trend discussion for Key Sources

The following diagram gives an overview of the fuel consumption in NFR 1.A.3.e



Since 1990 natural gas consumption has shown an increasing overall trend. Annual fluctuations are due to the varying primary energy consumption. The maximum fuel consumption occured in 2006, the year with the so far highest German total primary energy consumption of natural gas. Thereafter, natural gas consumption decreases considerably.

Recalculations

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no further improvements are planned.

[1)] AGEB (2024): Arbeitsgemeinschaft Energiebilanzen: Energiebilanz für die Bundesrepublik Deutschland;

https://ag-energiebilanzen.de/en/data-and-facts/energy-balance-2000-to-2030/, Berlin, 2024

[2)] Rentz et al. (2002) Rentz, O., Karl, U., Peter, H.: “Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010”; Forschungsbericht 299 43 142, on behalf of the Umweltbundesamt; Karslruhe / Dessau-Roßlau, December 2002.

[3)] UBA (2019): Juhrich, K., Beckers, R.: “Updating the Emission Factors for Large Combustion Plants”: https://www.umweltbundesamt.de/publikationen/updating-emission-factors-large-combustion-plants; Dessau-Roßlau, 2019

1.A.4 - Small Combustion (OVERVIEW)

Short description

NFR *1.A.4 - Small Combustion* comprises combustion systems in the areas Commercial and Institutional (NFR 1.A.4.a), Residential (NFR 1.A.4.b), and Agriculture (NFR 1.A.4.c), along with various mobile sources.

NFR-Code	Name of Category
1.A.4	Small Combustion
including / consisting of sub-categories:	
1.A.4.a i, b i, c i	Stationary Small Combustion
1.A.4.a ii, b ii, c ii, c iii	Small Combustion: Mobile Sources

The group of stationary combustion systems in the residential and commercial/institutional sectors is very diverse with regard to installation design and size. It covers a spectrum that includes individual room furnaces for solid fuels with a rated thermal output of approximately 4 kW (e.g. fireplaces, ovens), oil and gas furnaces used to generate room heat and hot water (e.g. central heating boilers), hand-fed and automatically fed wood-burning furnaces in the commercial sector.

Besides stationary combustion, mobile sources are covered, too: From fork lifters in NFR 1.A.4.a ii -Commercial / Institutional: Mobile via lawn mowers in NFR 1.A.4.b ii - Residential: Household and Gardening: Mobile to vehicles and other mobile machinery used in NFR 1.A.4.c ii - Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery and the emissions of the German deep sea fishing fleet under NFR 1.A.4.c iii - Agriculture/Forestry/Fishing: National Fishing.

1.A.4 - Small Combustion: Stationary Sources (OVERVIEW)

Short description

Source category 1.A.4 comprises stationary combustion systems in the sectors *Commercial and Institutional (1.A.4.a)*, *Residential (1.A.4.b)*, and *Agriculture (1.A.4.c)*.

NFR-Code	Name of Category
1.A.4	**Small Combustion**
including / consisting of sub-categories	
1.A.4.a i	Commercial and Institutional - Stationary Combustion
1.A.4.b i	Residential - Stationary Combustion
1.A.4.c i	Agriculture, Forestry, Fishing - Stationary Combustion

Method

Activity data

Activity data in source category *1.A.4* are based on the Energy Balance for the Federal Republic of Germany prepared by the Working Group on Energy Balances (AGEB)[1)]. For the period prior to 1995, separate Energy Balances are used for the new and old German Länder. Lines 66 (residential) and 67 (commercial, trade, services and other consumers) of the Energy Balance are of primary importance.

Since large quantities of wood fuels, used in households and in commerce and trade, are purchased privately or obtained from system owners' own forest parcels, data are outside official statistics. For this reason, additional studies are used by the Working Group on Renewable Energy Statistics (AGEE-Stat). The results for the residential sector are based on surveys of wood consumption carried out in the framework of the “Rohstoffmonitoring Holz” (“Monitoring of raw materials – wood”) project[2)]. That project collected data both on firewood purchased via commercial sellers and wood gathered in forests. For interim years, a regression model is applied that takes account of numbers of degree days, the price indexes for conventional fuels, and the heating systems, broken down by types, used in residential buildings. Conversions of volume units into energy units are carried out in conformance with the accepted conversion conventions of AGEE-Stat. Wood consumption in heat-generation-only systems of the commercial and institutional sector is derived via a remainder calculation. In the process, the data on total wood consumption (outside of private households), as determined via the “Rohstoffmonitoring Holz” surveys and via regression models, are blended with the relevant wood-quantity data from official energy statistics and the applicable wood-quantity data given by other relevant models. The wood consumption data derived via this approach, which relate to data on heat generation by CHP systems, are also part of the data on total wood consumption in the commercial and institutional sector.

Energy data and emissions from small engines using biomass as fuel are reported in source category 1.A.1.a, since all the plants feed electricity into the local network. However a small amount of biogas and liquid biofuel, used for heat production, is reported in source category 1.A.4.

The determination of these fuel activities is a result of a comprehensive evaluation of invoicing data of the EEG (Renewable Energy Law), provided by the Federal Network Agency. The EEG-accounting system contains primarily electricity generation data, but also additional information, since a bonus is paid for heat extraction. For the calculation a typical power to heat ratio is necessary according to manufacturers specification.

Emission factors

The database for the emission factors used for NO_x, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, heavy metals, PCDD/PCDF and PAH is the research report “Efficient provision of current emissions data for purposes of air quality control” (“Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung”; Struschka et al., 2008) [3)]. Within the context of that project, appliance-related and source-category-specific emission factors for the combustion systems in the residential and commercial/ institutional sectors were calculated, with a high level of detail, for all important emission components for the

reference year 2005.

In 2016 the revision of the emission factors for the main pollutants was necessary due to changes in legislation. Data source for emission factors of several pollutants from 2010 onwards is the research report “Ermittlung und Aktualisierung von Emissionsfaktoren für das nationale Emissionsinventar bezüglich kleiner und mittlerer Feuerungsanlagen der Haushalte und Kleinverbraucher”; Tebert et al., 2016)[4)].

The determination of emission factors is based on a source-category-specific “bottom-up” approach that, in addition, to differentiating (sub-) source categories and fuels, also differentiates appliance technologies in detail. In the process, several technology-specific emission factors are aggregated in order to obtain mean emission factors for all systems within the source categories in question. Use of system-specific / category-specific emission factors ensures that all significant combustion-related characteristics of typical systems for the various categories are taken into account. The procedure is in keeping with the Tier-2 and Tier-3 methods, respectively.

The emission factors are structured in accordance with the relevant fuels involved in final energy consumption in Germany:

- Light Heating Oil,
- Natural gas,
- Lignite (briquettes from Rhine and Lausitz areas, and imported briquettes),
- Hard coal (coke, briquettes, anthracite) and
- Wood (unprocessed wood, wood pellets, residual wood).

In addition, emission factors for combustion systems are determined in accordance with device design, age level, output category and typical mode of operation. The emissions behaviour of the combustion systems in question were determined via a comprehensive review of the literature, in an approach that distinguished between results from test-bench studies and field measurements. Transfer factors were used to take account of the fact that emissions in a test-bench environment tend to be considerably lower than those of corresponding installed systems.

The description of the structure for installed combustion systems was prepared using statistics from the chimney-sweeping trade. These data were used to estimate the energy inputs for various system types, to make it possible to determine sectoral emission factors weighted by energy inputs.

The SO_2 emission factors for natural gas and lignite briquettes is calculated by the sulfur content of the fuel which is determined by measurents. In terms of light fuel oil the limit values were used. Since 2008 there are two qualities of light fuel oil available: fuel oil with a sulfur content of 1,000 mg/kg and fuel oil with a sulfur content of 50 mg/kg. In small combustion plants nowadays almost exclusively low-sulfur fuel oil is used. the share of the different light fuel oil qualities is annually available from the oil statistic. Regarding lignite briquettes can be assumed that 10 % of the sulfur were stored in the ash while 90 % were emitted as SO_2. Since the sulfur content of lignite briquettes depends on the region, a weighted average emission factor has been calculated.

Black carbon emission factors are given by the EMEP/EEA Guidebook 2019.



For more detailed information on specific acitivity data, emission factors, emissions trends, recalculations and planned improvements, please refer to the sub-chapters linked above.

[1)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen - AGEB): National energy balance and Satellite balance for renewable energy: https://ag-energiebilanzen.de/en/data-and-facts/energy-balance-2000-to-2030/, Berlin, 2024.

[2)] Mantau et al. (2018): Mantau, Prof. Dr. U., Döring, P. (INFRO e. K.) and Weimar, Dr. H., Glasenapp, S. (Thünen-Institut): ROHSTOFFMONITORING HOLZ - Mengenmäßige Erfassung und Bilanzierung der Holzverwendung in Deutschland; Schriftenreihe Nachwachsende Rohstoffe Band 38, publisher: Fachagentur Nachwachsende Rohstoffe e. V. (FNR), https://www.charta-fuer-holz.de/fileadmin/charta-fuer-holz/dateien/service/mediathek/Rohstoffmonitoring_SR38_Final_Web_20180612.pdf, ISBN 978-3-942147-37-8, Gülzow-Prüzen, 2018.

[3)] Struschka et al. (2008): Struschka, Dr. M., Kilgus, D., Springmann, M.; Baumbach, Prof. Dr. Günter: Effiziente Bereitstellung aktueller Emissonsdaten für die Luftreinhaltung; UBA Forschungsbericht 205 42 322; https://www.umweltbundesamt.de/en/publikationen/effiziente-bereitstellung-aktueller-emissionsdaten, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008.

[4)] Tebert et al. (2016): Tebert, Chr., Volz, S., Töfge, K., Friedrich, Chr.: Ermittlung und Aktualisierung von Emissionsfaktoren für das nationale Emissionsinventar bezüglich kleiner und mittlerer Feuerungsanlagen der Haushalte und Kleinverbraucher

(unpublished), 2016.

1.A.4.a i - Commercial and Institutional: Stationary Combustion

Short description



The source category *1.A.4.a.i - Commercial and Institutional: Stationary Combustion* emissions from commercial and institutional combustion installations are reported.

NFR Code	Method	AD	EF
1.A.4.a.i	T2, T3	NS	CS, D

NFR Code	Method	AD	EF
Method(s) applied			
D	Default		
T1	Tier 1 / Simple Methodology *		
T2	Tier 2*		
T3	Tier 3 / Detailed Methodology *		
C	CORINAIR		
CS	Country Specific		
M	Model		
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.			
(source for) Activity Data			
NS	National Statistics		
RS	Regional Statistics		
IS	International Statistics		
PS	Plant Specific		
As	Associations, business organisations		
Q	specific Questionnaires (or surveys)		
M	Model / Modelled		
C	Confidential		
(source for) Emission Factors			
D	Default (EMEP Guidebook)		
CS	Country Specific		
PS	Plant Specific		
M	Model / Modelled		
C	Confidential		

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAHs	HCB	PCBs
-/-	**L/T**	-/-	-/-	**L/T**	**L/T**	**L/T**	L/-	**L/T**	**L/-**	-/-	-/-	**L/-**	-/-	-/-	-/-	NE	**L/T**	**L/-**	**L/-**	**L/-**	**L/-**	**L/-**	**L/-**	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

For further information on activity data please refer to the superordinate chapter on small stationary combustion.

Emission factors

For further information on the emission factors applied please refer to the superordinate chapter on small stationary combustion.

Table 1: Emission factors for commercial and institutional combustion installations

	NO_x	SO_x	CO	NMVOC	TSP	PM_{10}	$PM_{2.5}$	PAH	PCDD/F
	[kg/TJ]							[mg/TJ]	[kg/TJ]
Hard Coal	89.8	331.7	2,162	30.3	18.5	17.6	15.7	19,215	16.3
Residual Wood	92.7	8.2	704.1	51.0	36.1	34.7	31.2	144,957	355.3

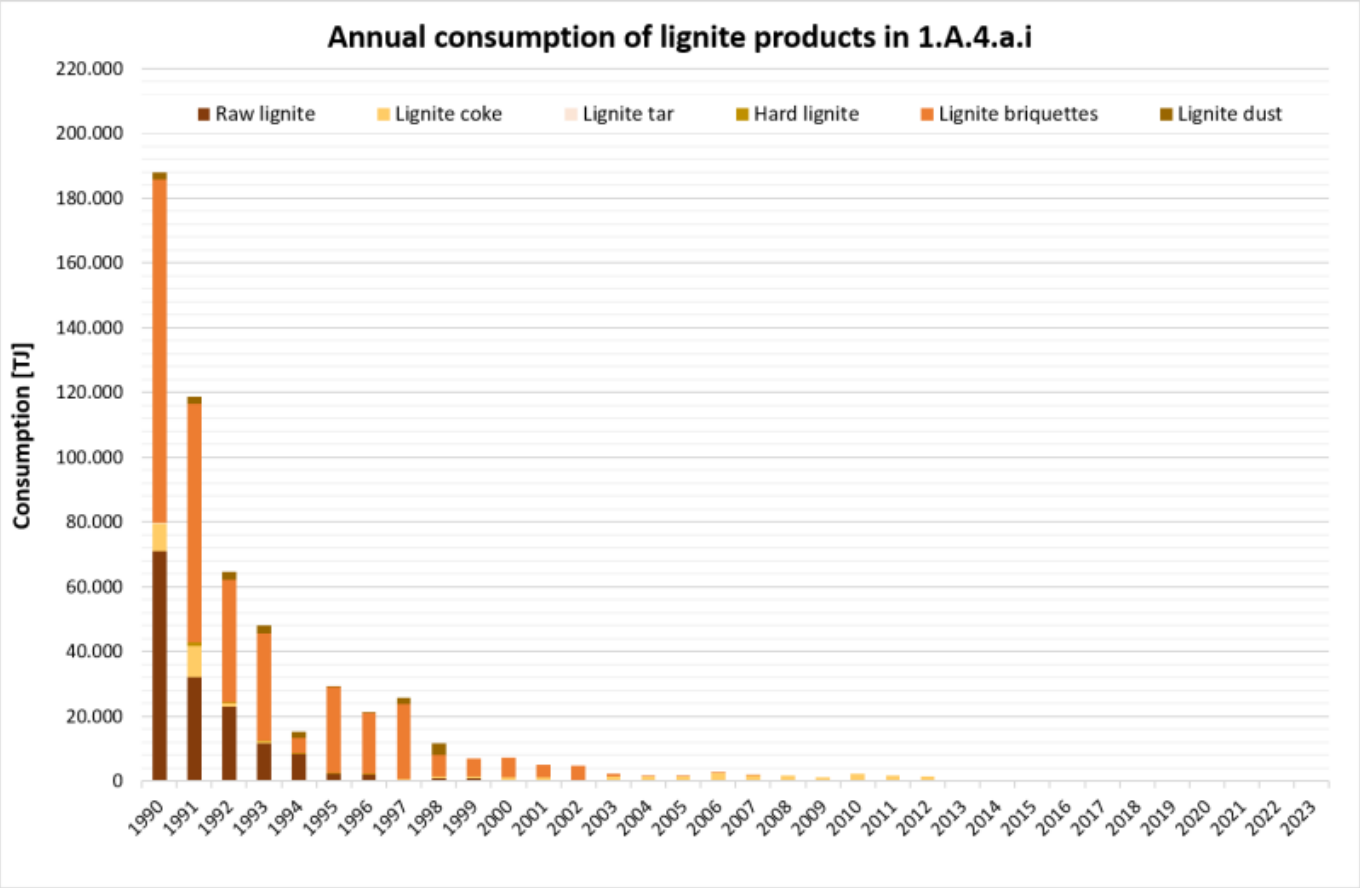
	NO_x	SO_x	CO	NMVOC	TSP	PM_{10}	$PM_{2.5}$	PAH	PCDD/F
Light Heating Oil	43.6	8.1	11.9	2.3	1.0	1.0	1.0	20.10	2.7
Natural Gas	22.0	0.1	12.0	0.4	0.03	0.03	0.03	3.08	1.6

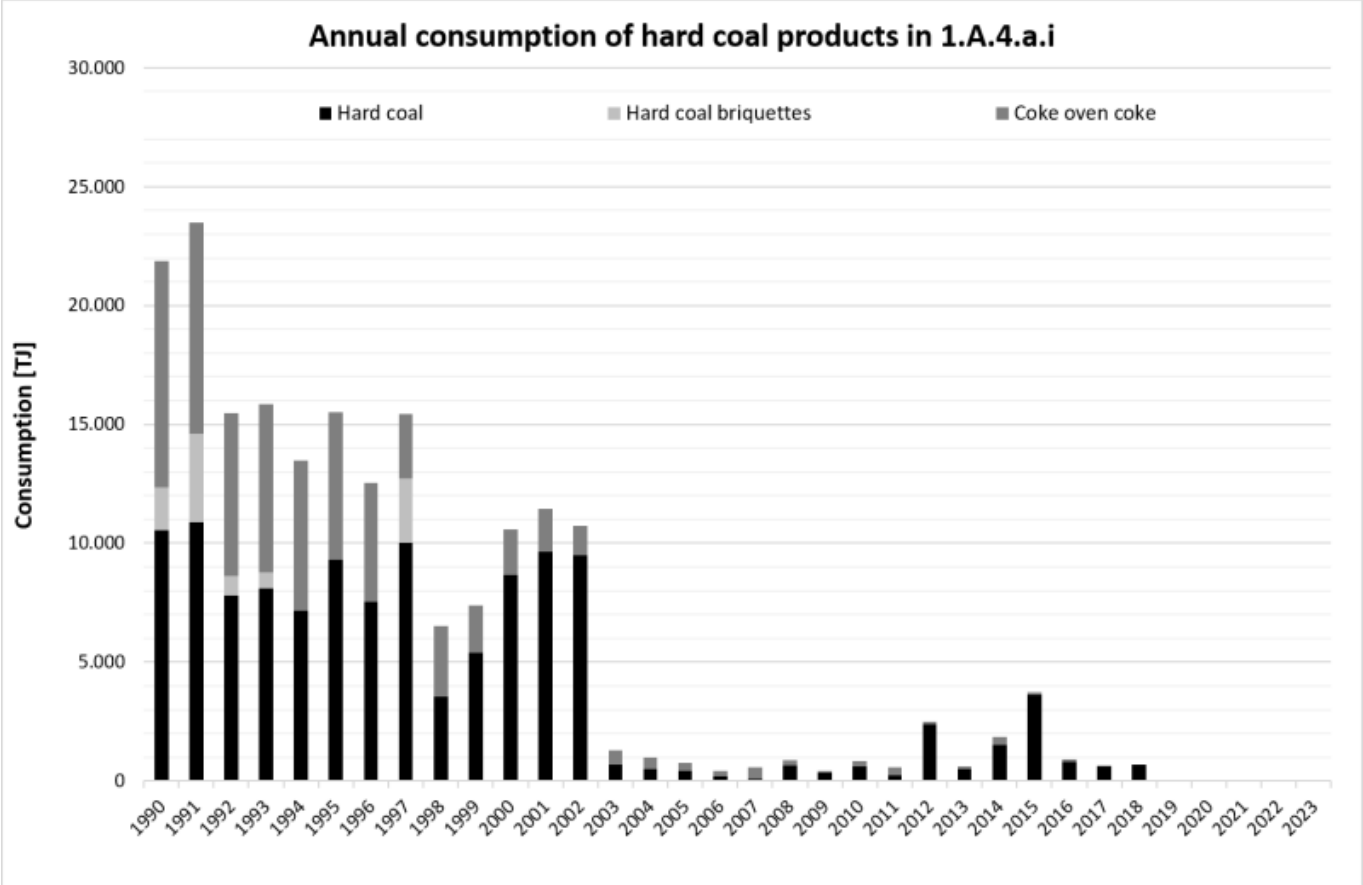
TSP and PM emission factors are to a large extend based on measurements without condensed compounds, according to CEN-TS 15883, annex I. PAH measurement data contain the following individual substances: Benzo(a)pyrene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Benzo(b)fluoranthene, Benzo(j)fluoranthene, Benzo(ghi)perylene, Anthracene, Benzo(a)anthracene, Chrysene(+Trihenylene) and Dibenz(a,h)anthracene, as a specific part of US EPA.

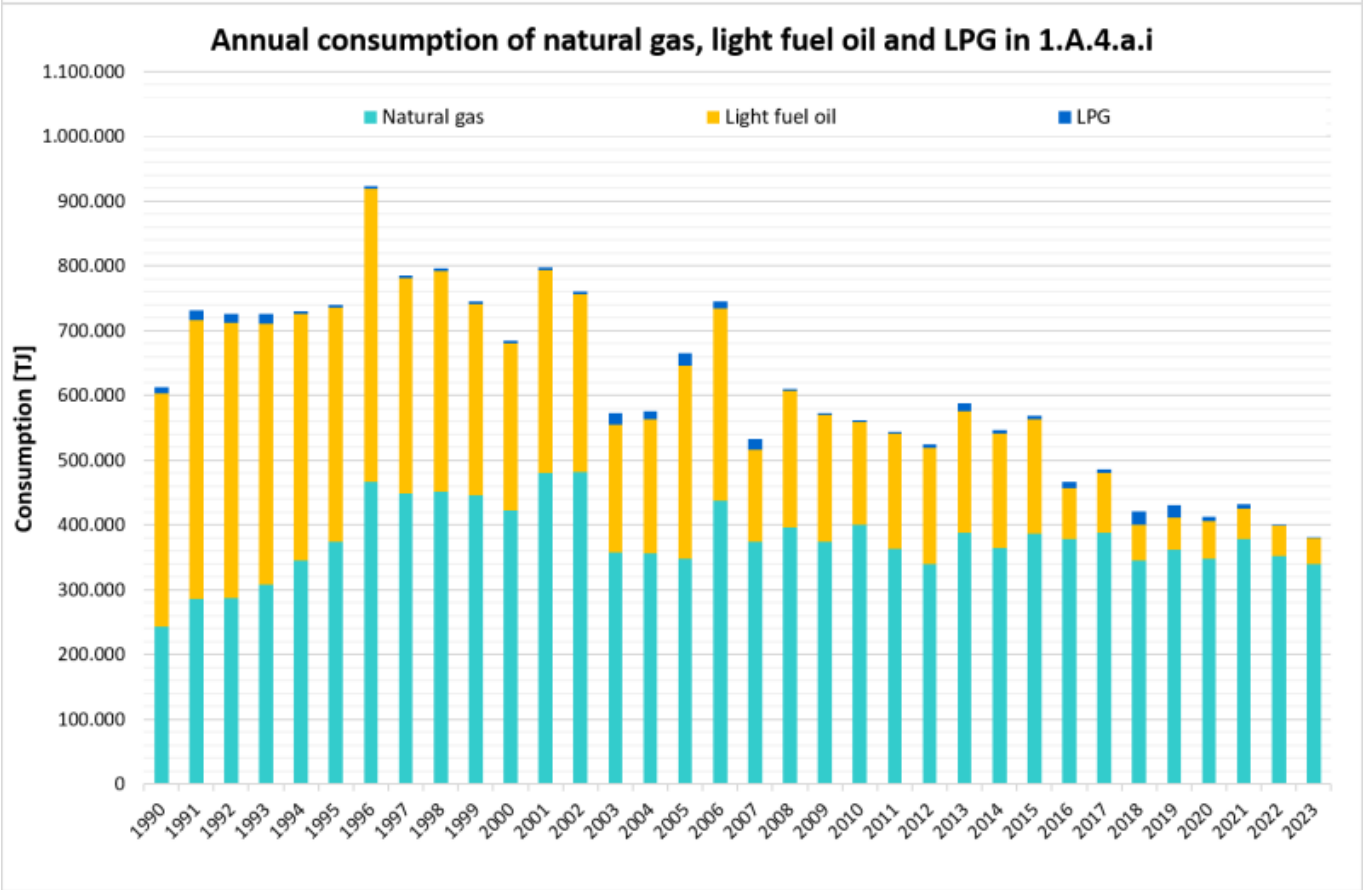
Trend Discussion for Key Sources

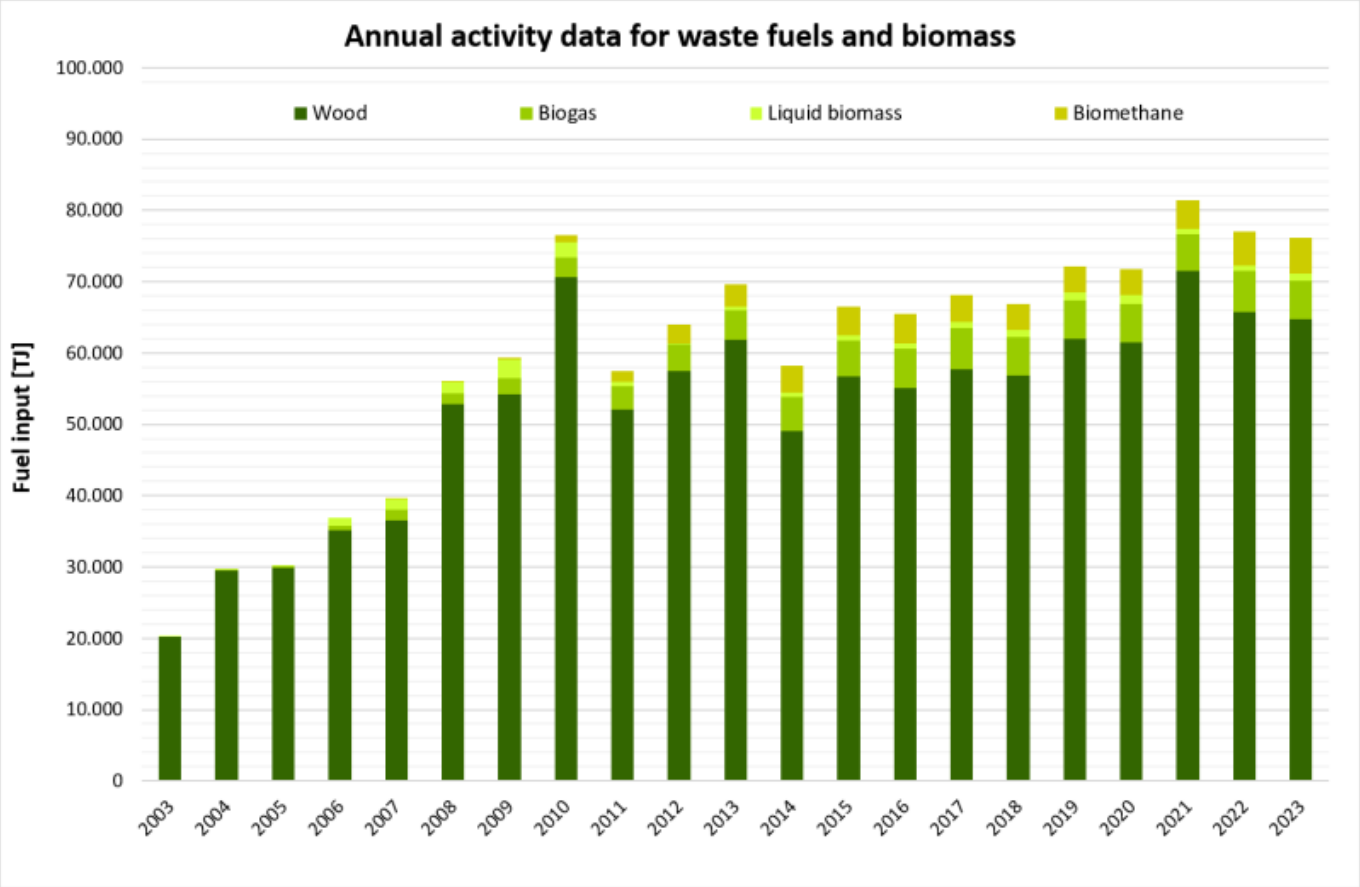
The following charts give an overview and assistance for explaining dominant emission trends of selected pollutants.

Fuel Consumption




Annual consumption of hard coal products in 1.A.4.a.i
Hard coal
Hard coal briquettes
Coke oven coke
Consumption [TJ]
30.000
25.000
20.000
15.000
10.000
5.000
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

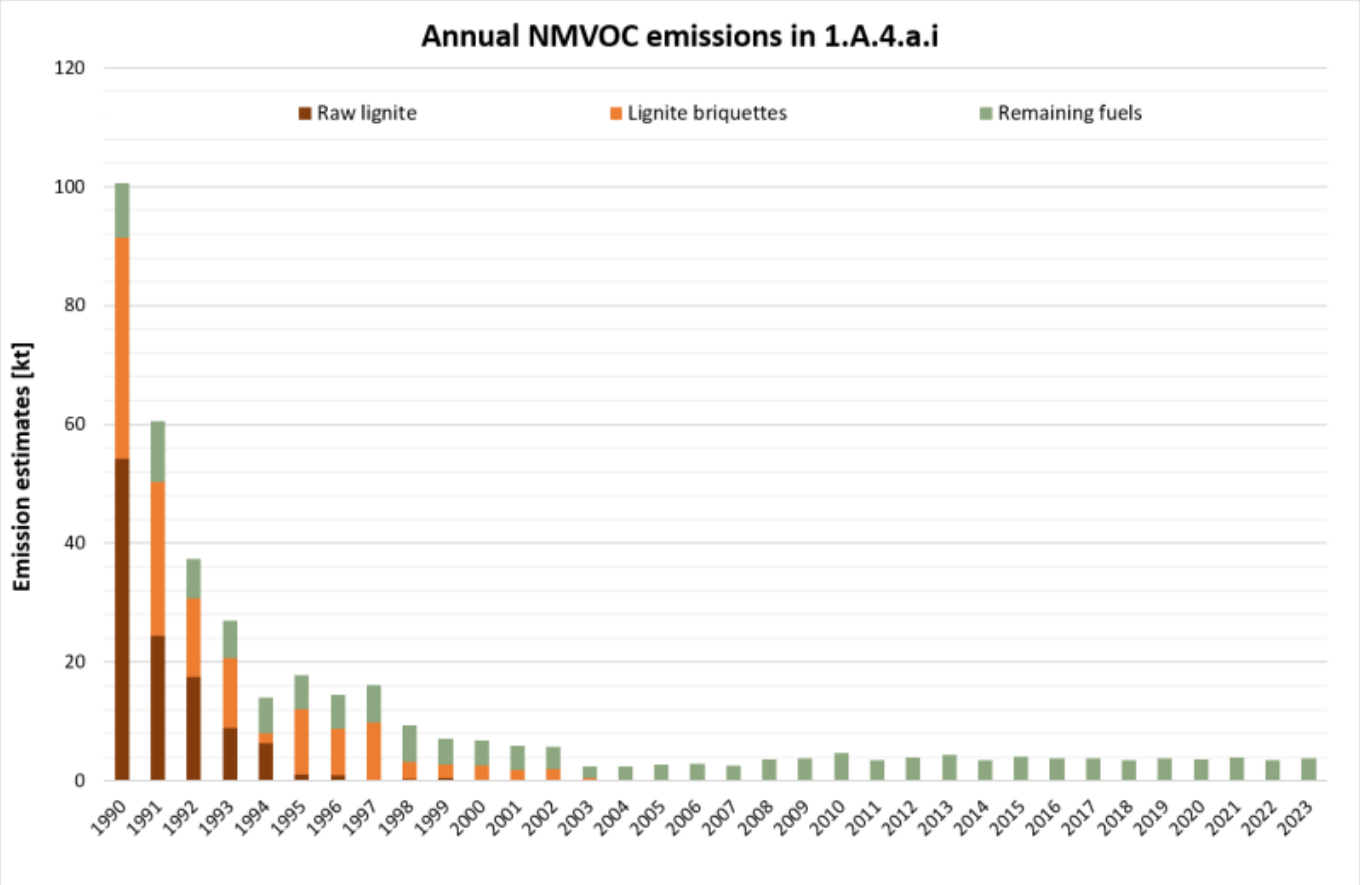

Annual consumption of natural gas, light fuel oil and LPG in 1.A.4.a.i
Natural gas
Light fuel oil
LPG
Consumption [TJ]
1.100.000
1.000.000
900.000
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

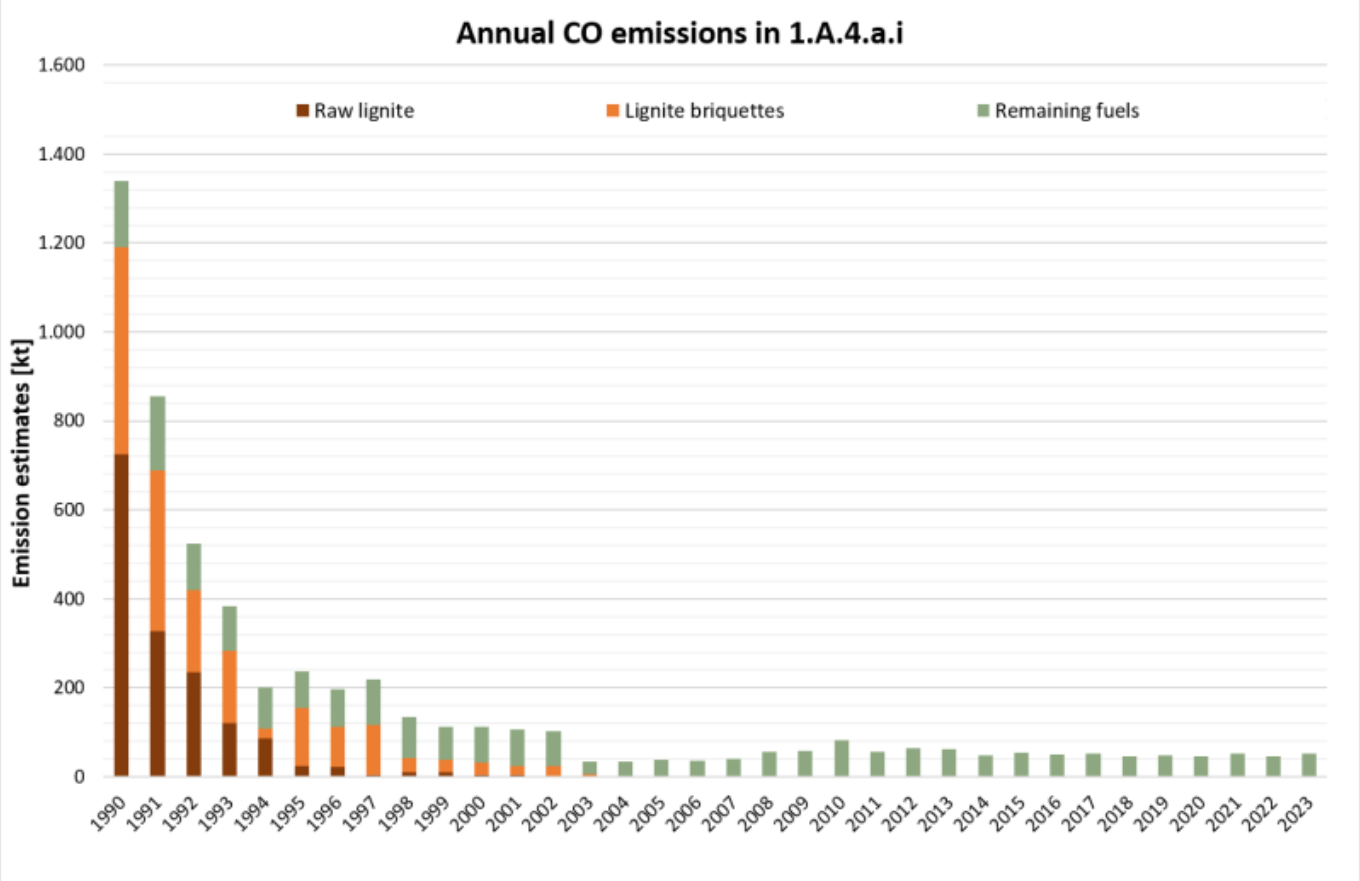


Annual fluctuations of all fuel types in source category *1.A.4* depend on heat demand subject to winter temperatures. From 1990 to the present time, fuel use changed considerably from coal & lignite to natural gas. The consumption of light heating oil decreased as well. As the activity data for light heating oil is based on the sold amount, it fluctuates due to fuel prices and changing storage amounts.The remarkable decrease of hard coal consumption in 2003 is caused by a change in statistics (data source).

Non-Methane Volatile Organic Compounds - NMVOC and Carbon monoxide - CO

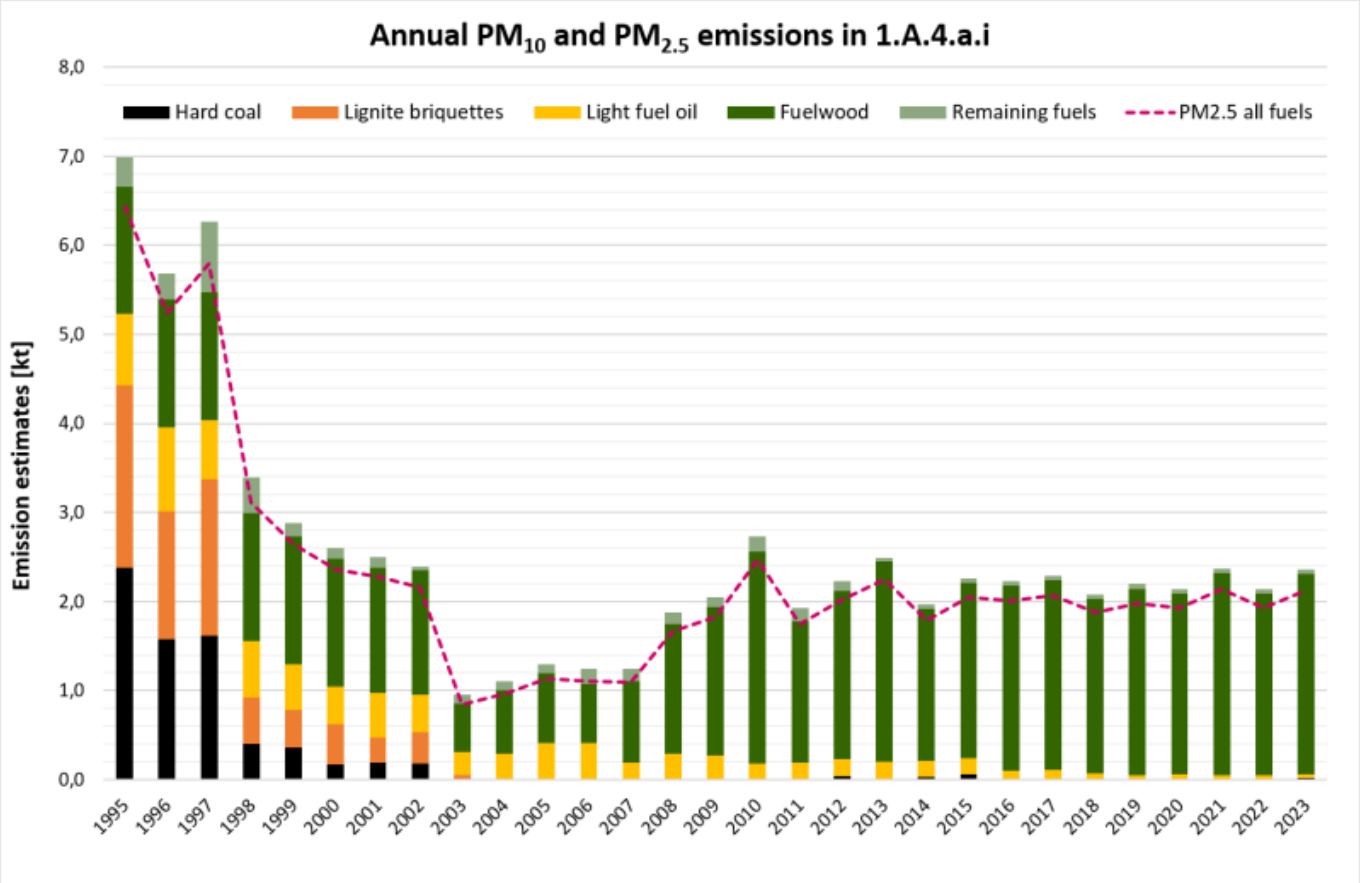
Main driver of the NMVOC and CO emission trends is the decreasing lignite consumption: Since 1990 the fuel use changed from solid fuels causing high NMVOC and CO emissions to gaseous fuels producing much lower emissions.

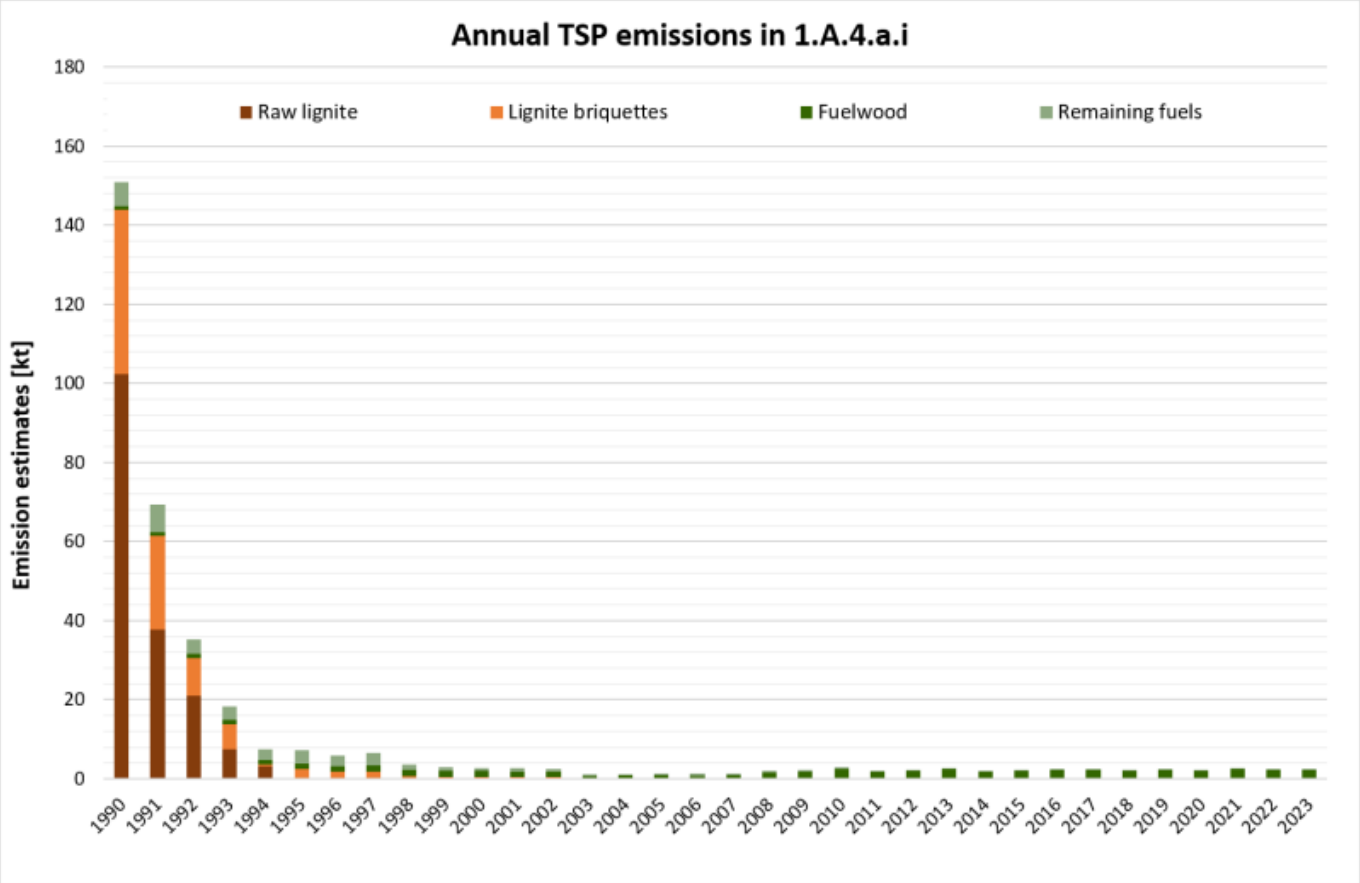




Particulate Matter - PM2.5 & PM10 & TSP

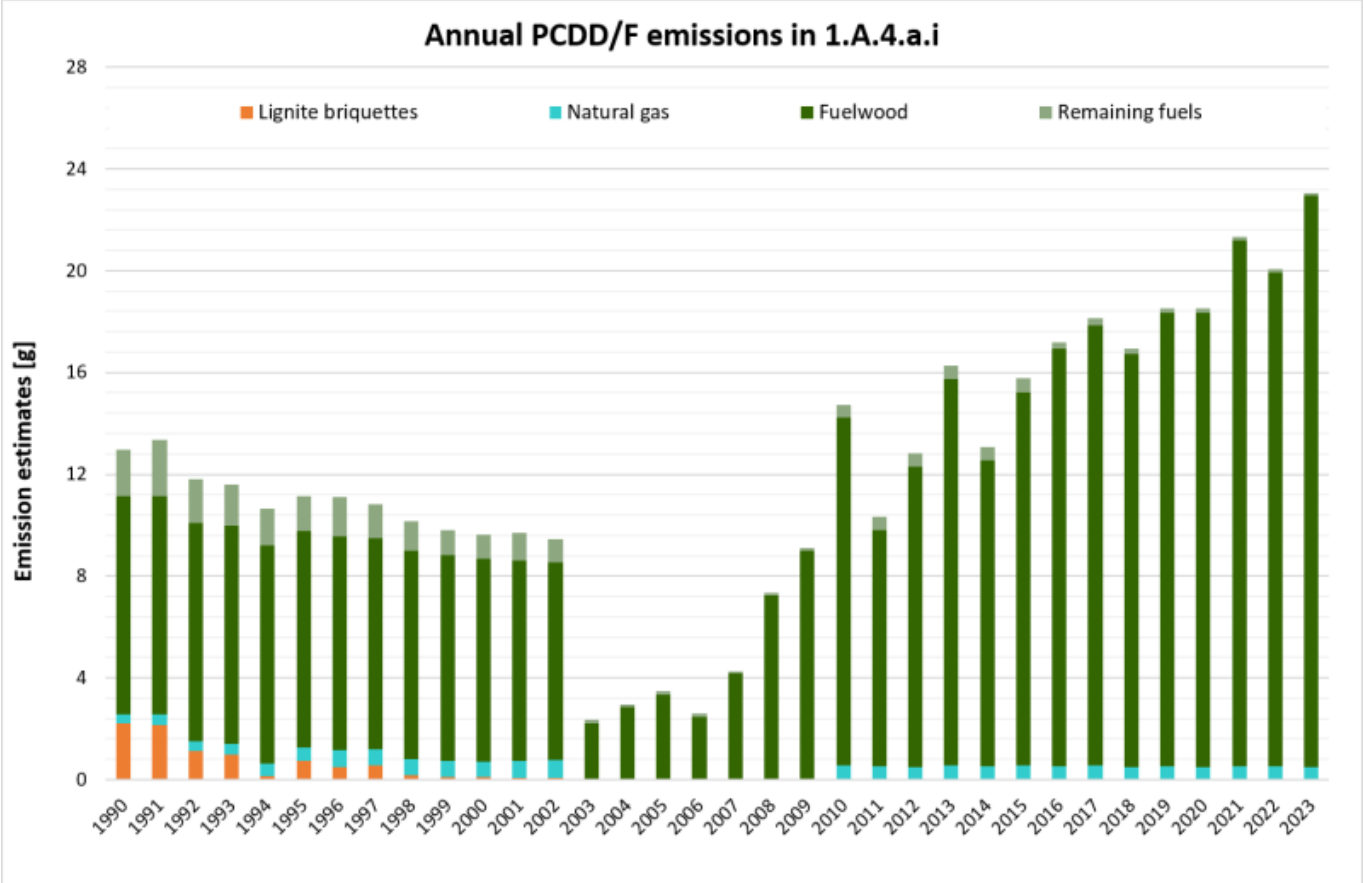
The emission trends for $PM_{2.5}$, PM_{10}, and TSP are also influenced severely by decreasing coal consumption in small combustion plants, particularly in the period from 1990 to 1994. Since 1995 the emission trend hardly changed. Increasing emissions in the last years are caused by the rising wood combustion.

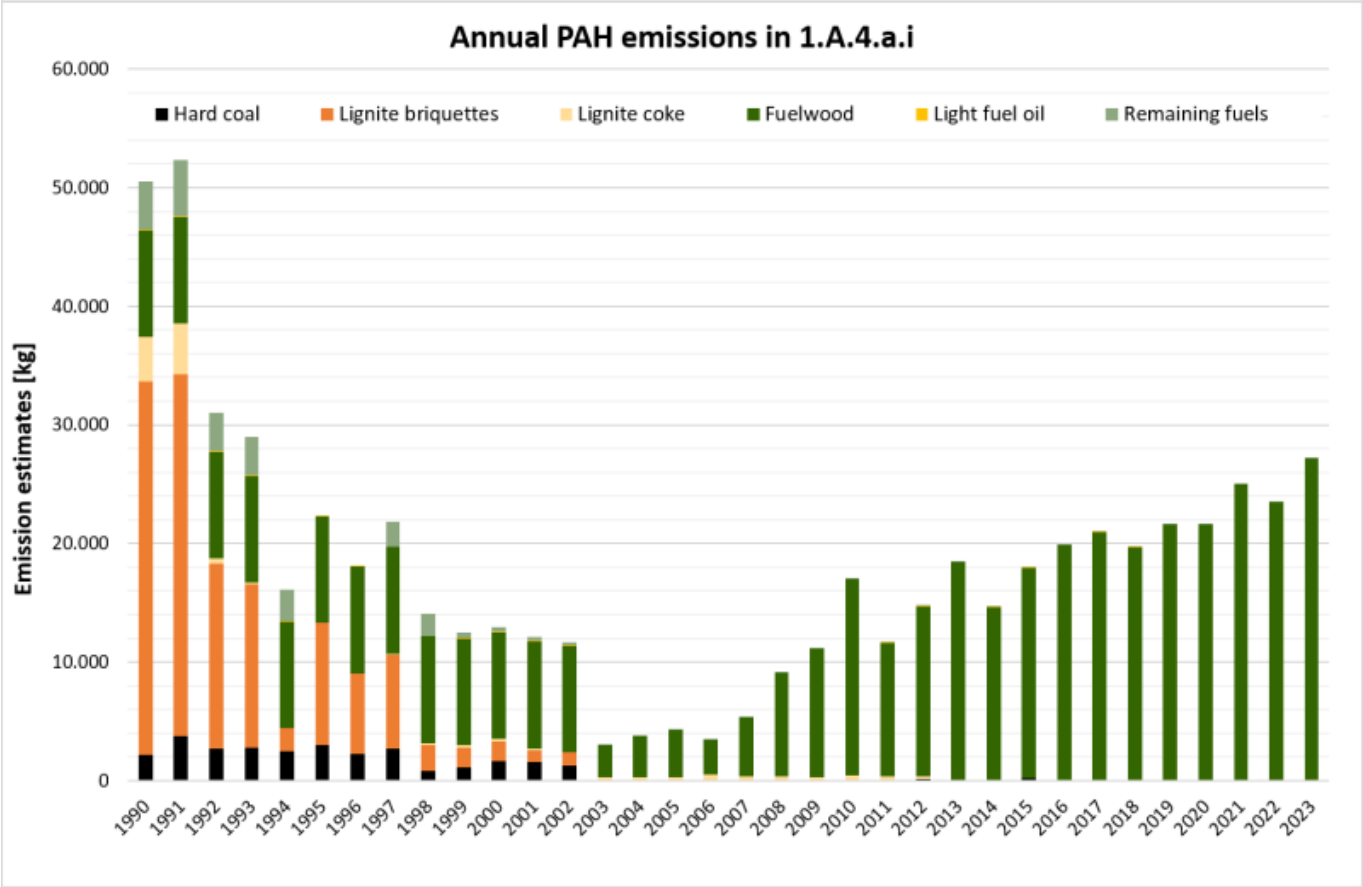




Persistent Organic Pollutants

The main driver of the POPs emission trend are coal and fuelwood. PCDD/F emissions decrease from 1990 to 2003 due to decreasing lignite consumption. The use of firewood and therefore PCDD/F emissions from wood combustion show a constant development.





Recalculations

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter

9.1 - Recalculations.

Planned improvements

There is an ongoing research project on new emission factors for small combustion plants using updated data from the chimney sweepers and new measurement data. As soon as results are available, implementation into the emission inventory will be checked.

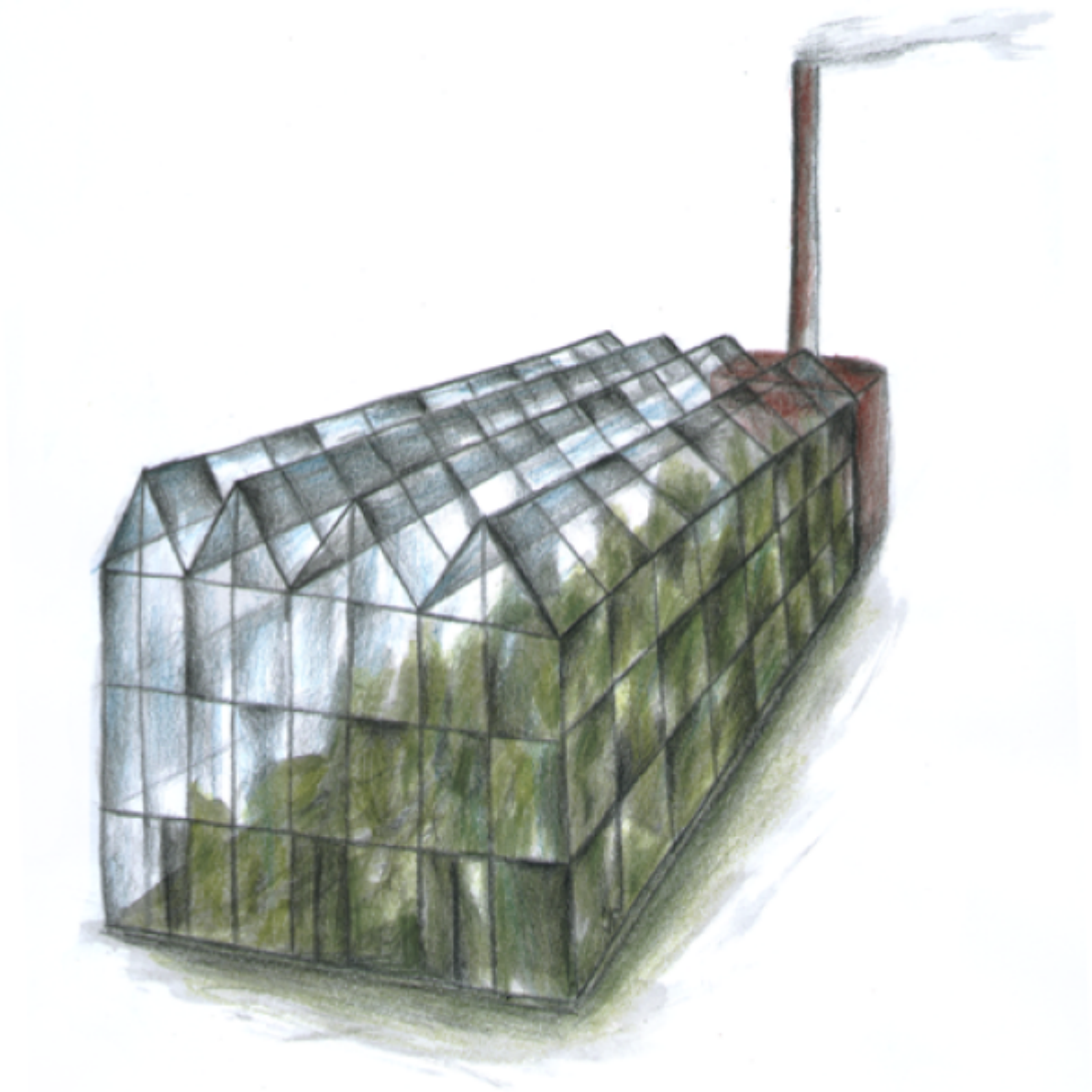
1.A.4.c.i - Agriculture/Forestry/Fishing: Stationary

Short description

In source category *1.A.4.c.i - Agriculture/Forestry/Fishing: Stationary* emissions from smaller combustion plants in agricultural facilities and greenhouses are reported.

NFR Code	Method	AD	EF
1.A.4.c.i	T2, T3	NS	CS, D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential



NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	PAHs	HCB	PCBs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

For further information on activity data please refer to the superordinate chapter on small stationary combustion.

Emission factors

For further information on the emission factors applied please refer to the superordinate chapter on small stationary combustion.

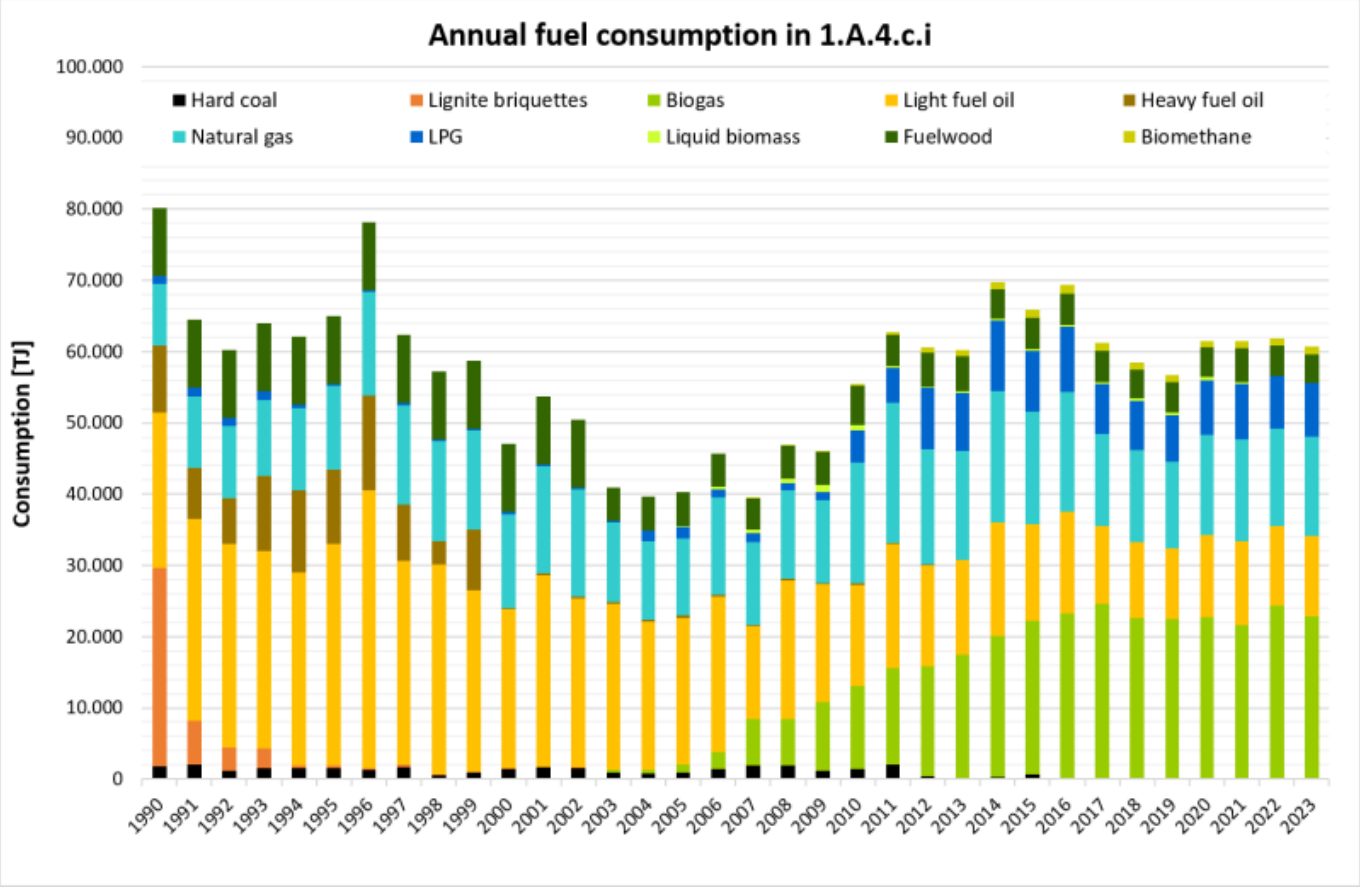
Table 1: Emission factors for commercial and institutional combustion installations

	NO_x	SO_x	CO	NMVOC	TSP	PM_{10}	$PM_{2.5}$	PAH	PCDD/F
	[kg/TJ]							[mg/TJ]	[kg/TJ]
Hard Coal	76.2	331.7	2,709	48.4	18.5	17.6	15.7	19,215	16.3
Firewood	79.2	6.5	2,285	122.1	84.2	81.6	76.9	144,957	355.3
Light Fuel Oil	43.7	8.1	11.9	2.3	1.0	1.0	1.0	20.10	2.7
Natural Gas	27.2	0.1	11.1	0.4	0.03	0.03	0.03	3.08	1.6

TSP and PM emission factors are to a large extend based on measurements without condensed compounds, according to CEN-TS 15883, annex I.

Trend Discussion for Key Sources

The following charts give an overview and assistance for explaining dominant emission trends of selected pollutants.



Annual fluctuations of all fuel types in source category *1.A.4* depend on heat demand subject to winter temperatures. Between 1990 and 2014 the fuel use changed considerably from coal & lignite to natural gas & biogas. The consumption of light heating oil decreased as well. As the activity data for light heating oil is based on the sold amount, it fluctuates due to fuel prices and changing storage amounts.

Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the Energy Balance for 2022 led to recalculations. Additionally, due to the updates in data source for biomass fuels, recalculations took place between 2003-2022.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

There is an ongoing research project on new emission factors for small combustion plants using updated data from the chimney sweepers and new measurement data. As soon as results are available, implementation into the emission inventory will be checked.

1.A.4.b i - Residential: Stationary Combustion

Short description



In source category *1.A.4.b.i. - Other: Residential* emissions from small residential combustion installations are reported.

NFR Code	Method	AD	EF
1.A.4.b.i	T2, T3	NS	CS, D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAHs	HCB	PCBs

L/-	L/T	L/T	-/-	L/T	L/T	L/T	L/-	L/T	-/-	-/-	L/-	-/-	-/-	-/-	-/-	NE	L/T	L/-	L/T	L/T	L/T	L/T	L/T	L/-	L/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

For further information on activity data please refer to the superordinate chapter on small stationary combustion.

Emission factors

For further information on the emission factors applied please refer to the superordinate chapter on small stationary combustion.

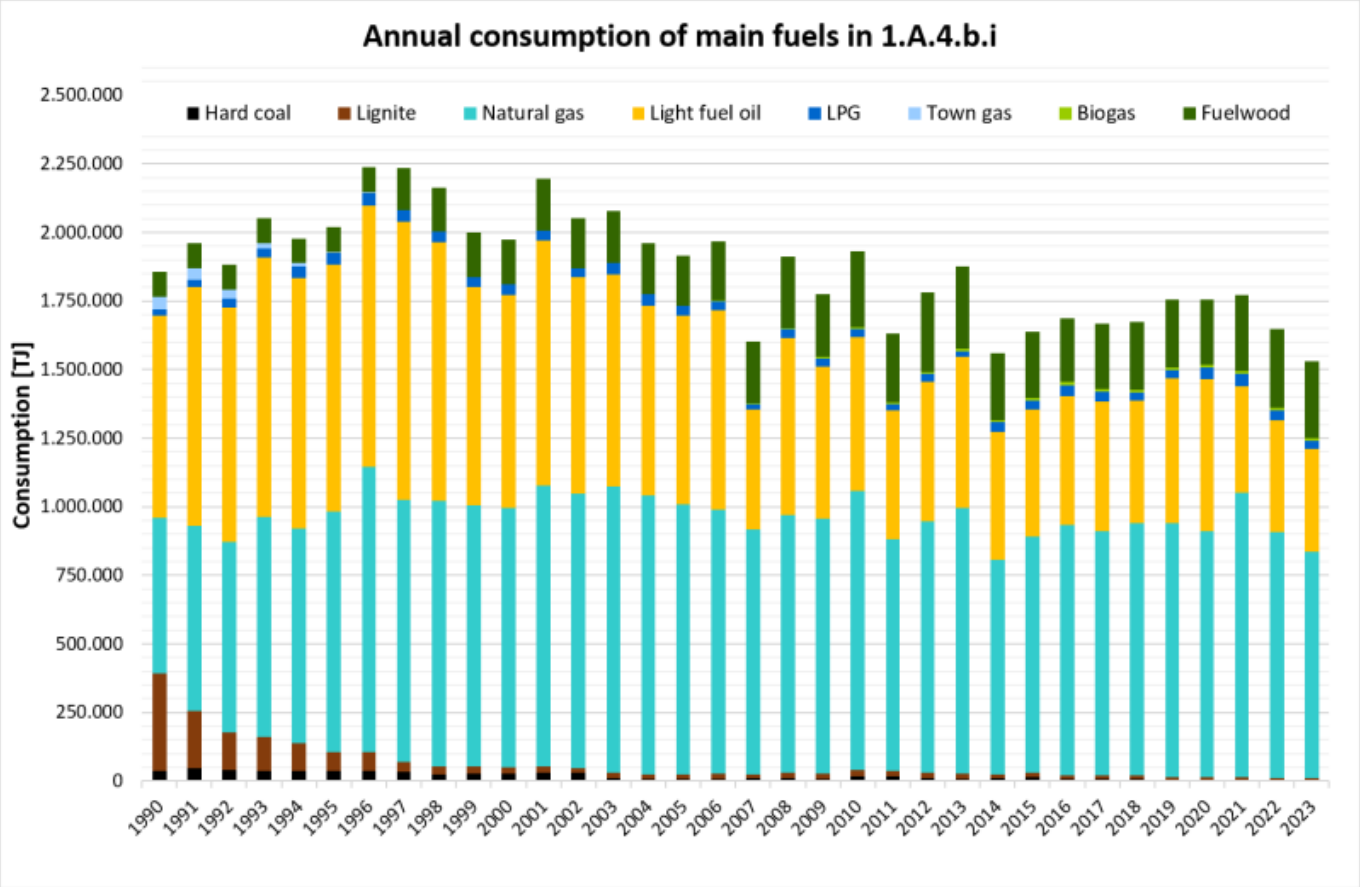
Table 1: Emission factors for domestic combustion installations

	NO_x	SO_x	CO	NMVOC	TSP	PM_{10}	$PM_{2.5}$	PAH	PCDD/F
	[kg/TJ]							[mg/TJ]	[µg/TJ]
Hard Coal	61.1	385.5	3,422	67.0	18.5	17.6	15.7	19,215	20.8
Hard Coal Coke	40.0	458.6	5,448	11.5	16.6	15.8	14.2	32,700	45.7
Hard Coal Briquettes	50.4	563.5	4,875	184.1	265.4	252.8	227.3	165,858	20.2
Lignite Briquettes	87.0	450.7	2,349	158.0	79.5	76.5	68.2	148,329	24.8
Natural Wood	69.9	8.1	1,304	123.3	57.1	56.0	53.4	202,265	45.2
Light Fuel Oil	41.8	8.1	11.8	1.5	0.9	0.9	0.9	350.0	2.2
Natural Gas	20.5	0.1	13.2	0.6	0.03	0.03	0.03	3.08	2.1

TSP and PM emission factors are to a large extend based on measurements without condensed compounds, according to CEN-TS 15883, annex I.

Trend Discussion for Key Sources

The following charts give an overview of the fuel use and the dominant emission trends of selected pollutants.

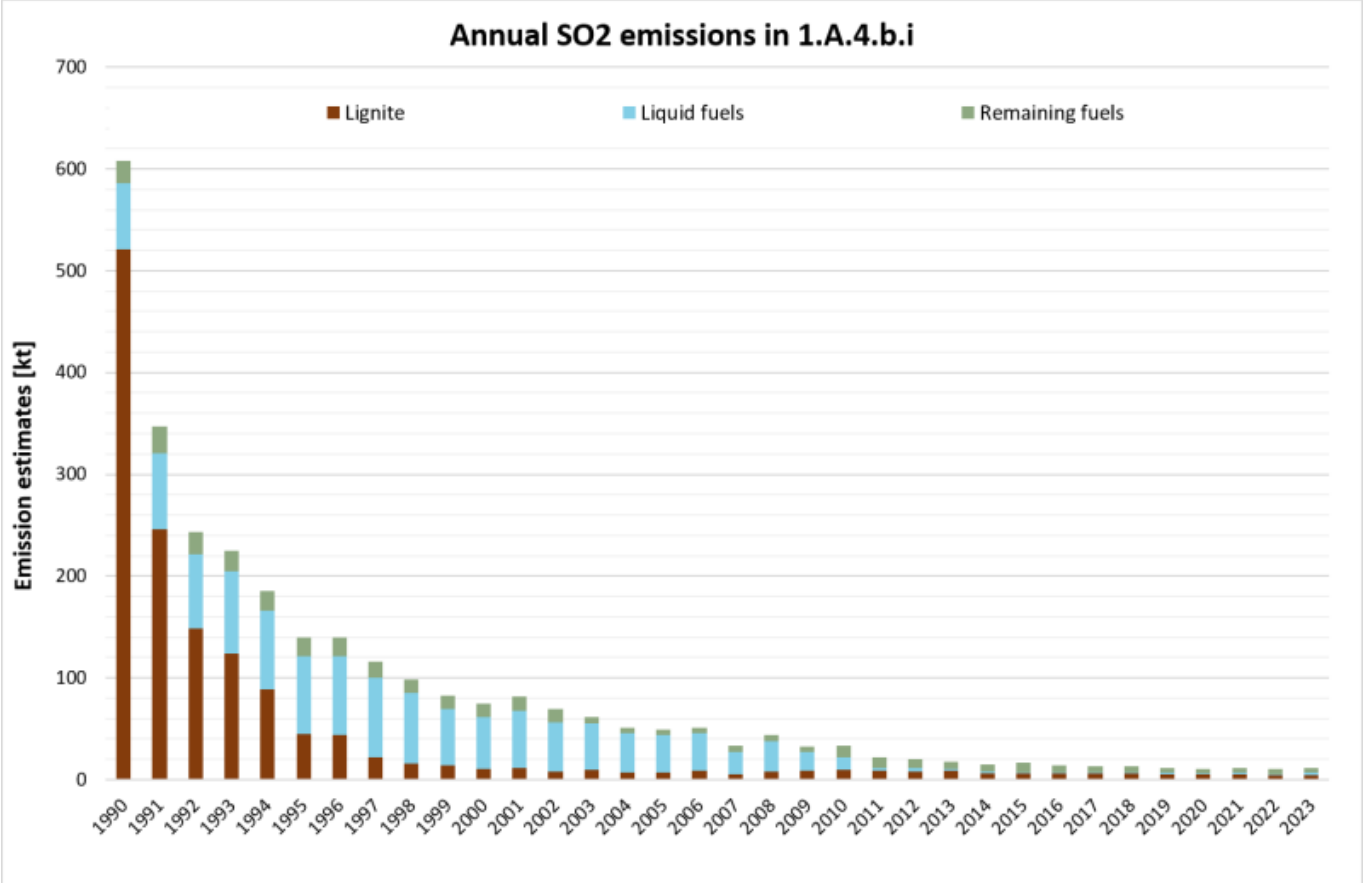


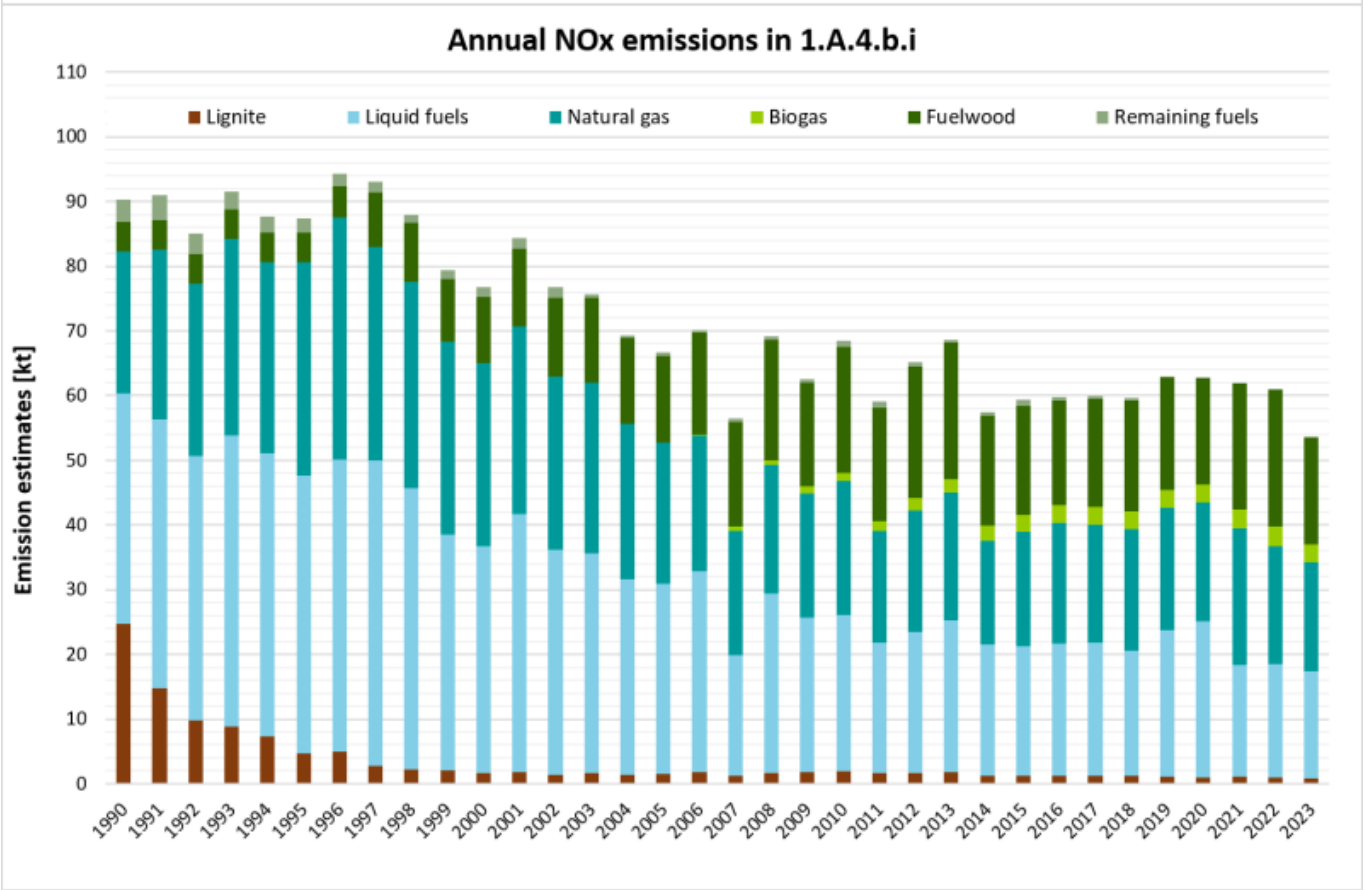
Annual fluctuations of all fuel types in source category *1.A.4.b.i* depend on heat demand subject to winter temperatures. Between 1990 and 2002 the fuel use changed considerably from coal & lignite to natural gas. The consumption of light heating oil decreased as well. As the activity data for light heating oil is based on the sold amount, it fluctuates due to fuel prices and changing storage amounts. In 2010 and 2013 fuel consumption was particularly high due to the cold winter. The higher fuel consumption in 2014 - 2017 is a result of lower temperatures during the heating period. In 2019 and 2020 the fuel demand increased due to decreasing oil prices, and therefore less in 2021.

Sulfur Oxides & Nitrogen Oxides - SOx & NOx

SO_2 emissions decrease due to the fuel switch from coal (especially lignite with a high emission factor) to natural gas with a lower emission factor. A further SO_2 reduction from 2008 onwards can be explained by the increasing use of low-sulfur fuel oil. Nowadays almost exclusively low-sulfur fuel oil is used.

In contrast to SO_2 emissions NO_x emission trend is less influenced by fuel characteristics but more by combustion conditions. Therefore NO_x emission values shows lower reduction. During the last years the use of fuelwood gain influence.

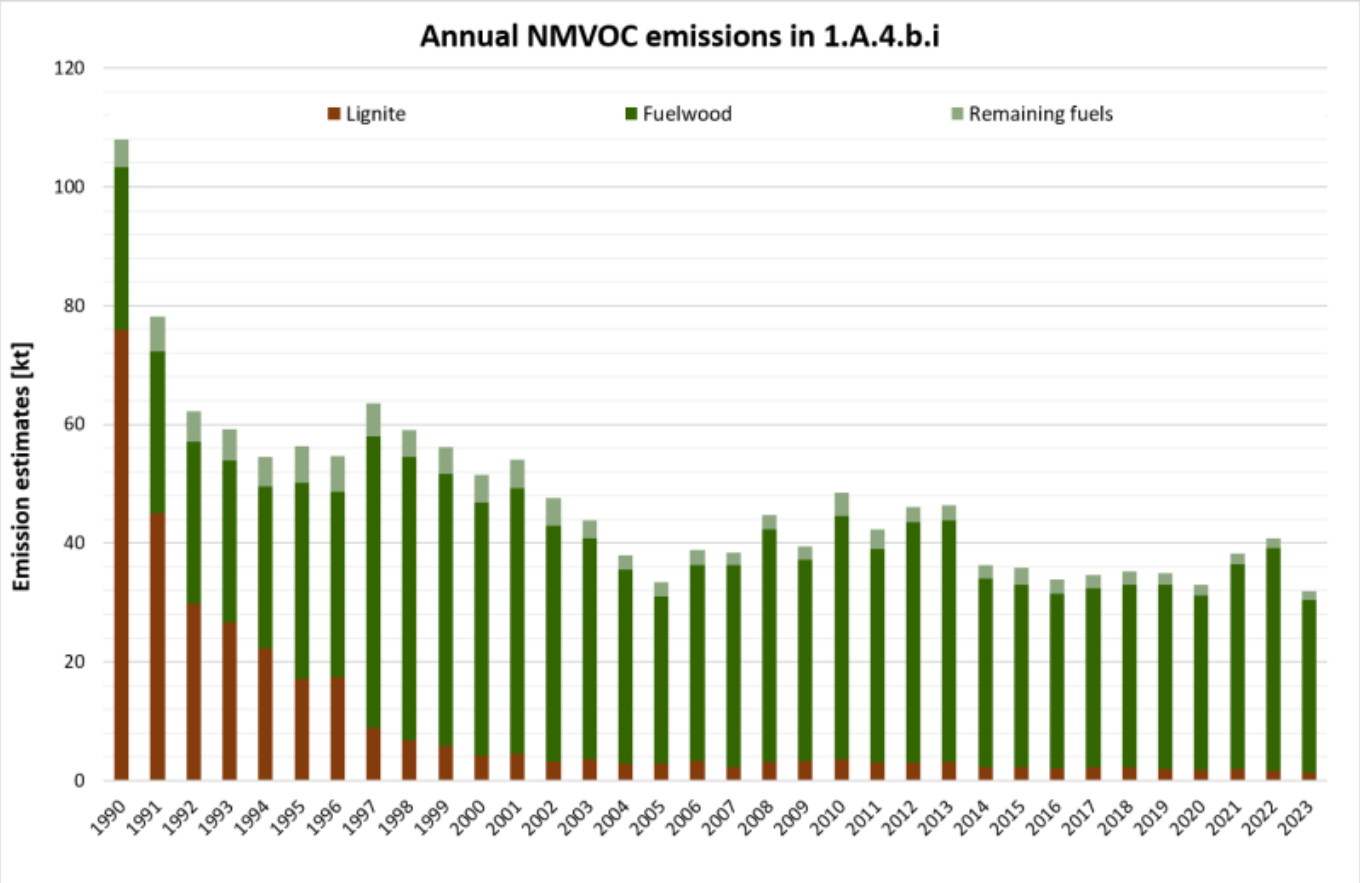


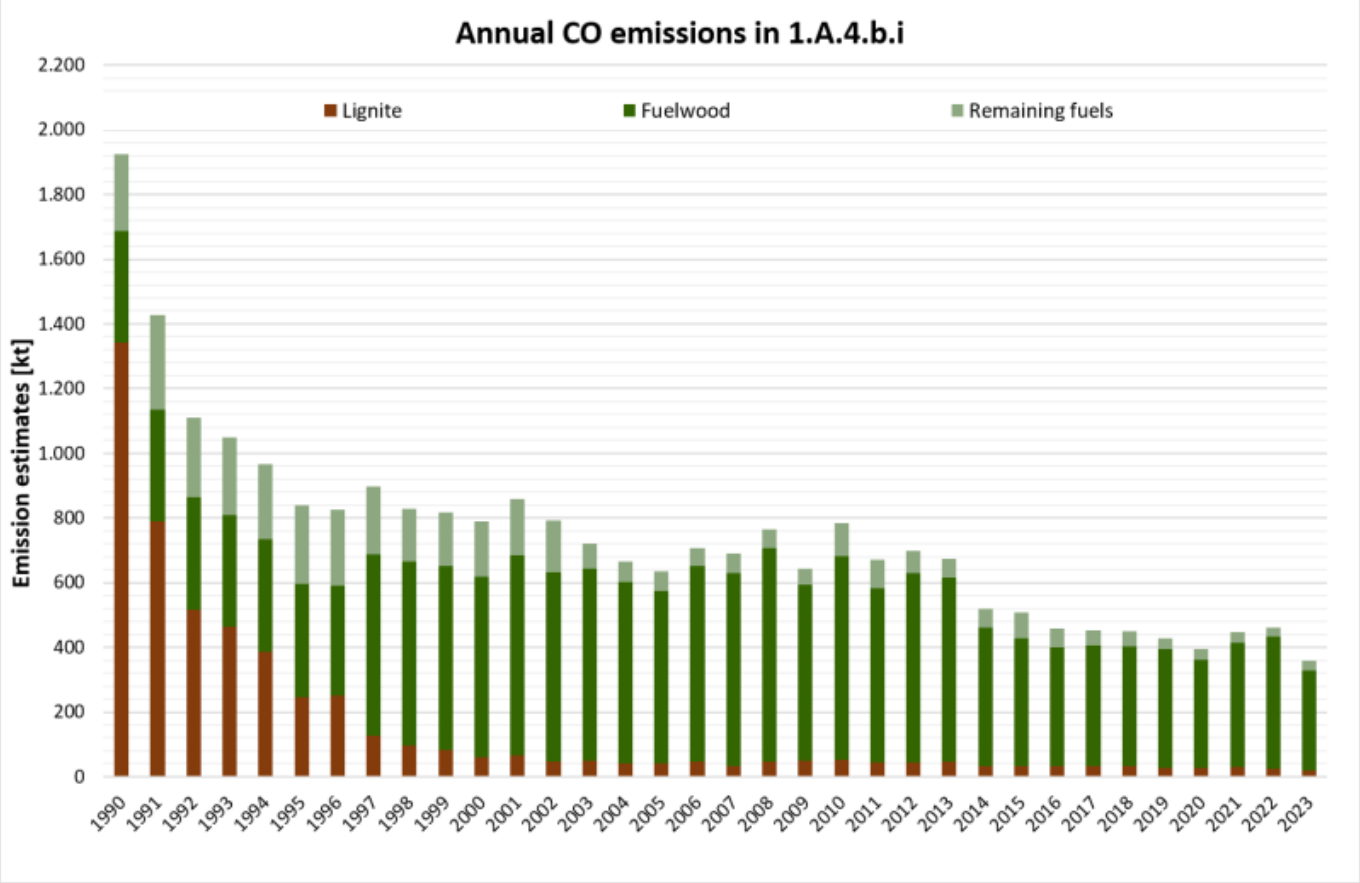


Non-Methane Volatile Organic Compounds & Carbon Monoxide - NMVOC & CO

Main driver of the NMVOC emission trend is the decreasing lignite consumption. In the residential sector the emission trend is also affected by the increasing use of fuelwood with high emission factors which levels off the emission reduction. The explanation for decreasing carbon monoxide emissions is similar to the trend discussion for SO_2 and NMVOC. Since 1990 the

fuel use changed from solid fuels, which causes high CO-emissions, to gaseous fuels, which produce less CO emissions.

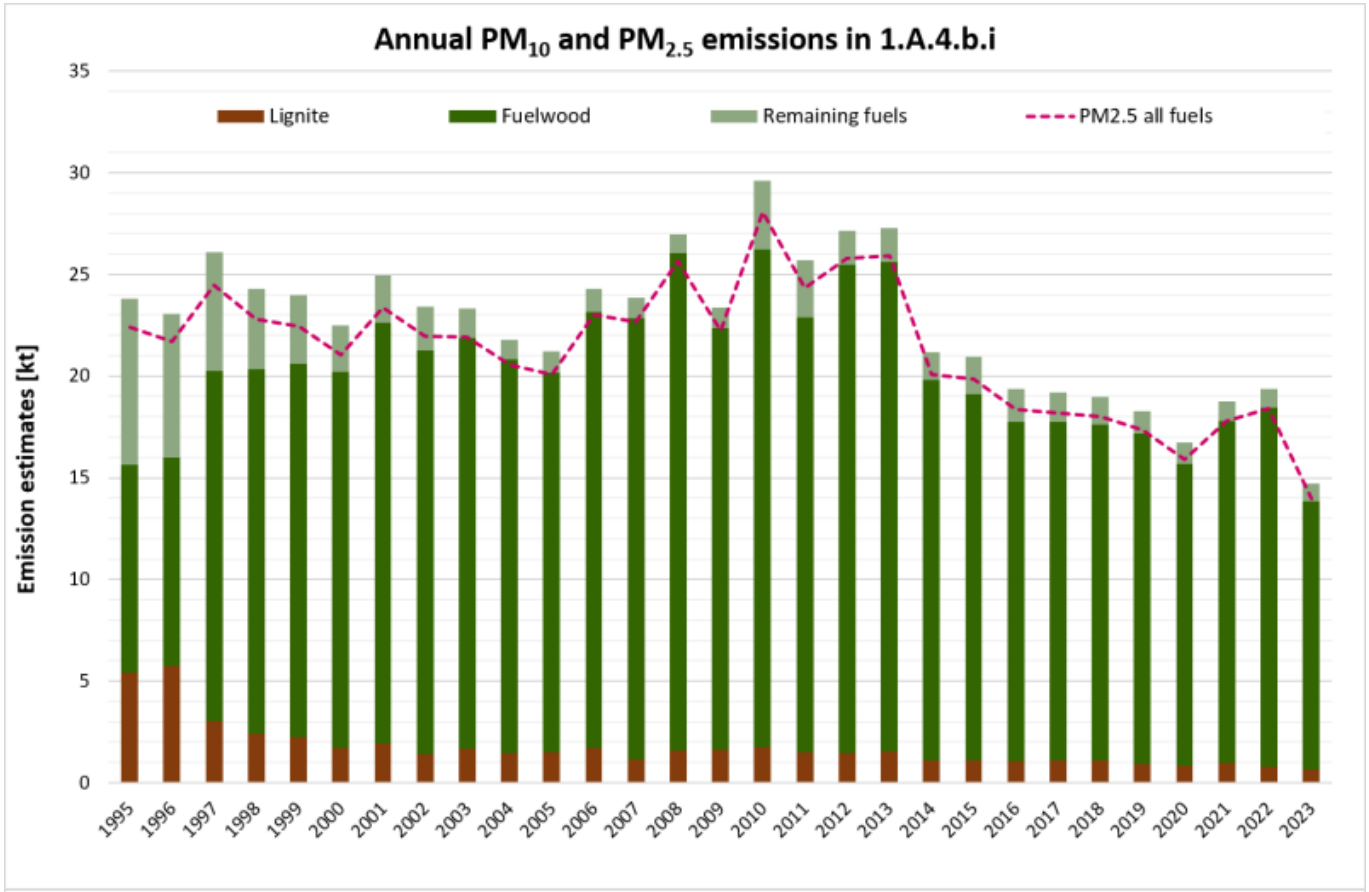


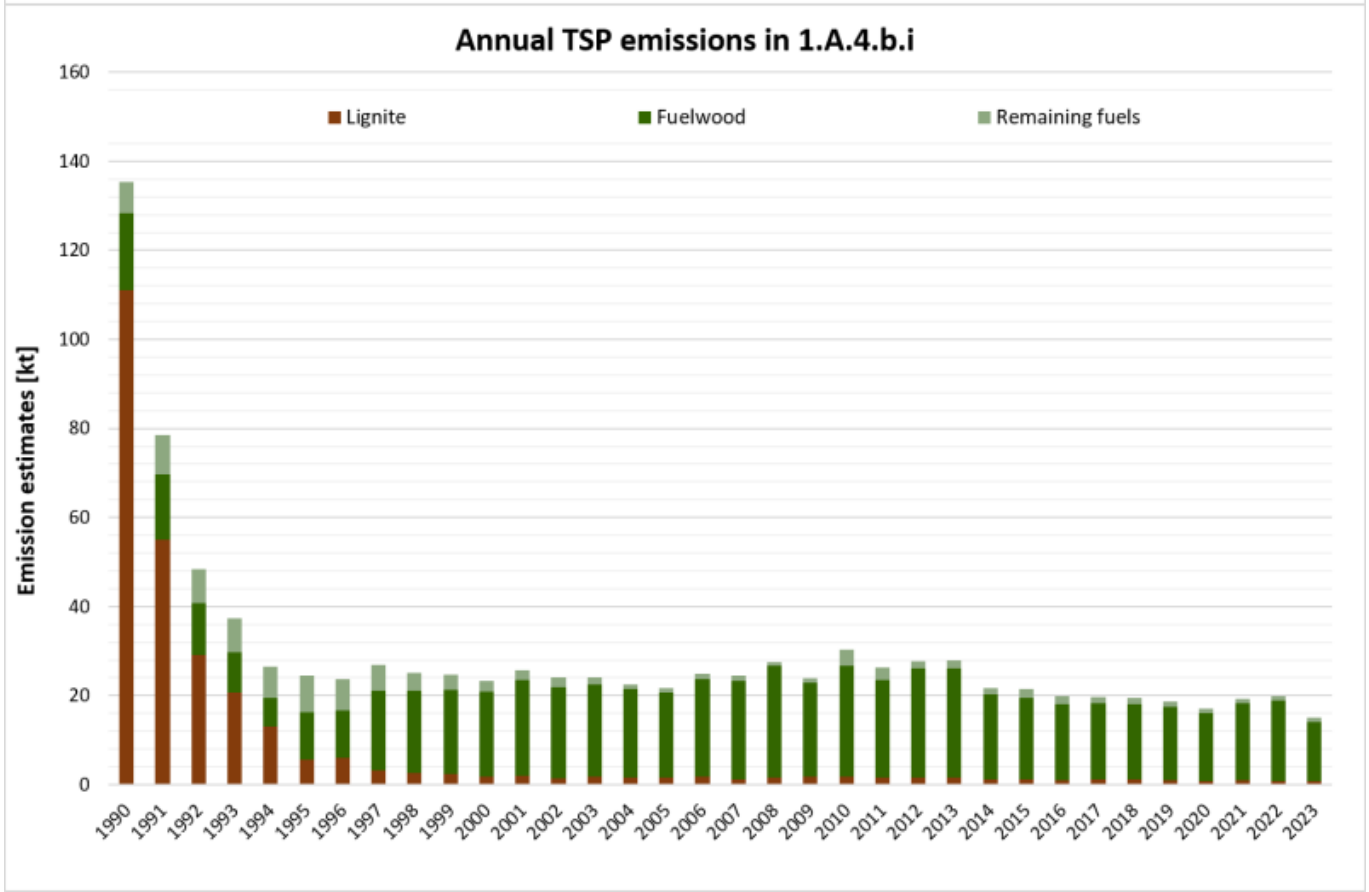


Particulate Matter - PM2.5 & PM10 & TSP

The emission trend for $PM_{2.5}$, PM_{10}, and TSP are also influenced strongly by decreasing coal consumption in small combustion

plants, particularly in the period from 1990 to 1994. Since 1995 the emission trend hardly changed. Increasing emissions in the last years are caused by the rising wood combustion in residential fire places and stoves.

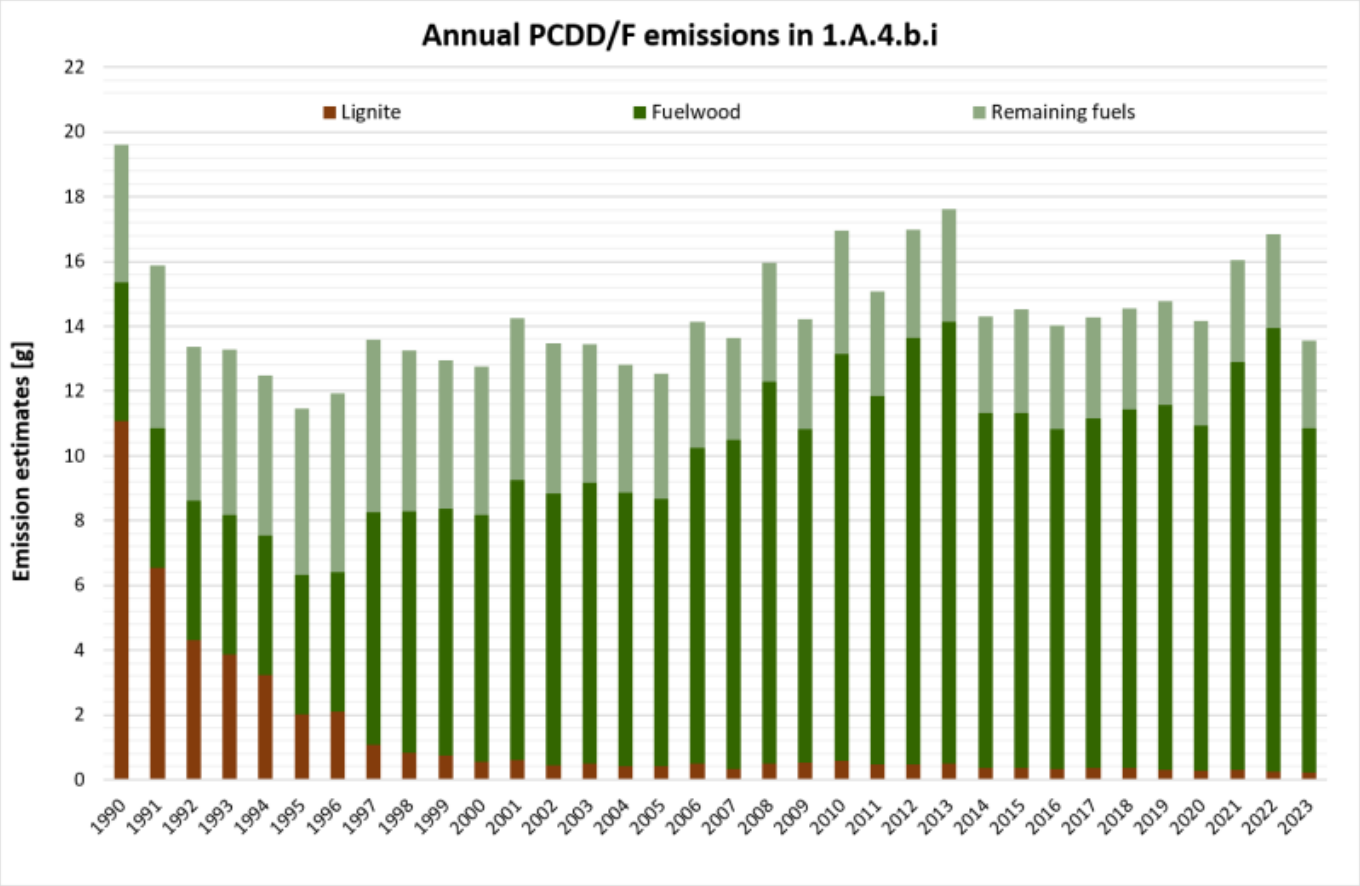


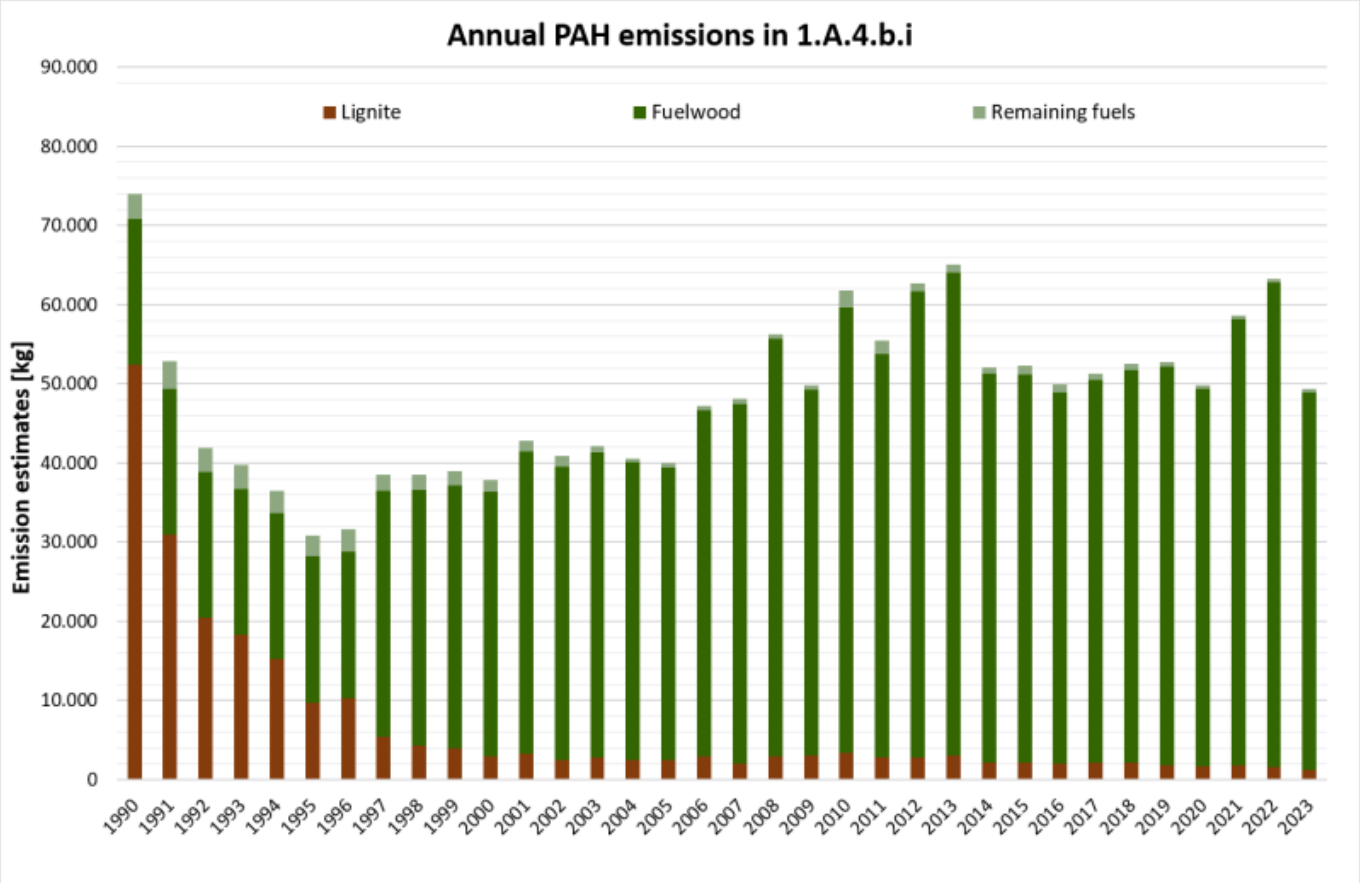


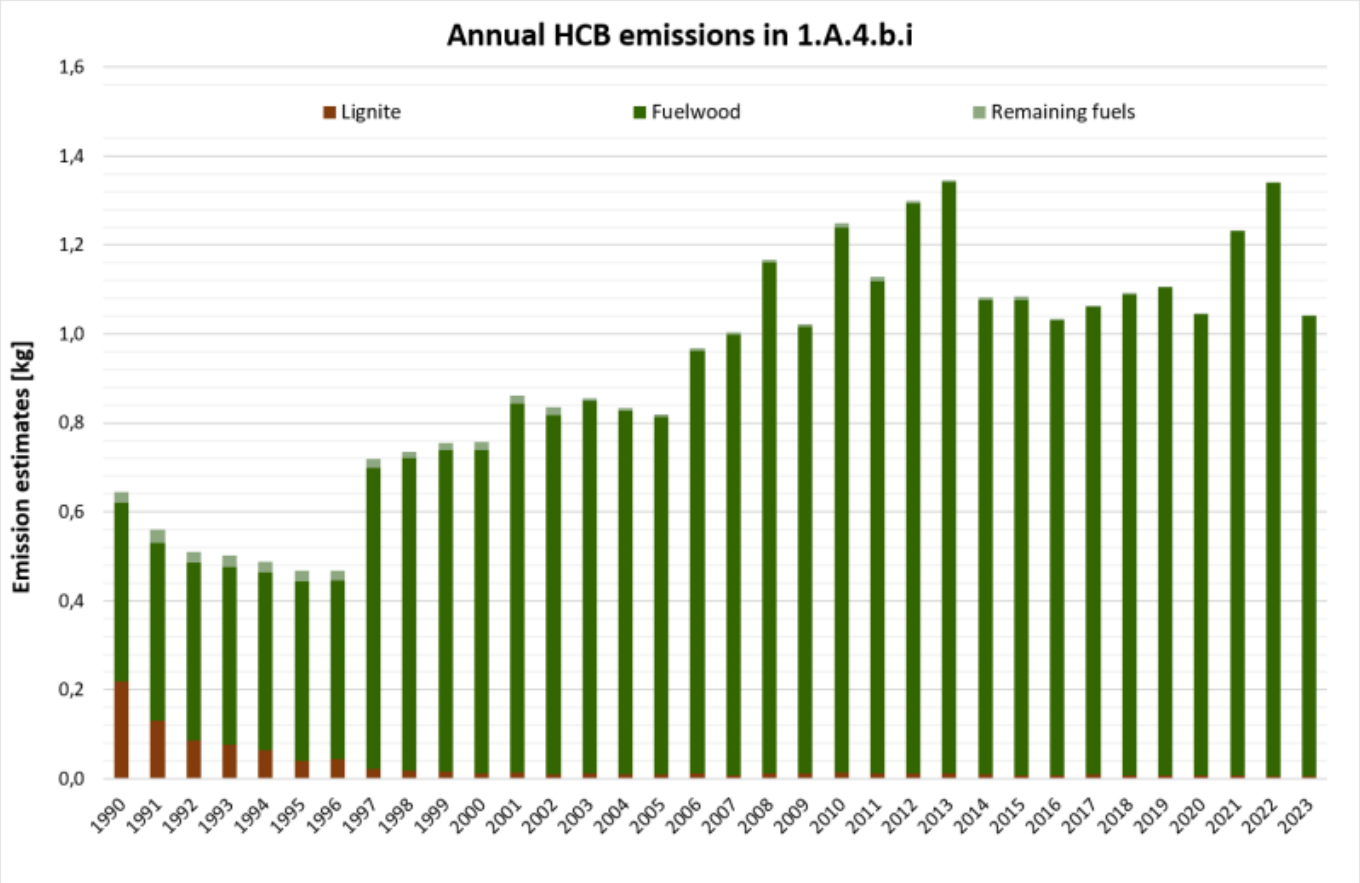
Persistent Organic Pollutants

The main driver of the POP emission trend are coal and fuelwood combustion. PCDD/F emissions from coal fired furnaces are declining but the effect is retarded by increasing wood consumption. The same influencing variables apply accordingly to the PAH emission trends. The emission trend of HCB shows a high dominance of emissions from wood-burning. Emission factors for HCB are constant from 1990 to 2020. Furthermore, the difference between the EFs for coal and fuelwood is very large. Therefore, the emission trend depends solely on the development of fuelwood consumption. Regarding HCB emissions the inventory is incomplete. This is one of the reasons for the importance of emissions from small combustion plants. In 2010, 2012 and 2013 emissions are particularly high because of the cold winter.

It is known that in spite of the existing legislation, an unknown quantity of waste wood is illegally burned. However, it's impossible to ascertain the fuel quantity, since the use of waste wood for heating purposes in small combustion plants is illegal. Therefore all emission factors and emissions refer to the use of untreated wood.







Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the energy balance for 2022 led to recalculations. Additionally, due to the updates in data source for biomass fuels, recalculations took place between 2003-2022.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

There is an ongoing research project on new emission factors for small combustion plants using updated data from the chimney sweepers and new measurement data. As soon as results are available, implementation into the emission inventory will be checked.

1.A.4 - Small Combustion: Mobile Sources (OVERVIEW)

Short description

NFR-Code	Source category
1.A.4	**Small Combustion**
including mobile sources sub-categories:	
1.A.4.a ii	Commercial / Institutional: Mobile
1.A.4.b ii	Residential: Household and Gardening: Mobile
1.A.4.c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery
1.A.4.c iii	Agriculture/Forestry/Fishing: National Fishing

Mobile sources reported under *NFR 1.A.4 - Small combustion* comprise of such versatile mobile equipment as forklifters (1.A.a ii), gasoline-driven lawn mowers used for gardening (1.A.4.b ii) over tractors in agriculture and harvesters and chain saws in forestry (1.A.4.c ii) to the German deep sea fishing fleet (1.A.4.c iii).

For further information on sub-sector specific consumption data, emission factors and emissions as well as further information on emission trends, recalculations and planned improvements, please follow the links above.

Method

Activity data

Primary activity data are available from National Energy Balances (NEBs) (AGEB, 2024) [1)].

Here, aggregated data for NFRs *1.A.a ii*,*1.A.4.c ii* and *1.A.2.g vii* are included in line 67: 'Commercial, trade, services and other consumers'. In contrast, AD for is available directly from line 66: 'Households'. Furthermore, AD for is included partly in NEB lines 6: 'Maritime Bunkers' and 64: 'Coastal and inland navigation'.

Table 1 below tries to demonstrate the breaking-down of primary data in NEB line 67 onto NFRs *1.A.2.g vii*, *1.A.4a ii* and *1.A.4.c ii*. For further information on the resulting specific shares as well as the fuel consumption in NFRs *1.A.4.b ii* and *1.A.4.c iii* please refer to the respective sub-chapters.

Table 1: Primary AD from NEB line 67: 'Commercial, trade, services and other consumers', in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
diesel oil	126,920	105,800	96,425	85,271	89,724	103,914	105,768	106,894	103,495	106,054	104,452	106,457	102,720	101,133
biodiesel				5,681	7,018	5,772	5,733	5,827	5,840	6,016	8,543	7,465	7,126	7,496
gasoline	26,036	17,264	14,881	14,151	14,923	12,227	11,588	10,895	10,806	11,040	10,489	10,833	10,872	10,769
biogasoline				98.1	357	495	473	445	468	455	470	510	504	509
LPG		7,963	9,238	25,297	11,432	18,702	22,483	16,723	31,269	28,897	18,598	18,139	13,962	10,117

In a first step, annual fuel deliveries to the military as provided in (BAFA, 2024) [2)]...

Table 2: Annual fuel deliveries to the military as included in NEB line 67, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
diesel oil	15,037	8,001	1,364	3,196	976	579	577	415	279	281	134	137	359	292
biodiesel				223	76.3	32.2	31.3	22.1	15.8	15.9	10.9	9.64	24.90	21.63
gasoline	21,508	9,800	7,477	6,838	4,790	3,300	2,969	2,464	2,305	2,273	1,771	1,923	2,082	2,076
biogasoline				47.4	186	133	121	104	100	93.7	79.4	90.6	96.5	98.0

...are deduced from these primary AD, giving the remaining amounts of gasoline and diesel oil for NFRs 1.A.2.g vii, 1.A.a ii and 1.A.4.c ii:

Table 3: Annual fuel deliveries to the remaining sectors covered by NEB line 67, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
diesel oil	111,883	97,799	95,061	82,075	88,749	103,335	105,192	106,479	103,216	105,774	104,318	106,320	102,361	100,841
biodiesel				5,458	6,942	5,740	5,702	5,804	5,824	6,000	8,533	7,456	7,101	7,474
gasoline	4,528	7,464	7,404	7,313	10,133	8,927	8,618	8,431	8,500	8,767	8,718	8,910	8,791	8,693
biogasoline				50,7	171	362	352	341	368	361	391	420	407	411
LPG		7,963	9,238	25,297	11,432	18,702	22,483	16,723	31,269	28,897	18,598	18,139	13,962	10,117

As the National Enregy Balances provide no consumption data for LPG before 1995 and as part of the LPG provided in NEB line 67 is used for stationary combustion (whereas all diesel and gasoline fuels are allocated to mobile combustion), activity data for LPG used in in NRMM are taken directly from TREMOD MM (Knörr et al. (2024b)) [3)].

In another step, the following sub-sectors specific annual percentual contributions to NEB line 67 as computed within TREMOD-MM are apllied to these primary AD to deduce sub-sectors specific AD.

Table 4: Annual percentual contributions of NFRs 1.A.2.g vii, 1.A.a ii and 1.A.4.c ii

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
DIESEL FUELS														
1.A.2.g vii	29.7%	18.9%	17.0%	15.6%	21.6%	25.5%	26.2%	26.4%	24.2%	25.1%	25.1%	23.8%	21.9%	20.3%
1.A.4.a ii	5.98%	3.95%	3.67%	3.66%	5.07%	5.40%	5.41%	5.37%	4.83%	4.93%	4.91%	4.58%	4.30%	4.00%
1.A.4.c ii: Agriculture	62.4%	76.6%	78.5%	79.6%	71.8%	67.4%	66.9%	66.7%	69.2%	68.1%	67.8%	69.5%	71.8%	74.0%
1.A.4.c ii: Forestry	1.91%	0.63%	0.87%	1.13%	1.56%	1.70%	1.54%	1.57%	1.70%	1.86%	2.21%	2.14%	1.97%	1.68%
TOTAL NRMM	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
GASOLINE FUELS														
1.A.2.g vii	31.5%	59.7%	55.1%	58.6%	64.5%	68.0%	70.9%	71.1%	67.9%	67.1%	63.5%	63.4%	63.8%	66.2%
1.A.4.c ii: Forestry	68.5%	40.3%	44.9%	41.4%	35.5%	32.0%	29.1%	28.9%	32.1%	32.9%	36.5%	36.6%	36.2%	33.8%
TOTAL NRMM	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

source: own estimates, based on TREMOD MM

For the **NFR-specific activity data and emission factors** please refer to the corresponding chapters linked at the top of this page.

Recalculations

Primary activity data were revised in accordance with the revised National Energy Balances 2003 to 2021 with the most significant changes occuring for gasoline fuels and LPG.

Table 2: Revised primary activity data 2020, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
DIESEL OIL												
current submission	126,920	105,800	96,425	85,271	89,724	103,914	105,768	106,894	103,495	106,054	104,452	106,457
previous submission	126,920	105,800	96,425	85,293	89,516	101,911	105,895	108,752	101,513	102,836	105,634	106,432
absolute change	0.00	0.00	0.00	-22.4	208	2.003	-127	-1.858	1.982	3.218	-1.182	25.4
relative change	0.00%	0.00%	0.00%	-0.03%	0.23%	1.97%	-0.12%	-1.71%	1.95%	3.13%	-1.12%	0.02%
BIODIESEL												
current submission				5,681	7,018	5,772	5,733	5,827	5,840	6,016	8,543	7,465

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
previous submission				5,460	6,863	5,575	5,614	5,806	5,901	5,857	8,775	7,394
absolute change				221	155	198	119	20.9	-61.6	159	-231	71.3
relative change				4.05%	2.26%	3.55%	2.12%	0.36%	-1.04%	2.71%	-2.63%	0.96%
GASOLINE												
current submission	26,036	17,264	14,881	14,151	14,923	12,227	11,588	10,895	10,806	11,040	10,489	10,833
previous submission	26,036	17,264	14,881	14,151	9,204	8,329	7,991	7,484	7,315	6,913	8,410	8,691
absolute change	0.00	0.00	0.00	0.00	5,719	3,898	3,597	3,411	3,491	4,127	2,079	2,142
relative change	0.00%	0.00%	0.00%	0.00%	62.1%	46.8%	45.0%	45.6%	47.7%	59.7%	24.7%	24.6%
BIOGASOLINE												
current submission				98.1	357	495	473	445	468	455	470	510
previous submission				97.2	356	361	347	316	329	298	384	413
absolute change				0.87	1.86	134	126	129	139	157	86.3	96.9
relative change				0.90%	0.52%	37.0%	36.3%	41.0%	42.2%	52.6%	22.5%	23.4%
LPG												
current submission		7,963	9,238	25,297	11,432	18,702	22,483	16,723	31,269	28,897	18,598	18,139
previous submission		7,963	9,238	28,246	24,605	19,916	23,260	16,971	19,426	22,054	16,960	14,810
absolute change		0.00	0.00	-2,949	-13,173	-1,214	-777	-248	11,843	6,843	1,638	3,329
relative change		0.00%	0.00%	-10.4%	-53.5%	-6.10%	-3.34%	-1.46%	61.0%	31.0%	9.66%	22.5%

[1)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024.

[2)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.

[3)] Knörr et al. (2024b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2024, Heidelberg, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2024.

1.A.4.a ii - Commercial / Institutional: Mobile

Short description

In *NFR 1.A.4.a ii - Commercial/institutional: Mobile* fuel combustion activities and emissions from non-road diesel and LPG-driven (forklifters) vehicles used in the commercial and institutional sector are taken into account.

Category Code	Method	AD	EF
1.A.4.a ii	T1, T2	NS, M	CS, D, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

Sector-specific **diesel** consumption data are included in the primary fuel-delivery data available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2024) [1)].

Table 1: Sources for primary fuel-deliveries data

through 1994	NEB line 79: 'Households and small consumers'
as of 1995	NEB line 67: 'Commercial, trade, services and other consumers'

Following the deduction of diesel oil inputs for military vehicles as provided in (BAFA, 2024) [2)], the remaining amounts of diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and off-road vehicles in commercial/institutional use (1.A.4.a ii) as well as agriculture and forestry (1.A.4.c ii) based upon annual shares derived from (Knörr et al. (2024b)) [3)] (cf. superordinate chapter).

Table 2: Annual contribution of NFR 1.A.4.a ii to the over-all amounts of diesel oil provided in NEB line 67

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
5.98%	3.95%	3.67%	3.66%	5.07%	5.40%	5.41%	5.37%	4.83%	4.93%	4.91%	4.58%	4.30%	4.00%

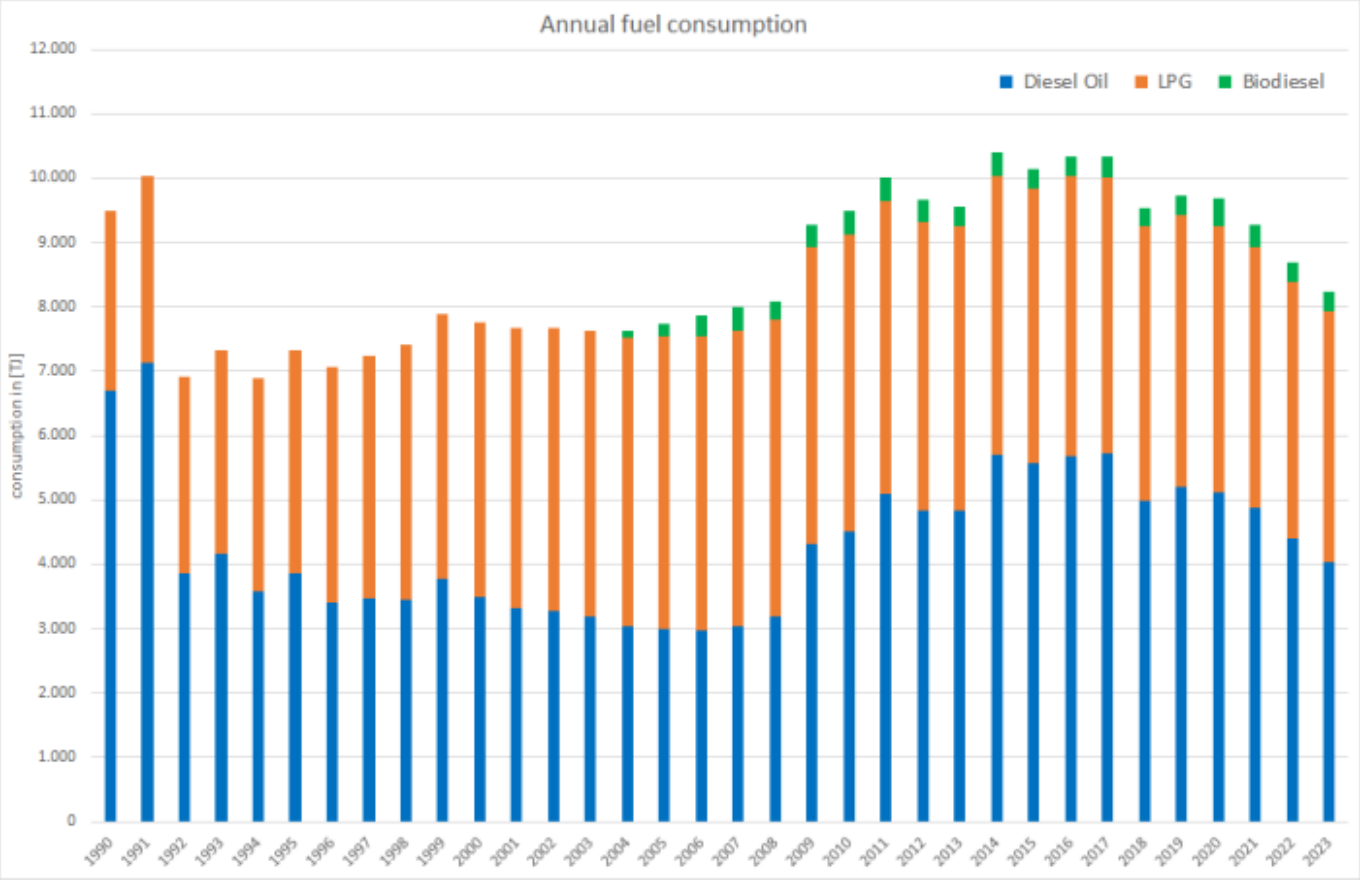
source: TREMOD MM [4)]

As the NEB does not distinguish into specific biofuels, consumption data for biodiesel are calculated by applying Germany's official annual shares of biodiesel blended to fossil diesel oil.

In contrast, for **LPG**-driven forklifters, specific consumption data is modelled by Knörr et al. (2024) [5)]. These amounts are then subtracted from the over-all amount available from NEB line 67 to estimate the amount of LPG used in stationary combustion.

Table 3: Annual fuel consumption, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel Oil	6,696	3,868	3,487	3,001	4,501	5,579	5,686	5,714	4,985	5,209	5,122	4,866	4,397	4,029
Biodiesel				200	352	310	308	312	281	295	419	341	305	299
LPG	2,787	3,450	4,261	4,533	4,629	4,256	4,336	4,301	4,264	4,213	4,139	4,063	3,987	3,912
Σ 1.A.4.a ii	**9,482**	**7,318**	**7,749**	**7,733**	**9,482**	**10,144**	**10,330**	**10,327**	**9,530**	**9,718**	**9,680**	**9,270**	**8,689**	**8,239**



Emission factors

The emission factors used here are of rather different quality: Basically, for all **main pollutants**, **carbon monoxide** and **particulate matter**, annual IEF modelled within TREMOD MM are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

As no such specific EF are available for biofuels, the values used for diesel oil are applied to biodiesel, too.

Table 4: Annual country-specific emission factors from TREMOD MM, in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel fuels[1]														
NH_3	0.15	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
NMVOC	247	223	197	139	93.0	58.5	53.3	48.9	45.3	42.0	38.8	35.4	31.8	28.4
NO_x	999	1.025	1.003	833	633	476	451	426	404	384	364	344	324	304
SO_x	79.6	60.5	14.0	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[3]	107	88.6	74.4	55.3	42.2	32.1	30.0	28.3	26.8	25.5	24.0	22.3	20.4	18.3
PM[2]	194	161	134	93.6	64.4	43.0	39.5	36.7	34.5	32.6	30.6	28.4	26.0	23.6
CO	856	795	725	560	429	321	301	283	266	250	233	215	195	176
LPG														
NH_3	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
NMVOC	147	147	145	145	145	145	145	145	145	144	141	134	126	116
NO_x	1,346	1,342	1,325	1,325	1,325	1,325	1,325	1,325	1,325	1,316	1,284	1,225	1,144	1,056
SO_x	0.42	0.42	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
BC[3]	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.12	0.12	11.6%	0.11	0.10
PM[2]	0.85	0.85	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
CO	114	114	112	112	112	112	112	112	112	112	112	112	112	112

[1] due to lack of better information: similar EF are applied for fossil and biofuels
[2] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP consists of $PM_{2.5}$)
[3] estimated via a f-BCs as provided in [6)], Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery

With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [9)]

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources. - Here, for lead (Pb) from leaded gasoline and corresponding TSP emissions, additional emissions have been calculated from 1990 to 1997 based upon contry-specific emission factors from TREMOD MM.

Discussion of emission trends

> **NFR 1.A.4.a ii** is no key source.

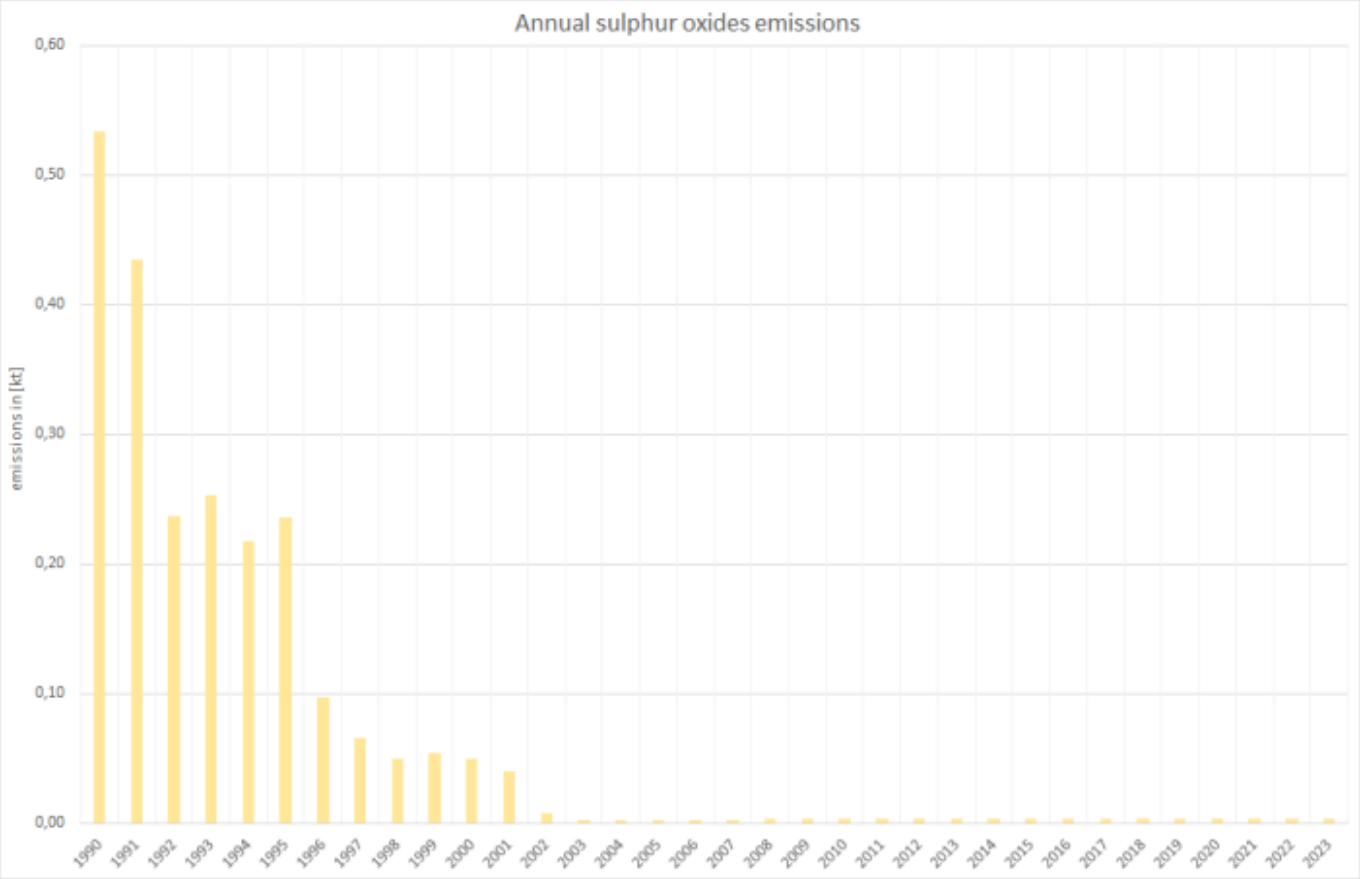
Unregulated pollutants

For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.

Regulated pollutants

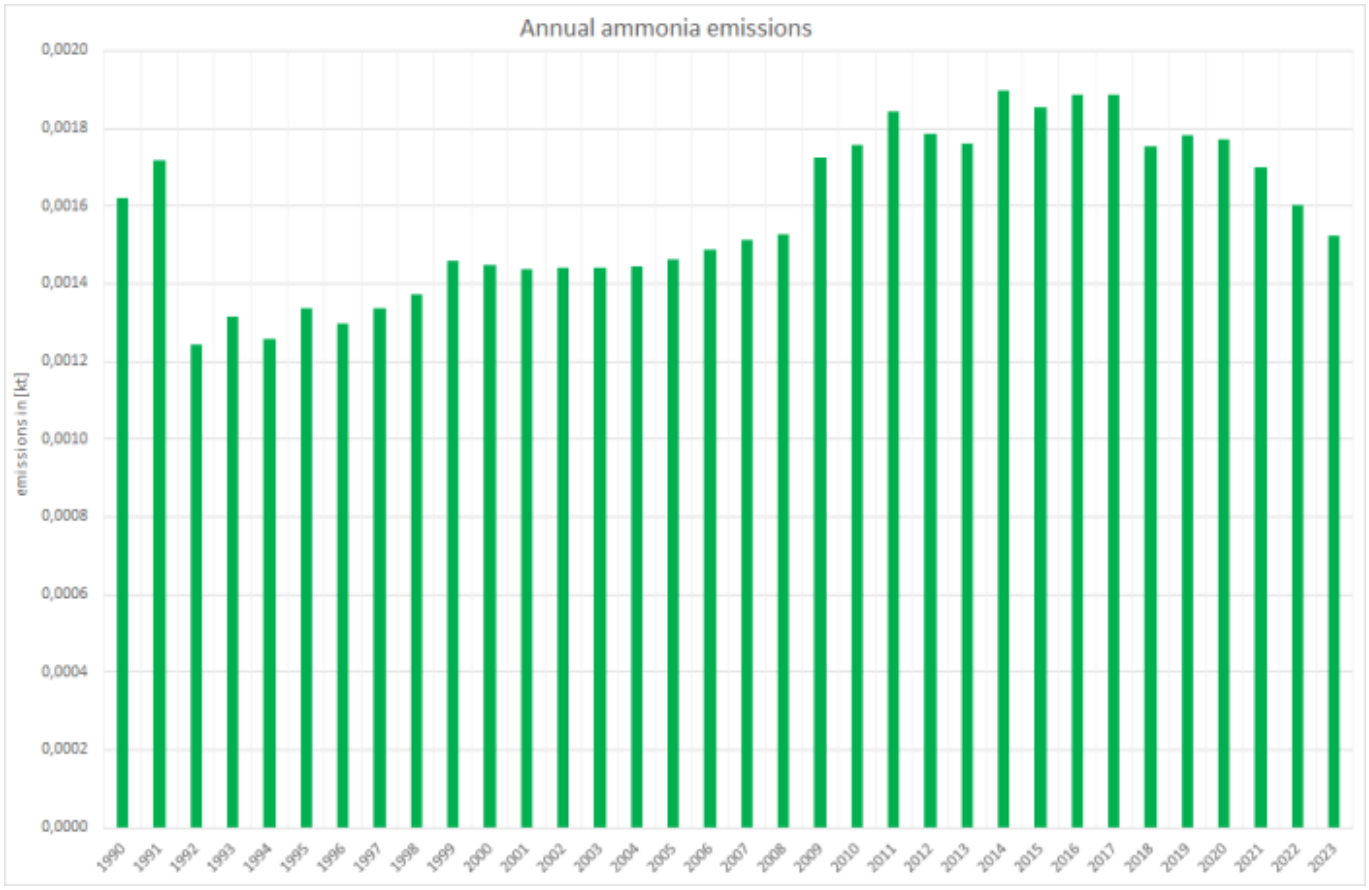
Nitrogen oxides and Sulphur dioxide

For all regulated pollutants, emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation. Here, emissions of sulphur oxides follow the step-by-step reduction of sulphur contents in liquid fuels, resulting in a reduction of over 99% since 1990.



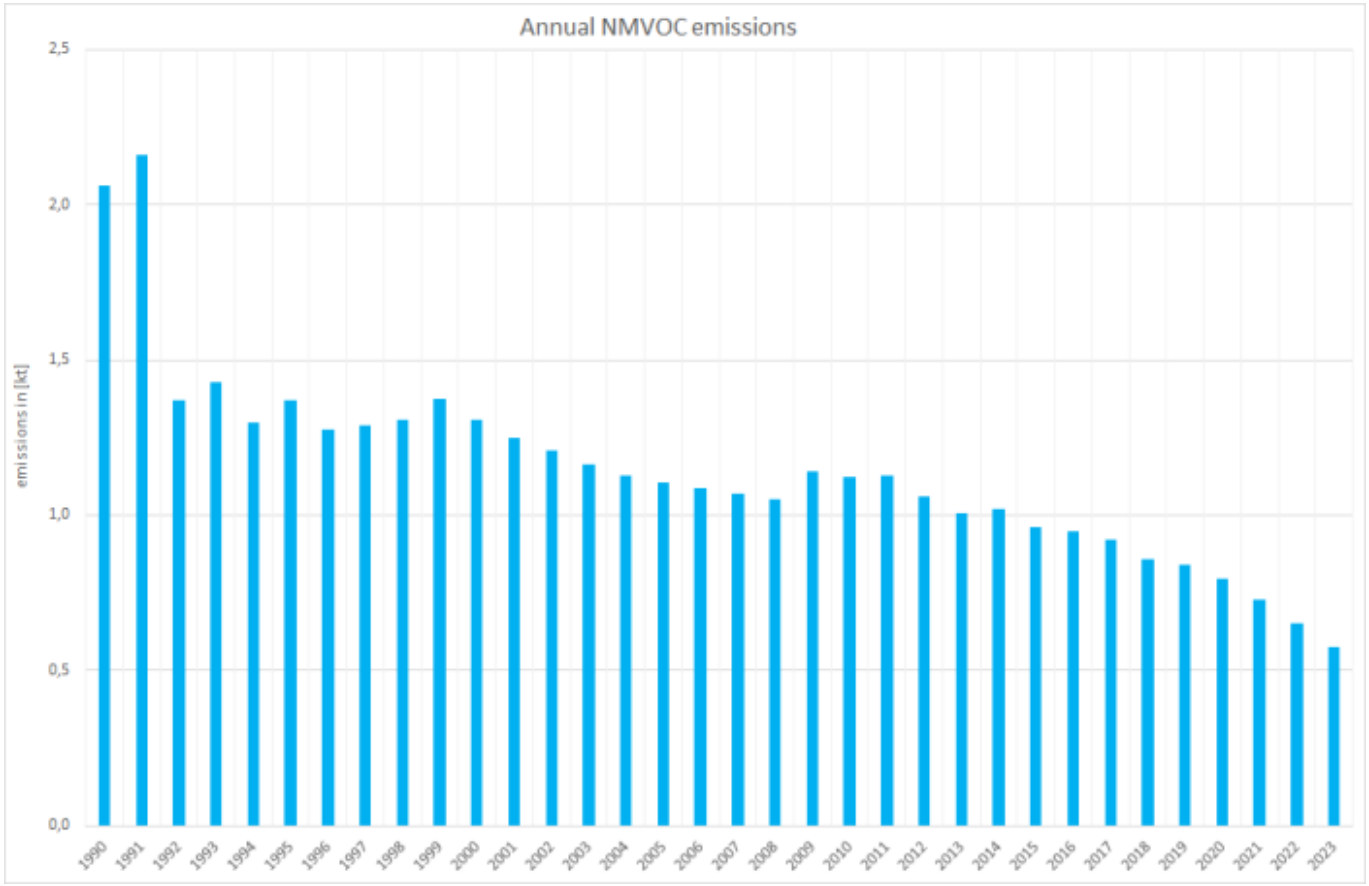
Ammonia

Ammonia emissions are driven by the consumption of LPG with its comparably high emission factor.



NMVOC

Emissions oif NMVOC are again driven by the consumption of LPG with its comparably high emission factor. Here, the ongoing downward trend results from the decrease in the emission factor applied for diesel fuels.

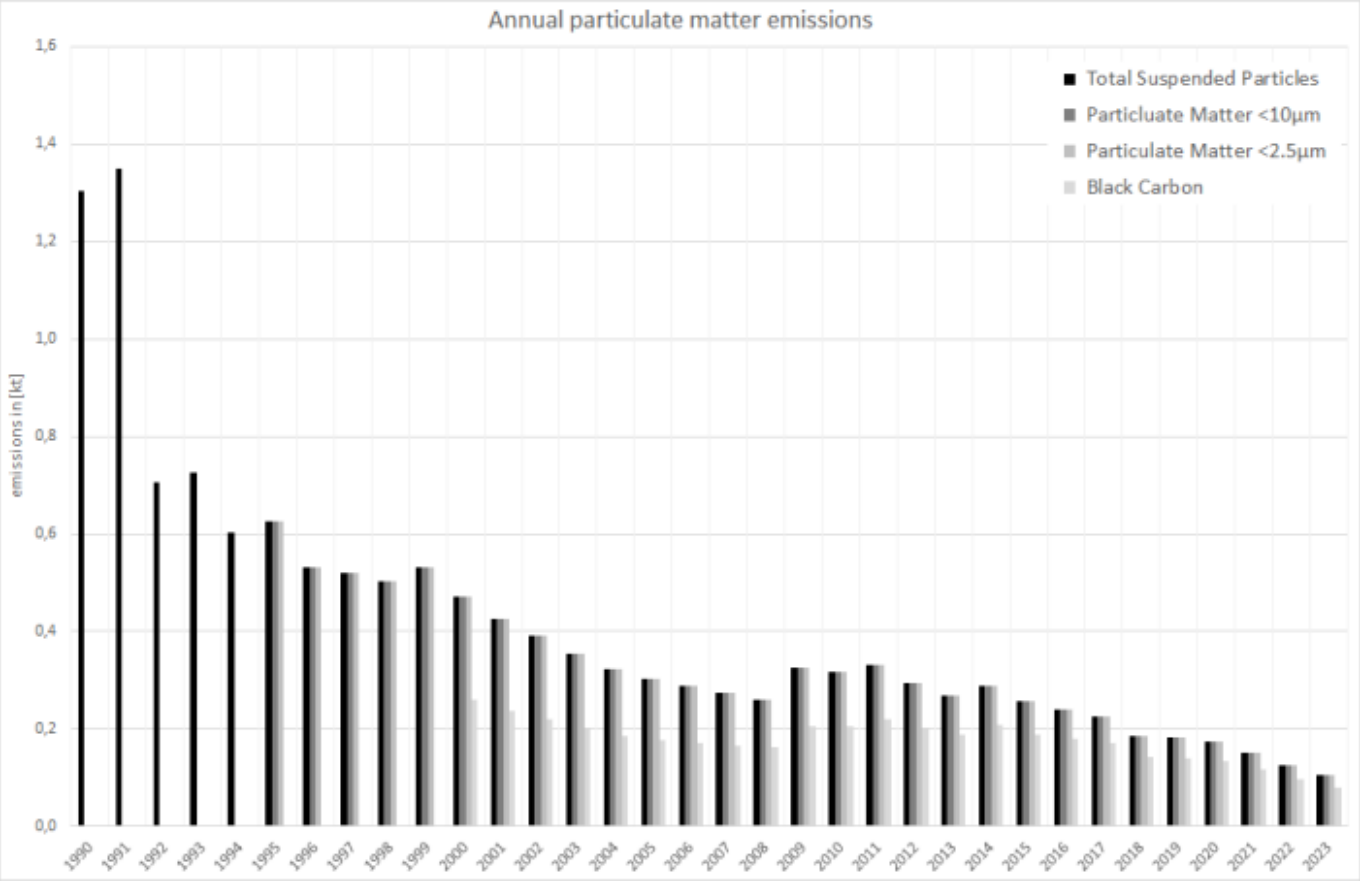


Particulate matter & Black carbon

Over-all PM emissions are by far dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption between 2000 and 2005. Nonetheless, the decrease of the over-all emission trend was and still is amplified by the expanding use of particle filters especially to eliminate soot emissions.

Additional contributors such as the impact of TSP emissions from the use of leaded gasoline (until 1997) have no significant effect onto over-all emission estimates.

Here, as the EF(BC) are estimated via fractions provided in the 2019 EMEP Guidebook [7)], black carbon emissions follow the corresponding emissions of $PM_{2.5}$.



Recalculations

Compared to the previous submission, recalcultaions in primary activity data (PAD) result from the revision of the National Energy Balance 2022 and the percental shares as compiled in TREMOD MM [8)].

Table 5: Revised percental shares

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
current submission	0.060	0.040	0.037	0.037	0.051	0.054	0.054	0.054	0.048	0.049	0.049	0.046	0.043
previous submission	0.061	0.040	0.037	0.037	0.051	0.058	0.060	0.061	0.056	0.058	0.057	0.056	0.051
absolute change	-0.001	0.000	0.000	0.000	0.000	-0.004	-0.006	-0.007	-0.008	-0.008	-0.008	-0.010	-0.008
relative change	-2.16%	-0.70%	0.00%	0.00%	0.35%	-6.29%	-10.1%	-11.5%	-13.7%	-14.6%	-14.1%	-18.6%	-15.9%

Source-specific activity data have been revised accordingly:

Table 6: Revised source-specific activity data, in terajoules [TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL OIL													
current submission	6,696	3,868	3,487	3,001	4,501	5,579	5,686	5,714	4,985	5,209	5,122	4,866	4,397
previous submission	6,844	3,895	3,487	3,001	4,485	5,953	6,324	6,458	5,778	6,099	5,960	5,979	5,239
absolute change	-148	-27,3	0,00	0,00	15,8	-375	-639	-743	-793	-889	-838	-1,114	-843
relative change	-2.16%	-0.70%	0.00%	0.00%	0.35%	-6.29%	-10.1%	-11.5%	-13.7%	-14.6%	-14.1%	-18.6%	-16.1%
BIODIESEL													
current submission				200	352	310	308	312	281	295	419	341	305
previous submission				200	351	331	343	352	326	346	487	419	364
absolute change				0.00	1.23	-20.8	-34.6	-40.5	-44.7	-50.5	-68.5	-78.1	-59.1
relative change				0.00%	0.35%	-6.29%	-10.1%	-11.5%	-13.7%	-14.6%	-14.1%	-18.6%	-16.2%
LPG													
current submission	2,787	3,450	4,261	4,533	4,629	4,256	4,336	4,301	4,264	4,213	4,139	4,063	3,987
previous submission	2,787	3,450	4,261	4,533	4,629	4,256	4,336	4,301	4,264	4,213	4,139	4,063	3,987
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Σ 1.A.4.a ii													
current submission	9,482	7,318	7,749	7,733	9,482	10,144	10,330	10,327	9,530	9,718	9,680	9,270	8,689
previous submission	9,630	7,345	7,749	7,733	9,465	10,540	11,004	11,110	10,368	10,658	10,586	10,462	9,591
absolute change	-148	-27.3	0.00	0.00	17.0	-395	-673	-784	-838	-940	-906	-1,192	-902
relative change	-1.54%	-0.37%	0.00%	0.00%	0.18%	-3.75%	-6.12%	-7.06%	-8.08%	-8.82%	-8.56%	-11.4%	-9.40%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by (Knörr et al. (2009)) [9)].

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

Planned improvements

Besides the annual **routine revision** of **TREMOD MM**, no specific improvements are planned.

FAQs

Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?

The EF provided in [10)] represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained in biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel and bioethanol.

[1)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

[2)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.

[3), 4), 5), 8)] Knörr et al. (2024b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2024, Heidelberg, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2024.

[6)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook – 2023, https://www.eea.europa.eu//publications/emep-eea-guidebook-2023, Copenhagen, 2023.

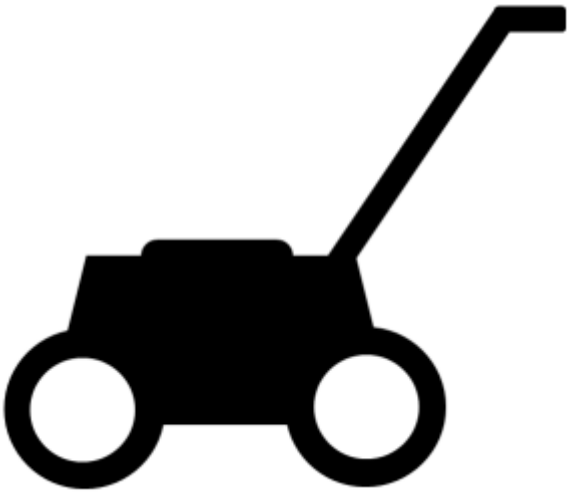
[9)] Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

[9)]
During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.A.4.b ii - Residential: Household and Gardening: Mobile

Short description

Under sub-category *1.A.4.b ii - Residential: Mobile Sources in Households and Gardening* fuel combustion activities and resulting emissions from combustion engine driven devices such as motor saws, lawn mowers and small leisure boats are being reported.



Category Code	Method	AD	EF
1.A.4.b ii	T1, T2	NS, M	CS, M, D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	**L/-**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

Activity data are taken from annual fuel delieveries data provided in line 66: 'Households' of the National Energy Balances (NEB) for Germany (AGEB, 2024) [1)].

Table 1: Sources for consumption data in 1.A.4.b ii

Relevant years	**Data Source**
through 1994	**AGEB** - National Energy Balance, line 79: Households
since 1995	**AGEB** - National Energy Balance, line 66: Households

Here, given the rare statistics on sold machinery, these activity data is of limited quality only (no annual but cascaded trend).

As the NEB only provides primary activity data for *total biomass* used in 'households', but does not distinguish into specific biofuels, consumption data for bioethanol used in NFR 1.A.4.b ii are calculated by applying Germany's official annual shares of biogasoline blended to fossil gasoline.

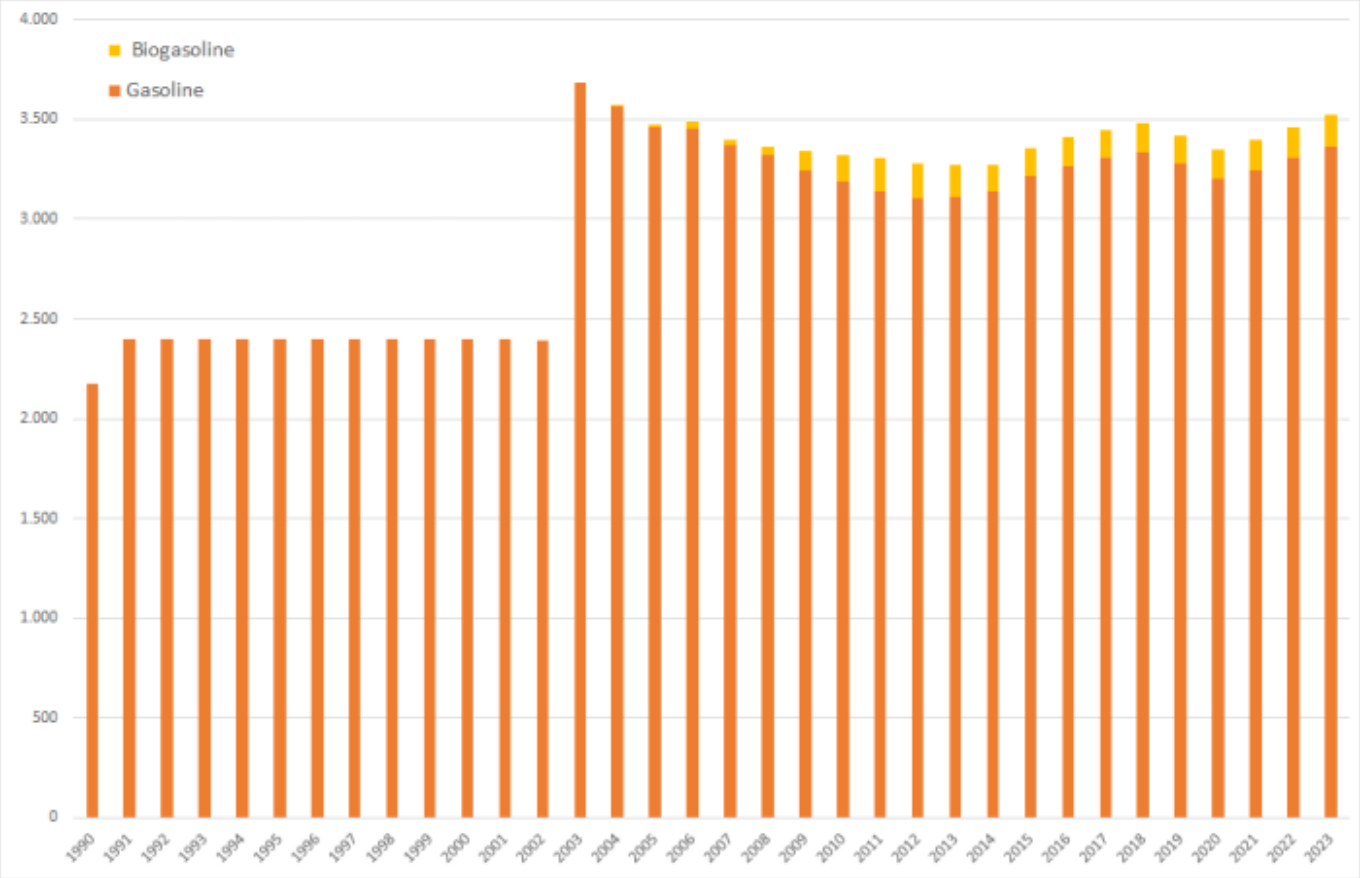
Please note: *Data on gasoline used in households* as provided in the National Energy Balances represents *a "residual item"* following the allocation of the majority of this fuel to road and military vehicles. Here, fuel sales to road vehicles might also include gasoline acquired on filling stations but used for household equipment.

Due to these reasons, activity data for gasoline consumption in households machinery and, hence, several emission estimates *show no realistic trend but a stepwise development* with significant jumps.

Table 2: Annual over-all fuel deliveries to residential mobile sources, in terajoules

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Gasoline	2,177	2,395	2,395	3,459	3,190	3,212	3,267	3,303	3,333	3,278	3,203	3,242	3,305	3,364
Biogasoline	NO	NO	NO	16.5	131	139	142	139	150	141	146	154	153	159
Σ 1.A.4.b ii	**2,177**	**2,395**	**2,395**	**3,475**	**3,321**	**3,352**	**3,409**	**3,443**	**3,483**	**3,419**	**3,349**	**3,396**	**3,458**	**3,523**

source: AGEB, 2024 [2)] and TREMOD MM [3)]



These primary activity data can be distributed onto 2- and 4-stroke mobile machinery and boats used in households via annual shares from Knörr et al. (2023b) [4)].

Table 3: Annual shares of 2- and 4-stroke engines

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
2-Stroke Machinery	25.0%	43.7%	58.4%	61.8%	65.8%	68.1%	68.3%	68.5%	68.6%	68.7%	68.8%	68.9%	69.1%	69.3%
4-Stroke Machinery	63.7%	44.2%	29.5%	27.0%	23.4%	19.5%	19.1%	18.7%	18.5%	18.3%	18.1%	17.9%	17.7%	17.4%
2-Stroke Boats	10.1%	10.3%	8.80%	5.61%	2.58%	2.11%	1.99%	1.87%	1.74%	1.60%	1.46%	1.33%	1.19%	1.05%
4-Stroke Boats	1.17%	1.79%	3.31%	5.61%	8.28%	10.3%	10.6%	10.9%	11.2%	11.4%	11.7%	11.8%	12.0%	12.2%
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

source: TREMOD MM [5)]

Table 4: Resulting estimates for fuel consumption in 2- and 4-stroke engines, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
2-stroke machinery														
Gasoline	545	1,046	1,400	2,138	2,098	2,187	2,230	2,263	2,287	2,252	2,203	2,235	2,284	2,331
Biogasoline	NO	NO	NO	10.2	85.8	94.9	96.9	95.4	103	97.1	101	106	106	110
4-stroke machinery														
Gasoline	1,387	1,059	705	933	746	627	624	619	615	599	580	581	585	587
Biogasoline	NO	NO	NO	4.44	30.5	27.2	27.1	26.1	27.7	25.8	26.5	27.6	27.1	27.7
2-stroke boats														
Gasoline	25.6	43.0	79.2	194	264	331	347	360	372	374	373	384	397	411
Biogasoline	NO	NO	NO	0.92	10.8	14.3	15.1	15.2	16.7	16.1	17.0	18.3	18.4	19.4
4-stroke boats														
Gasoline	220	248	211	194	82.4	67.8	65.1	61.7	57.9	52.5	46.9	43.1	39.4	35.4
Biogasoline	NO	NO	NO	0.92	3.37	2.94	2.83	2.60	2.60	2.26	2.14	2.05	1.83	1.67
Σ 1.A.4.b ii	**2,177**	**2,395**	**2,395**	**3,475**	**3,321**	**3,352**	**3,409**	**3,443**	**3,483**	**3,419**	**3,349**	**3,396**	**3,458**	**3,523**

Emission factors

The emission factors used here are of rather different quality: For all **main pollutants**, **carbon monoxide** and **particulate matter**, annually changing values computed within TREMOD-MM (Knörr et al. (2024b)) [6)] are used, representing the development of mitigation technologies and the effect of fuel-quality legislation.

Here, as no such specific EF are available for biofuels, the values used for gasoline are applied to bioethanol, too.

For lead (Pb) from leaded gasoline and corresponding TSP emissions, additional emissions are are calculated from 1990 to 1997 based upon contry-specific emission factors from [7)].)

Table 4: Annual country-specific emission factors from TREMOD MM[1], in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
4-stroke machinery														
NH_3 [1]	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
NMVOC - exhaust[1,2]	727	819	809	790	805	795	792	790	786	780	767	748	729	710
NMVOC - evaporation[1,3]	475	1,289	1,604	1,650	1,649	1,628	1,623	1,617	1,613	1,609	1,605	1,600	1,596	1,591
NO_x [1]	51.1	85.3	103	108	122	133	134	135	136	135	130	125	119	115
SO_x [1]	10.1	8.27	3.22	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC [2,5]	0.31	0.27	0.24	0.23	0.24	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
$PM_{2.5}$, PM_{10}, and TSP [2,4]	6.30	5.46	4.85	4.62	4.87	5.15	5.19	5.21	5.23	5.24	5.25	5.25	5.25	5.25
CO [1]	40,044	32,179	28,352	27,158	28,013	29,091	29,221	29,313	29,389	29,345	28,982	28,381	27,727	27,050
2-stroke machinery														
NH_3 [1]	0.07	0.07	0.07	0.07	0.07	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
NMVOC - exhaust[1,2]	6,121	5,907	5,877	5,813	5,830	3,343	3,198	3,063	2,939	2,835	2,757	2,697	2,651	2,622
NMVOC - evaporation[1,3]	1.387	1.128	510	392	280	323	326	328	328	328	327	327	327	328
NO_x [1]	19.8	25.7	36.3	53.4	63.7	56.5	57.2	57.8	58.3	58.7	59.2	59.6	59.9	60.1
SO_x [1]	10.1	8.27	3.22	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC [2,4]	6.91	6.13	5.13	4.93	4.79	5.46	5.50	5.53	5.56	5.59	5.61	5.62	5.64	5.65
$PM_{2.5}$, PM_{10}, and TSP [2,4]	138	123	103	98.7	95.8	109	110	111	111	112	112	112	113	113
CO [1]	20,271	18,743	16,255	15,480	14,682	16,741	16,901	17,049	17,186	17,304	17,397	17,472	17,526	17,563
4-stroke leisure boats														
NH_3 [1]	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
NMVOC - exhaust[1,2]	952	1.036	1.269	1.373	1.196	897	853	813	779	753	734	722	714	710
NMVOC - evaporation[1,3]	28.8	55.3	131	164	196	186	185	185	184	184	184	185	187	188
NO_x [1]	383	375	353	345	338	341	325	299	276	256	238	223	210	199
SO_x [1]	10.1	8.27	3.22	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[2,5]	0.38	0.38	0.38	0.38	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
$PM_{2.5}$, PM_{10}, and TSP [2,4]	7.50	7.50	7.50	7.50	7.50	7.49	7.49	7.49	7.49	7.49	7.49	7.49	7.49	7.49
CO[1]	30,204	30,817	32,595	33,248	26,105	18,536	17,387	16,286	15,336	14,583	13,995	13,565	13,241	12,996
2-stroke leisure boats														
NH_3 [1]	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
NMVOC - exhaust[1,2]	5,614	5,674	5,835	5,952	4,268	2,261	1,938	1,630	1,364	1,138	964	834	740	673
NMVOC - evaporation[1,3]	159	169	191	204	204	204	204	204	204	204	204	204	204	204
NO_x [1]	74.4	74.1	73.0	71.9	72.8	77.4	75.8	71.5	67.5	63.6	59.8	56.3	53.0	50.0

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
SO_x [1]	10.1	8.27	3.22	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC [2,4]	21.1	21.1	21.1	21.1	21.6	23.5	23.9	24.3	24.6	24.9	25.1	25.2	25.3	25.3
$PM_{2.5}$, PM_{10}, and TSP [2,4]	422	422	422	422	432	471	479	486	492	498	501	504	505	505
CO[1]	15,101	15,160	15,311	15,415	12,723	9,056	8,462	7,933	7,475	7,090	6,804	6,604	6,473	6,398
in addition, applied for any use of leaded gasoline (banned in 1997)														
Pb[6]	1,471	516	0.00											
TSP from exhaust Pb emissions[6]	2.35	0.82	0.00											

[1] due to lack of better information: similar EF are applied for fossil and biofuels
[2] from fuel combustion
[3] from gasoline evaporation
[4] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP consists of $PM_{2.5}$)
[5] estimated via a f-BCs as provided in [8)], Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery
[6] from leaded gasoline (until 1997)

With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [9)]

For lead (Pb) from leaded gasoline and corresponding TSP emissions, additional emissions are are calculated from 1990 to 1997 based upon contry-specific emission factors from [10)].

> **NOTE:** For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

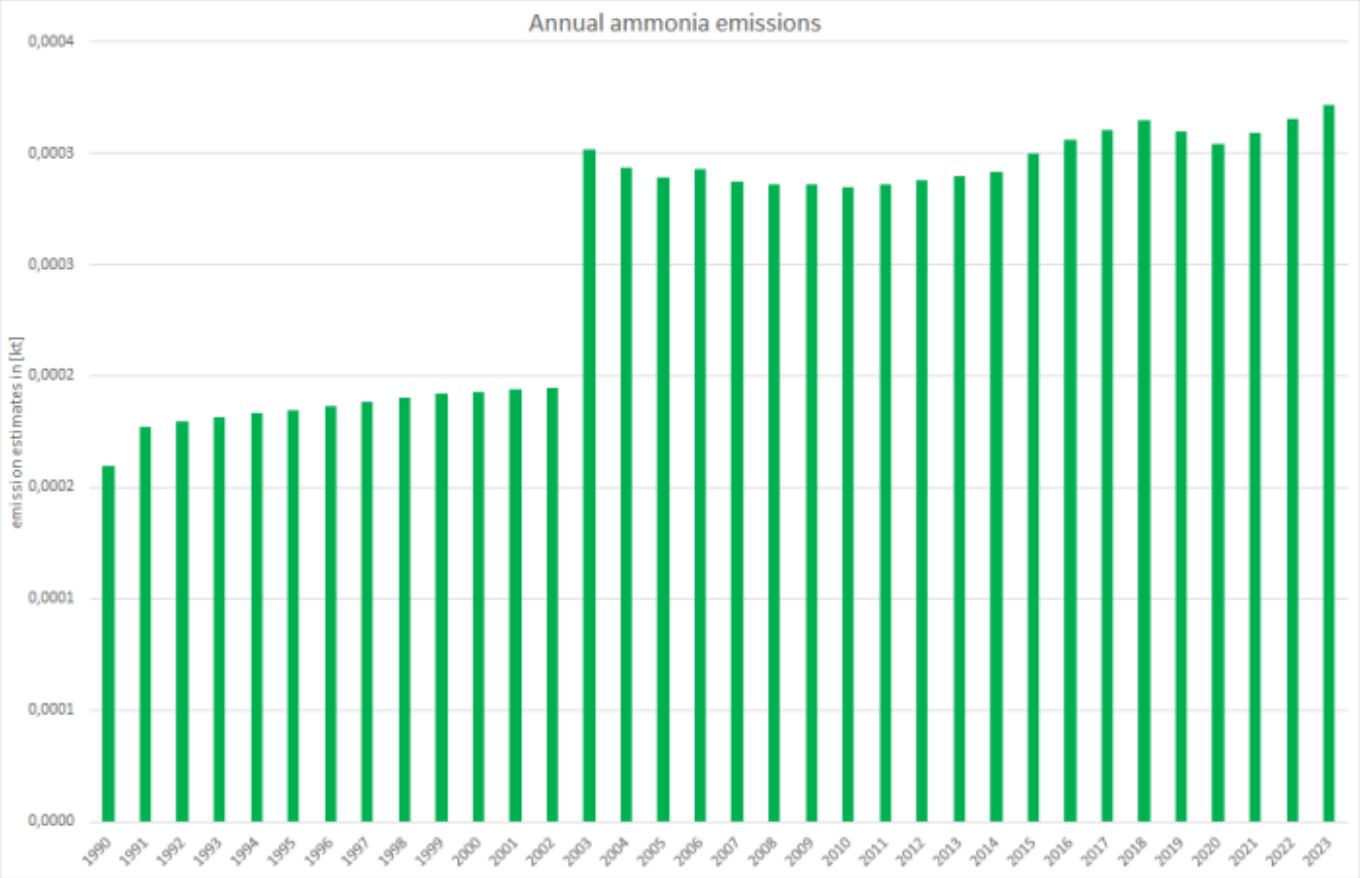
Discussion of emission trends

Given the limited quality of gasoline-deliveries data from NEB line 66 of the National Energy Balances, the following emission trends are of limited significance only.

Here, the jump in annual inland fuel deliveries between 2002 and 2003 (see table on primary acitivity data above) resulting in corresponding jumps in the emission trends for the reported pollutants cannot be eliminated by the inventory compiler but is already evident in the in the National Energy Balances compiled by the Working Group on Energy Balances (AGEB).

Unregulated pollutants (Ammonia, HMs, POPs, ...)

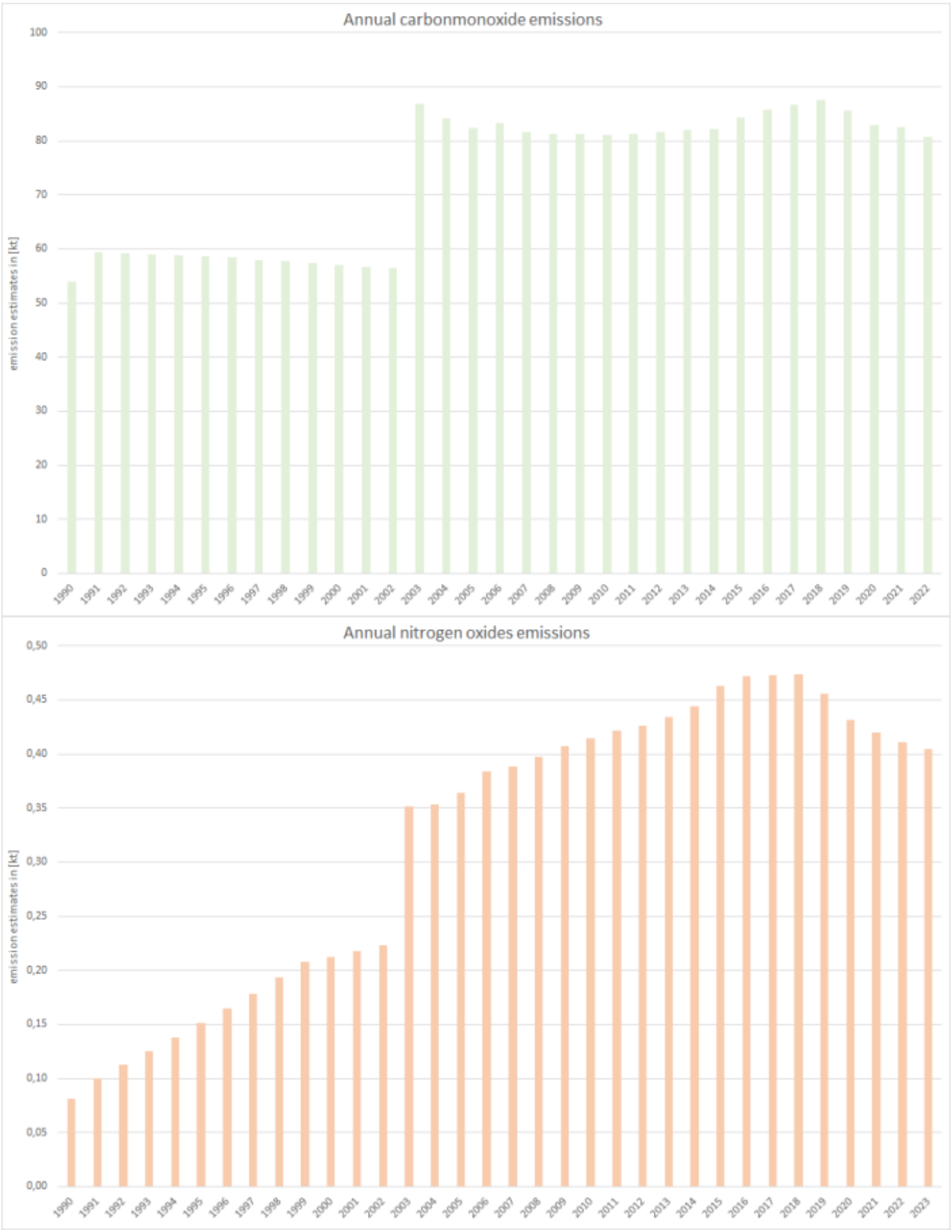
For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.



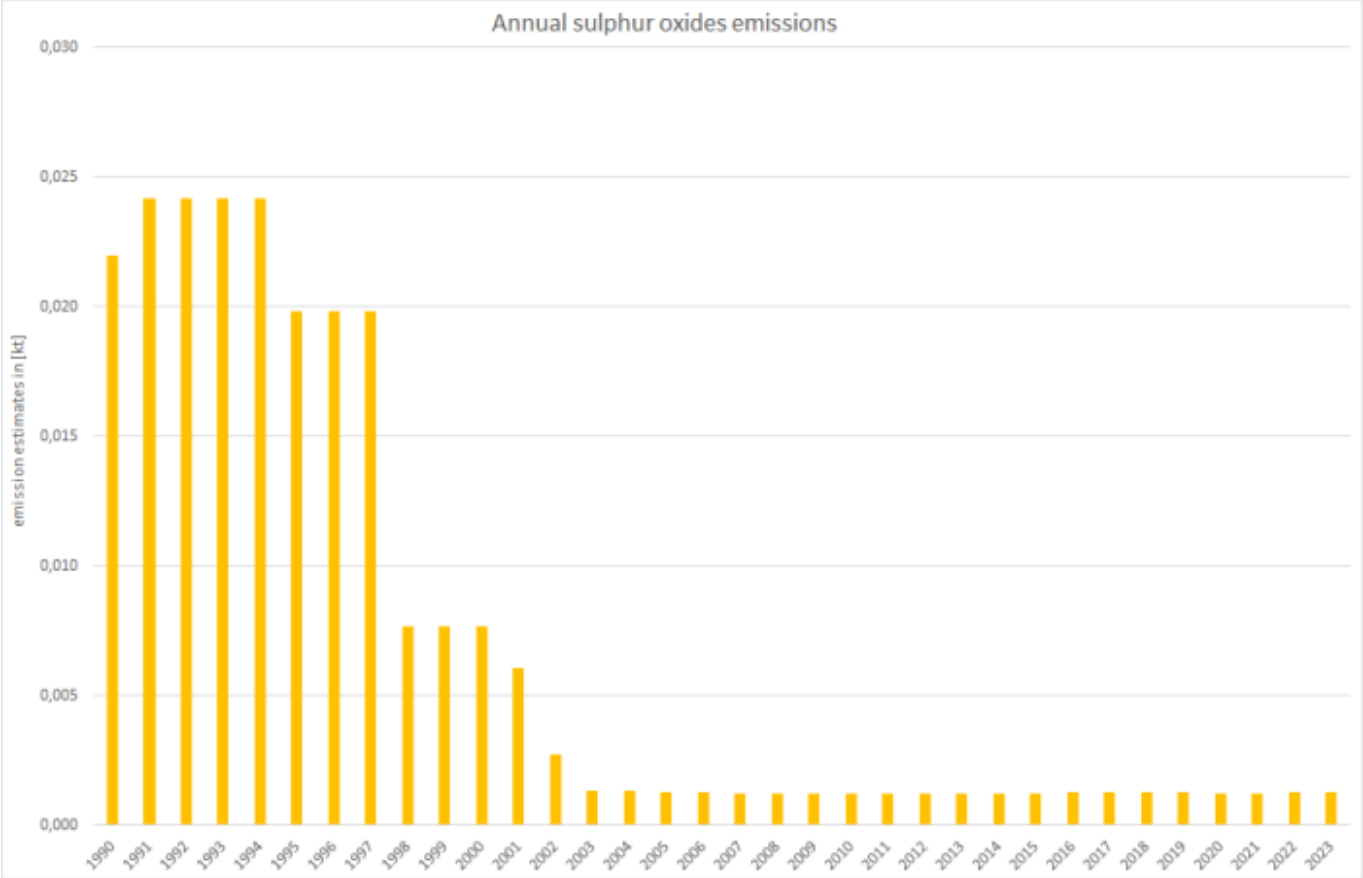
Here, as the emission factors for heavy metals (and POPs) are derived from tier1 default values, the emission's trend is stronlgy influenced by the share of 2-stroke gasoline fuel (containing lube oil with presumably higher HM content) consumed.

Regulated pollutants

For all regulated pollutants, emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation. However, especially for CO and NO_x, trends are strongly influenced by the changes in annual fuel deliveries as provided in NEB line 66.



Here, emissions of sulphur oxides follow the step-by-step reduction of sulphur contents in liquid fuels, resulting in a reduction of over 95% since 1990.

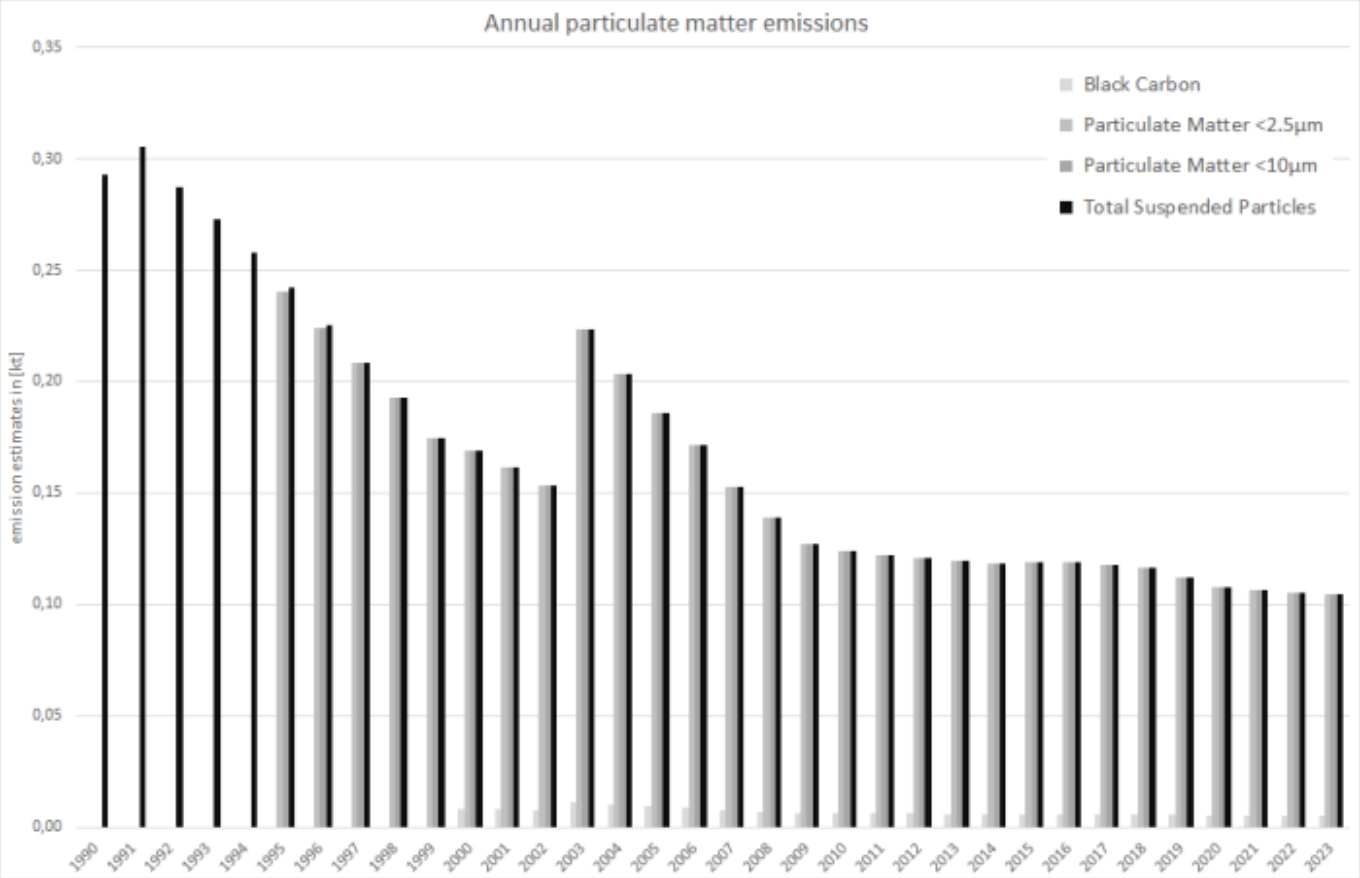


Particulate matter

Over-all PM emissions are by far dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption between 2000 and 2005. Nonetheless, the decrease of the over-all emission trend was and still is amplified by the expanding use of particle filters especially to eliminate soot emissions.

Additional contributors such as the impact of TSP emissions from the use of leaded gasoline (until 1997) have no significant effect onto over-all emission estimates.

Here, as the EF(BC) are estimated via fractions provided in [11)], black carbon emissions follow the corresponding emissions of $PM_{2.5}$.



Recalculations

Compared to the previous submission, recalcultaions in activity data result entirely from the revision of the National Energy Balance 2022.

Table 5: Revised primary activity data 2022, in terajoules [TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
gasoline													
current submission	2,177	2,395	2,395	3,459	3,190	3,212	3,267	3,303	3,333	3,278	3,203	3,242	3,305
previous submission	2,177	2,395	2,395	3,459	3,190	3,212	3,267	3,303	3,333	3,278	3,203	3,242	3,233
absolute change	0.00	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	72.1
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.23%
biogasoline													
current submission	NO	NO	NO	16.5	131	139	142	139	150	141	146	154	153
previous submission	NO	NO	NO	16.5	131	139	142	139	150	141	146	154	154
absolute change				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	-0.61
relative change				0.02%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%	0.01%	0.00%	-0.40%
over-all fuel consumption													
current submission	2,177	2,395	2,395	3,475	3,321	3,352	3,409	3,443	3,483	3,419	3,349	3,396	3,458
previous submission	2,177	2,395	2,395	3,475	3,321	3,352	3,409	3,443	3,483	3,419	3,349	3,396	3,387
absolute change	0.00	0.00	0.00	0.01	0.00	0.00	-0.01	0.00	0.00	-0.01	0.01	0.01	71.5
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.11%

Furthermore, the percental shares of 2- and 4-stroke mobile machinery and boats used in households were revised within TREMOD MM...

Table 6: Revised percental shares of 2- and 4-stroke mobile machinery and boats used in households

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
4-stroke machinery													

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
current submission	0.250	0.437	0.584	0.618	0.658	0.681	0.683	0.685	0.686	0.687	0.688	0.689	0.691
previous submission	0.250	0.437	0.584	0.618	0.660	0.673	0.673	0.673	0.673	0.672	0.672	0.672	0.673
absolute change	0.000	0.000	0.000	0.000	-0.003	0.008	0.010	0.012	0.014	0.015	0.016	0.017	0.018
relative change	0.00%	0.00%	0.00%	0.00%	-0.44%	1.19%	1.51%	1.84%	2.05%	2.21%	2.37%	2.53%	2.69%
2-stroke machinery													
current submission	0.637	0.442	0.295	0.270	0.234	0.195	0.191	0.187	0.185	0.183	0.181	0.179	0.177
previous submission	0.637	0.442	0.295	0.270	0.233	0.203	0.200	0.198	0.196	0.195	0.194	0.192	0.190
absolute change	0.000	0.000	0.000	0.000	0.001	-0.008	-0.009	-0.011	-0.012	-0.012	-0.013	-0.013	-0.014
relative change	0.00%	0.00%	0.00%	0.00%	0.41%	-3.72%	-4.58%	-5.46%	-5.96%	-6.23%	-6.51%	-6.80%	-7.12%
4-stroke boats													
current submission	0.012	0.018	0.033	0.056	0.083	0.103	0.106	0.109	0.112	0.114	0.117	0.118	0.120
previous submission	0.012	0.018	0.033	0.056	0.085	0.101	0.103	0.105	0.107	0.109	0.110	0.111	0.112
absolute change	0.000	0.000	0.000	0.000	-0.002	0.002	0.003	0.004	0.005	0.005	0.006	0.007	0.008
relative change	0.00%	0.00%	0.00%	0.00%	-2.64%	1.83%	2.65%	3.45%	4.23%	4.99%	5.74%	6.53%	7.32%
2-stroke boats													
current submission	0.101	0.103	0.088	0.056	0.026	0.021	0.020	0.019	0.017	0.016	0.015	0.013	0.012
previous submission	0.101	0.103	0.088	0.056	0.022	0.023	0.024	0.024	0.024	0.024	0.024	0.024	0.025
absolute change	0.000	0.000	0.000	0.000	0.004	-0.002	-0.004	-0.005	-0.007	-0.008	-0.010	-0.011	-0.013
relative change	0.00%	0.00%	0.00%	0.00%	19.4%	-9.92%	-15.8%	-21.8%	-27.7%	-33.7%	-39.7%	-45.6%	-51.6%

...resulting in revised source-specific activity data and, hence, source-specific emissions that are not provided here in detail.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023 (Knörr et al. (2009)) [12)]: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland”.

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

Planned improvements

Besides a **routine revision** of the **TREMOD MM** model, no specific improvements are planned.

FAQs

Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?

The EF provided in [13)] represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained in biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel and bioethanol.

[1), 2)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, Köln & Berlin,

2024

[3), 4), 5), 6), 7)] Knörr et al. (2024b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2024, Heidelberg, on behalf of the Umweltbundesamt, Dessau-Roßlau,2024.

[8), 10), 11)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019.

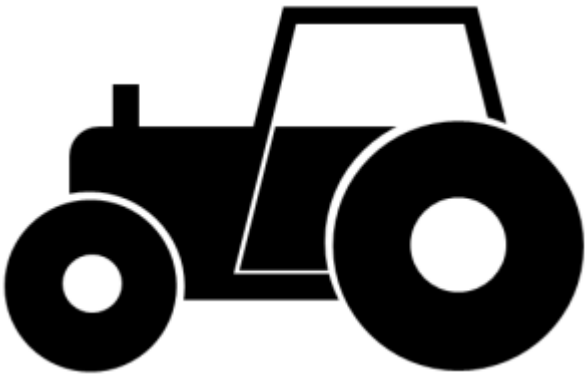
[9)] During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

[12)] Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; URL: https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

[13)] Rentz et al. (2008): Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung, Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), FKZ 205 67 444, UBA Texte 01/2008, https://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008.

1.A.4.c ii - Agriculture/Forestry/Fishing: Off-Road Vehicles and Other Machinery

Short description



Under sub-category *1.A.4.c ii - Agriculture/Forestry/Fishing: Off-road Vehicles and other Machinery* fuel combustion activities and resulting emissions from off-road vehicles and machinery used in agriculture and forestry are reported seperately.

NFR Code	Method	AD	EF
1.A.4.c ii	T1, T2	NS, M	CS, D, M
taking in to account emissions from:			
Off-road Vehicles and Other Machinery: Agriculture	T1, T2	NS, M	CS, D, M
Off-road Vehicles and Other Machinery: Forestry	T1, T2	NS, M	CS, D, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
L/-	-/-	-/-	-/-	**L/T**	**L/T**	-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

Sector-specific consumption data is included in the primary fuel-delivery data are available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2024) [1)].

Table 1: Sources for primary fuel-delivery data

through 1994	**AGEB** - National Energy Balance, line 79: 'Haushalte und Kleinverbraucher insgesamt'
as of 1995	**AGEB** - National Energy Balance, line 67: 'Gewerbe, Handel, Dienstleistungen u. übrige Verbraucher'

Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2024) [2)], the remaining amounts of gasoline and diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and commercial/institutional used off-road vehicles (1.A.4.a ii) as well as agriculture and forestry (NFR 1.A.4.c ii) based upon annual shares derived from TREMOD MM (Knörr et al. (2024b)) [3)] (cf. superordinate chapter).

To provide more specific information on mobile sources in agriculture and forestry, the inventory compiler further devides NFR sector 1.A.4.c ii into **1.A.4.c ii (i) - NRMM in agriculture** in and **1.A.4.c ii (ii) - NRMM in forestry**.

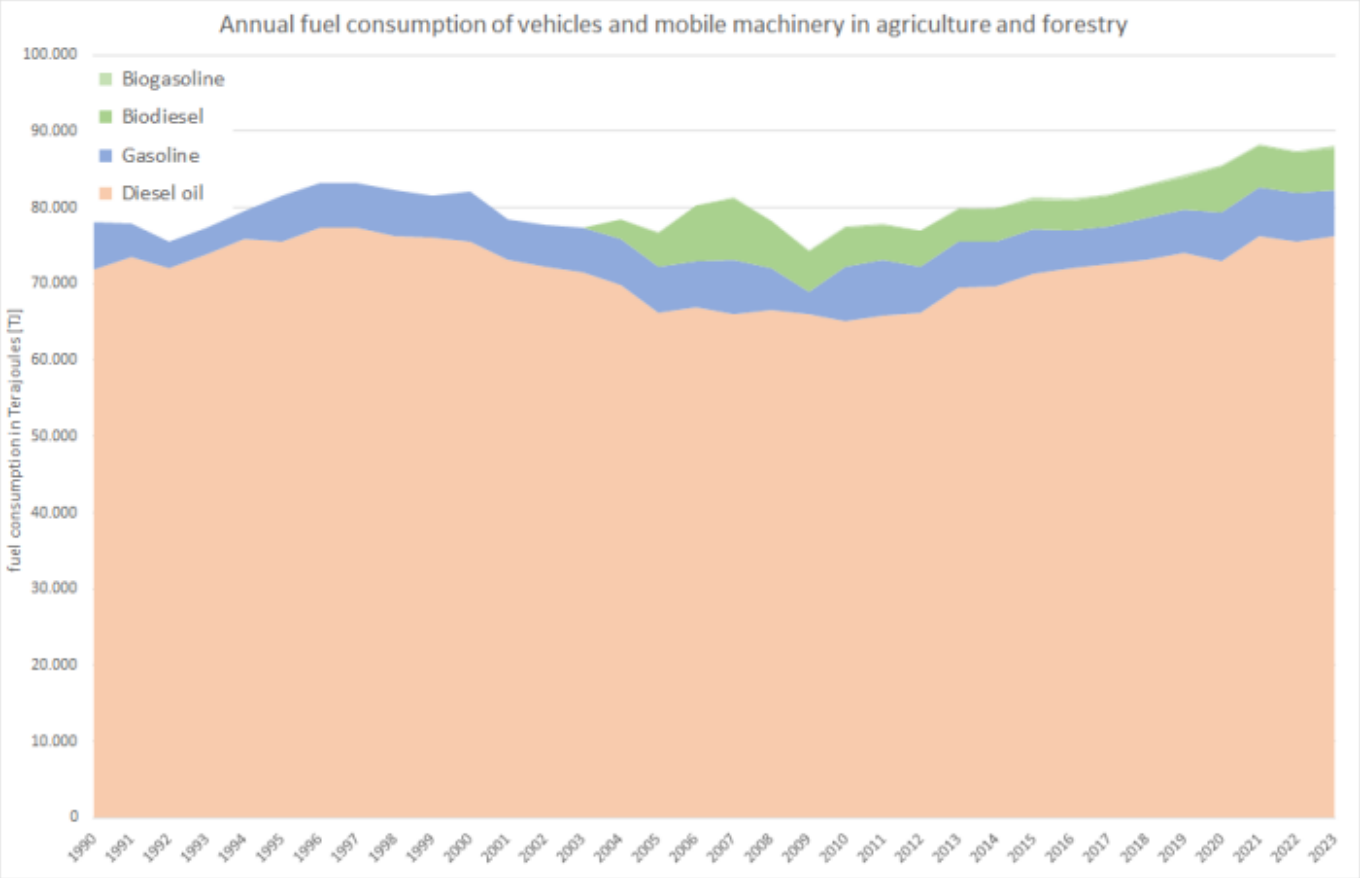
Table 2: Annual percentual contribution of NFR 1.A.4.c ii to the primary fuel delivery data provided in NEB line 67

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
DIESEL FUELS														
1.A.4.c ii (i)	62.4%	76.6%	78.5%	79.6%	71.8%	67.4%	66.9%	66.7%	69.2%	68.1%	67.8%	69.5%	71.8%	74.0%
1.A.4.c ii (ii)	1.91%	0.63%	0.87%	1.13%	1.56%	1.70%	1.54%	1.57%	1.70%	1.86%	2.21%	2.14%	1.97%	1.68%
GASOLINE FUELS[1]														
1.A.4.c ii (ii)	68.5%	40.3%	44.9%	41.4%	35.5%	32.0%	29.1%	28.9%	32.1%	32.9%	36.5%	36.6%	36.2%	33.8%

source: own estimations based on Knörr et al. (2024b) [4)] [1] no gasoline used in agriculatural vehicles and mobile machinery

Table 3: Annual mobile fuel consumption in agriculture and forestry, in terajoules

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Diesel oil	71,926	75,485	75,451	66,242	65,060	71,397	71,988	72,660	73,222	73,998	73,037	76,167	75,548	76,318
Gasoline	6,186	6,009	6,648	6,058	7,201	5,711	5,011	4,879	5,462	5,772	6,361	6,529	6,367	5,874
Biodiesel	0	0	0	4,405	5,089	3,966	3,902	3,961	4,131	4,197	5,974	5,341	5,241	5,656
Biogasoline				42.0	122	231	205	197	236	238	285	308	295	277
Σ 1.A.4.c ii	**78,112**	**81,494**	**82,100**	**76,747**	**77,471**	**81,305**	**81,106**	**81,697**	**83,052**	**84,205**	**85,657**	**88,345**	**87,451**	**88,125**



Emission factors

The emission factors applied here are of rather different quality:

Basically, for all **main pollutants**, **carbon monoxide** and **particulate matter**, annual IEF modelled within TREMOD MM are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

For Information on the country-specific implied emission factors applied to mobile machinery in agriculture and forestry, please refer to the respective sub-chapters linked above.

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Discussion of emission trends

Table 4: Outcome of Key Catgegory Analysis for NFR 1.A.4.c ii

for:	**NO_x**	**$PM_{2.5}$**	**PM_{10}**	**BC**
by:	Level	Level & Trend	L & T	L & T

Unregulated pollutants (Ammonia, HMs, POPs, ...)

For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.



Here, exemplary for cadmium, the extreme steps in emission estimates result from two effects:

(i) the annual amounts of gasoline fuels allocated to NFR 1.A.4.c ii depend on the amounts delivered to the military also covered in NEB line 67. (see superordinate chapter for further information). This approach results in strong declines in gasoline consumption after 2007 and 2011. In addition, in contrast to the main pollutants, all heavy-metal and POP emissions are calculated via a tier1 approach based on default EF from [5)].

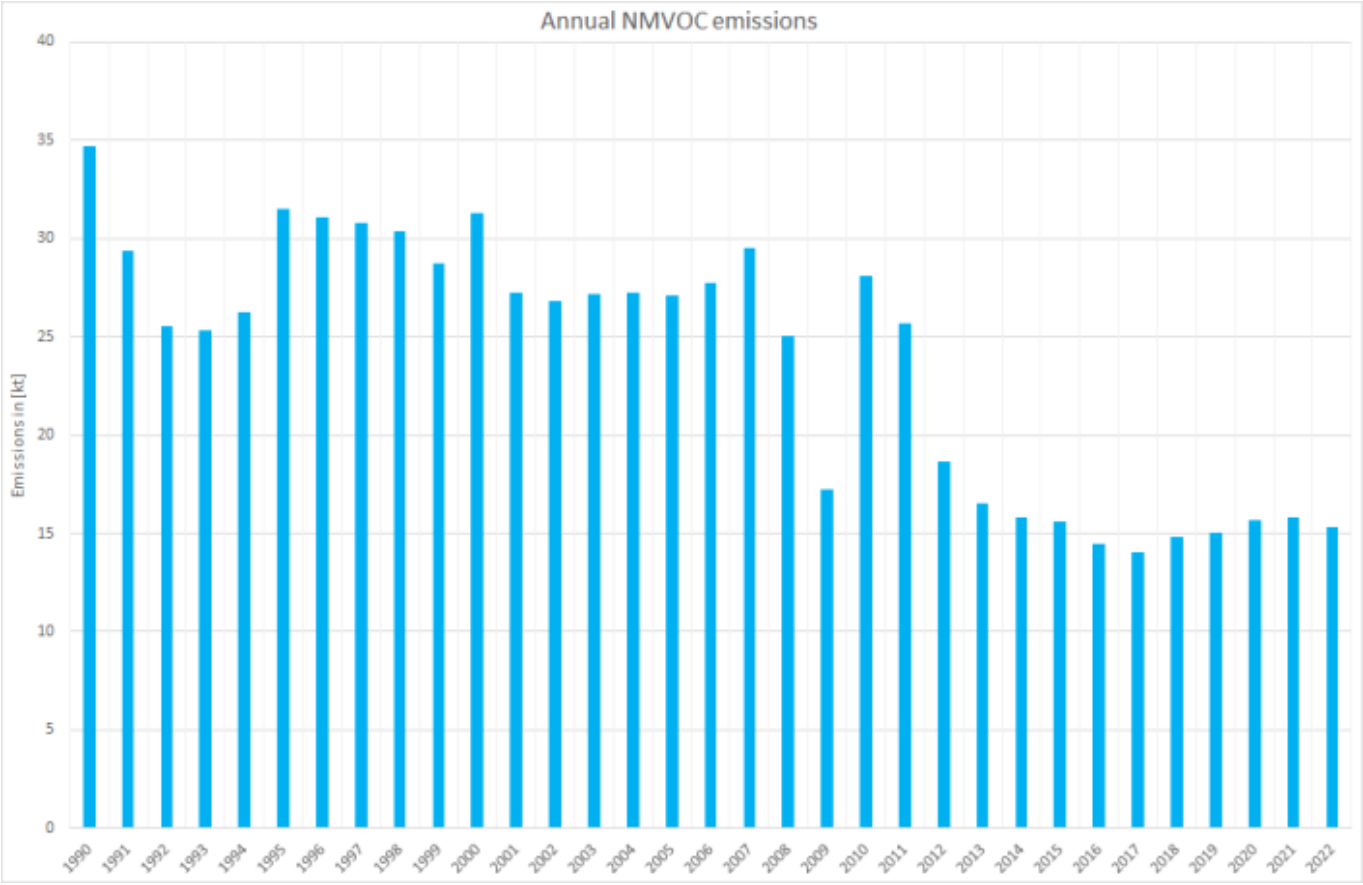


Table 5: Development of gasoline consumption in NFR 1.A.4.c ii, in terajoules

	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Gasoline	6,186	6,009	6,648	6,058	7,201	5,711	6,361	6,529	6,367	5,874
Biogasoline				42.0	122	231	285	308	295	277

(ii) All gasoline fuels allocated to NFR 1.A.4.c ii are used in 2-stroke-engines in forestry equipment. As the 2-stroke fuel also includes lubricant oil, the fuel's heavy metal content is significantly higher than that of 4-stroke gasoline (or diesel fuels). (see Appendix 2.3 for more information on the reporting of HM emissions.)

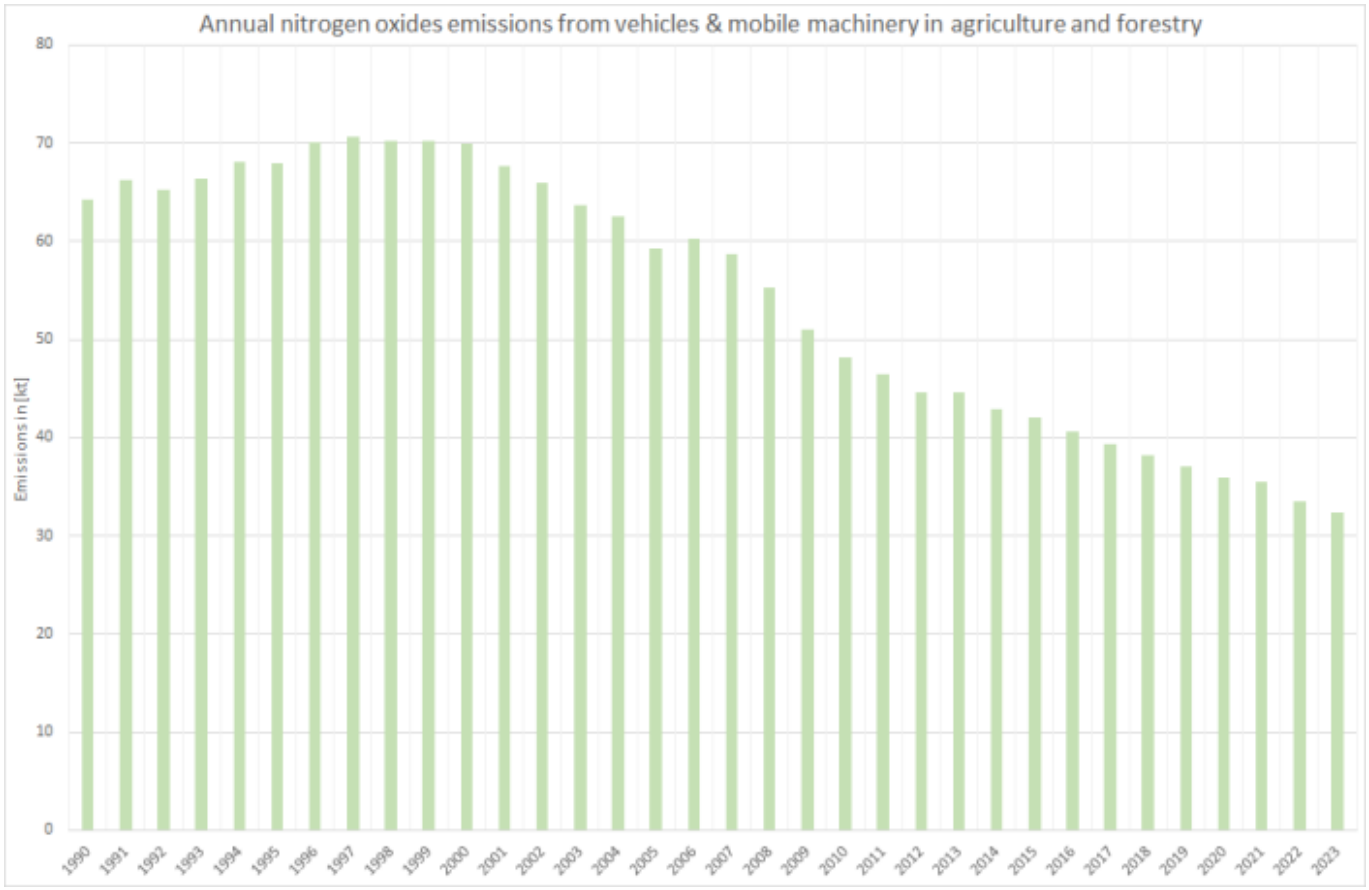
Table 6: Tier1 default emission factors applied to NRMM, in g/TJ

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Diesel oil	0.012	0.001	0.123	0.002	0.198	0.133	0.005	0.002	0.419
Biodiesel[1]	0.013	0.001	0.142	0.003	0.228	0.153	0.005	0.003	0.483
Gasoline fuels - 4-stroke	0.037	0.005	0.200	0.007	0.145	0.103	0.053	0.005	0.758
Gasoline fuels - 2-stroke[2]	0.051	2.10	0.196	0.007	8.96	357	14.7	2.09	208
LPG (1.A.4.a ii only)	NE								

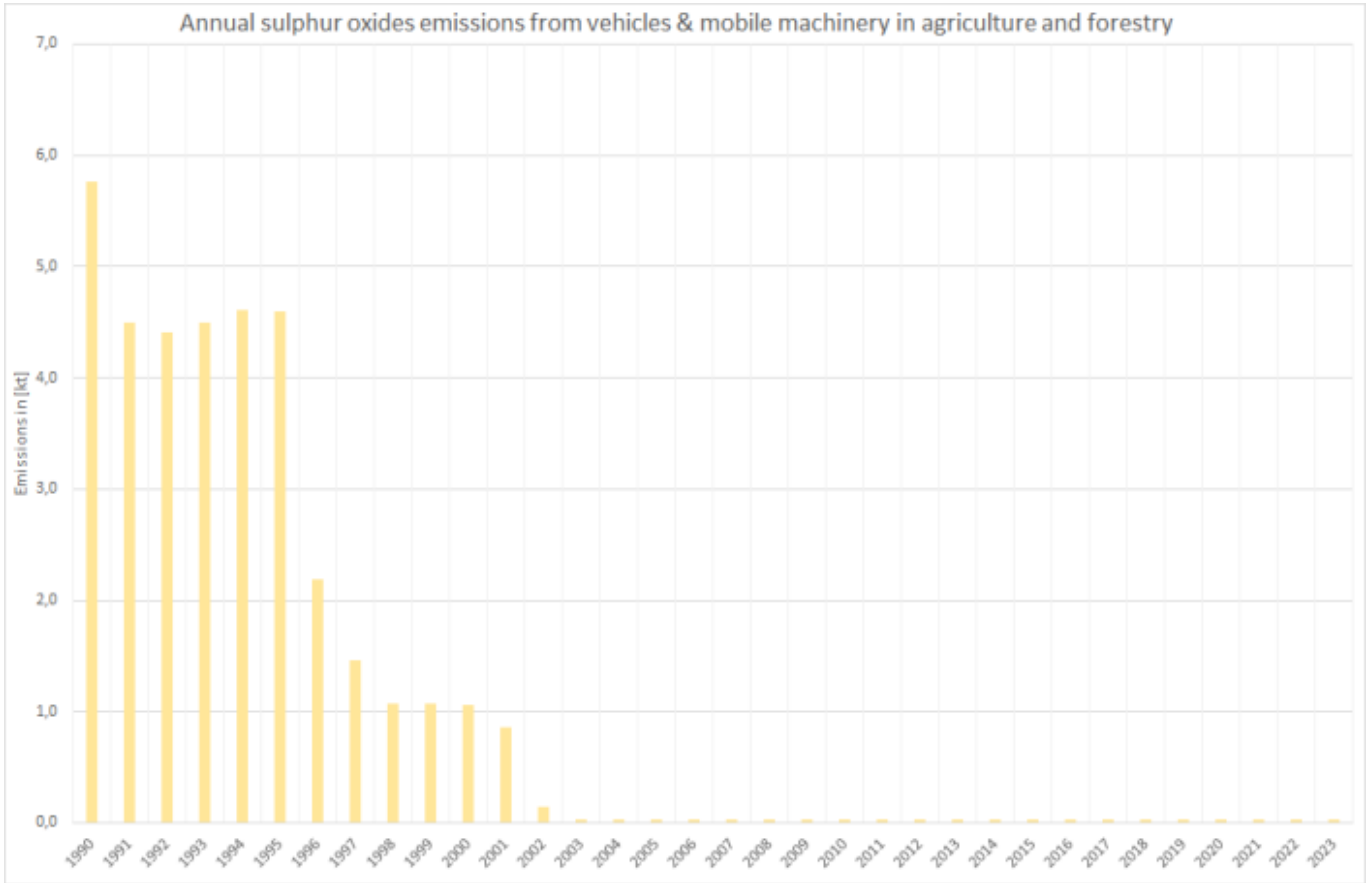
[1] values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel
[2] including the HM of 1:50 lube oil mixed to the gasoline Hence, emission estimates reported for cadmium are significantly higher for years with higher gasoline use (in 2-stroke enignes).

Regulated pollutants

For all regulated pollutants, emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation.



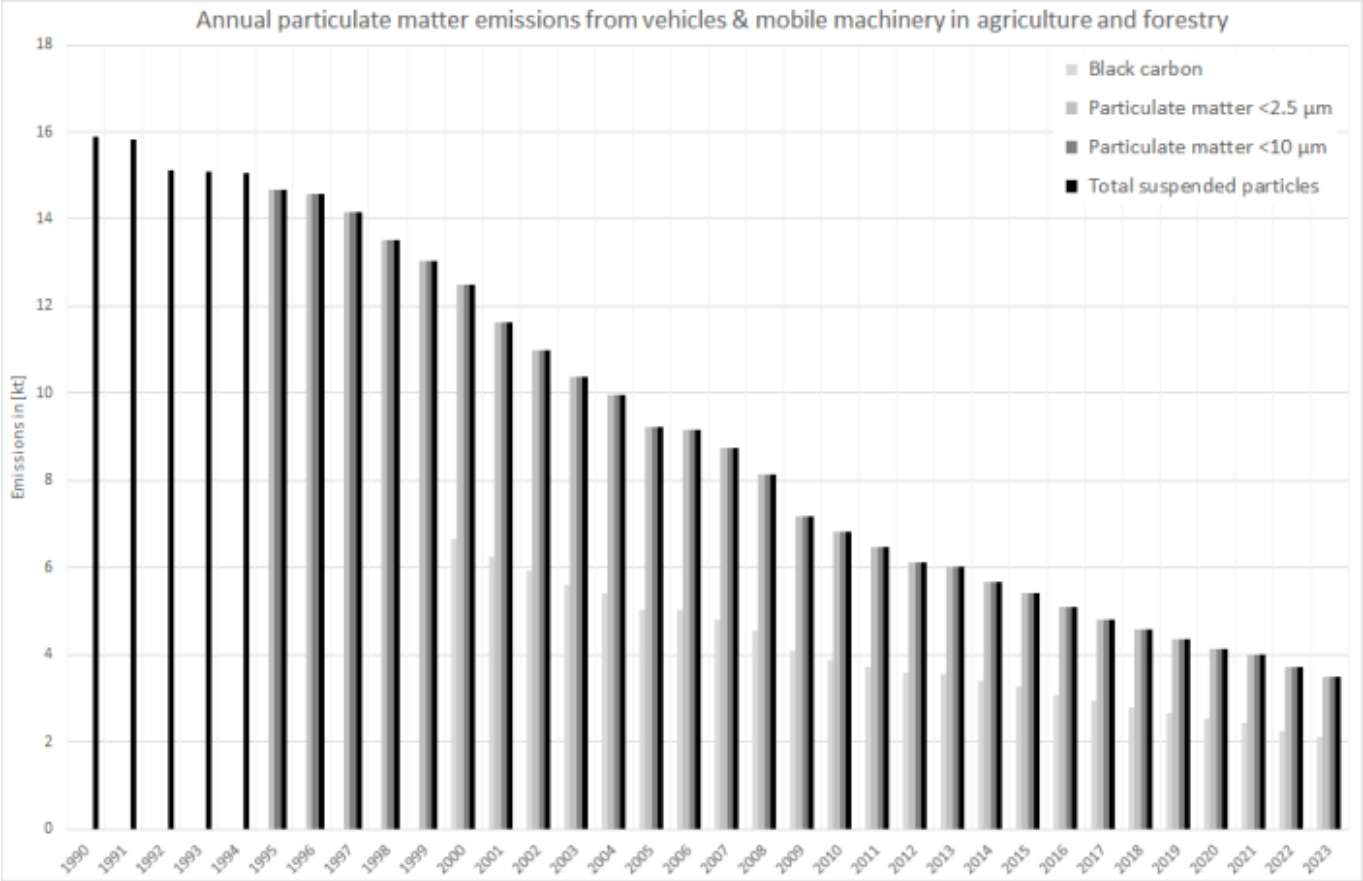
Here, emissions of sulphur oxides follow the step-by-step reduction of sulphur contents in liquid fuels, resulting in a reduction of over 99% since 1990:



Particulate matter & Black carbon

Over-all PM emissions are by far dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption between 2000 and 2005. Nonetheless, the decrease of the over-all emission trend was and still is amplified by the expanding use of particle filters especially to eliminate soot emissions.

Additional contributors such as the impact of TSP emissions from the use of leaded gasoline (until 1997) have no significant effect onto over-all emission estimates.



Recalculations

Compared to previous submissions, **activity data** has been recalculated for all years, but far less drastically as with the 2024 submission.

Here, as the consumption data for agricultural and forestry vehicles is estimated as part of the over-all amounts provided in row 67 of the National Energy Balance via percental shares, these shares have been revised as follows:

Table 7: Revision of annual percental shares of fuels consumed in both agriculture and forestry

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL FUELS: AGRICULTURE													
current submission	0.624	0.766	0.785	0.796	0.718	0.674	0.669	0.667	0.692	0.681	0.678	0.695	0.718
previous submission	0.615	0.764	0.785	0.796	0.719	0.662	0.652	0.647	0.669	0.655	0.651	0.653	0.688
absolute change	0.008	0.002	0.000	0.000	-0.001	0.012	0.017	0.020	0.023	0.026	0.027	0.042	0.031
relative change	1.35%	0.22%	0.00%	0.00%	-0.14%	1.86%	2.59%	3.03%	3.48%	3.89%	4.09%	6.49%	4.46%
DIESEL FUELS: FORESTRY													
current submission	0.019	0.006	0.009	0.011	0.016	0.017	0.015	0.016	0.017	0.019	0.022	0.021	0.020
previous submission	0.019	0.006	0.009	0.011	0.016	0.019	0.018	0.019	0.021	0.023	0.027	0.028	0.025
absolute change	0.000	0.000	0.000	0.000	0.000	-0.002	-0.003	-0.003	-0.004	-0.005	-0.005	-0.007	-0.005
relative change	-2.16%	-0.70%	0.00%	0.00%	0.35%	-8.32%	-14.0%	-16.0%	-18.9%	-20.3%	-19.4%	-24.1%	-21.0%

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
GASOLINE FUELS: FORESTRY													
current submission	0.685	0.403	0.449	0.414	0.355	0.320	0.291	0.289	0.321	0.329	0.365	0.366	0.362
previous submission	0.685	0.403	0.449	0.414	0.355	0.333	0.316	0.319	0.358	0.368	0.403	0.408	0.404
absolute change	0.000	0.000	0.000	0.000	0.000	-0.013	-0.025	-0.029	-0.037	-0.038	-0.039	-0.041	-0.042
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	-3.91%	-8.04%	-9.21%	-10.2%	-10.4%	-9.58%	-10.2%	-10.3%

Resulting from the revised annual shares, **activity data** have been re-calculated accordingly:

Table 8: Revision of annual activity data, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL FUELS													
current submission	71,926	75,485	75,451	70,647	70,149	75,363	75,890	76,621	77,354	78,196	79,011	81,508	80,788
previous submission	71,042	75,327	75,451	70,647	70,238	74,186	74,300	74,753	75,246	75,875	76,604	77,458	78,170
absolute change	884	158	-0.01	0.00	-89.7	1,177	1,590	1,868	2,108	2,321	2,406	4,050	2,619
relative change	1.24%	0.21%	0.00%	0.00%	-0.13%	1.59%	2.14%	2.50%	2.80%	3.06%	3.14%	5.23%	3.35%
GASOLINE FUELS													
current submission	6,186	6,009	6,648	6,100	7,322	5,942	5,216	5,076	5,698	6,010	6,647	6,837	6,662
previous submission	6,186	6,009	6,648	6,100	7,322	6,184	5,671	5,591	6,346	6,710	7,351	7,610	7,462
absolute change	0.00	0.00	0.00	0.00	-0.01	-242	-456	-515	-648	-700	-704	-773	-800
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	-3.91%	-8.04%	-9.21%	-10.2%	-10.4%	-9.6%	-10.2%	-10.7%
OVER-ALL FUEL CONSUMPTION													
current submission	78,112	81,494	82,100	76,747	77,471	81,305	81,106	81,697	83,052	84,205	85,657	88,345	87,451
previous submission	77,228	81,336	82,100	76,747	77,561	80,370	79,972	80,343	81,592	82,585	83,955	85,068	85,632
absolute change	884	158	-0.01	0.00	-89.7	935	1,134	1,353	1,460	1,620	1,702	3,277	1,819
relative change	1.14%	0.19%	0.00%	0.00%	-0.12%	1.16%	1.42%	1.68%	1.79%	1.96%	2.03%	3.85%	2.12%

For information on revised **emission factors** please refer to the sub-chapters on mobile sources in agriculture and forestry as linked above.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by (Knörr et al. (2009)) [6)].

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

Planned improvements

Besides a **routine revision of TREMOD MM**, no specific improvements are planned.

FAQs

Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?

The EF provided in [7)] represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained the biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel and bioethanol.

[1)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

[2)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.

[3), 4)] Knörr et al. (2024b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2024, Heidelberg, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2024.

[5)] EMEP/EEA, 2023: EMEP/EEA air pollutant emission inventory guidebook – 2023, https://www.eea.europa.eu//publications/emep-eea-guidebook-2023, Copenhagen, 2023.

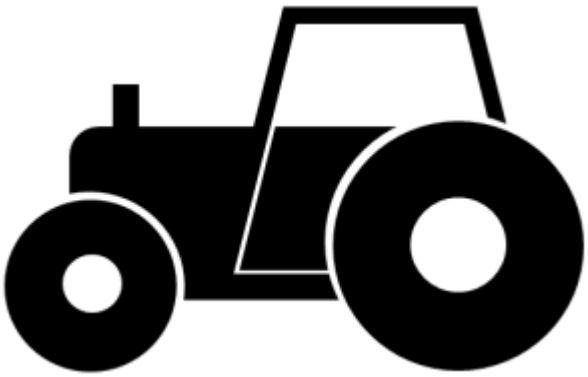
[6)] Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; URL: https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau,2009.

1.A.4.c ii (a) - Off-road Vehicles and other Machinery: Agriculture

Short description

Under sub-category *1.A.4.c ii (a)* fuel combustion activities and resulting emissions from agricultural off-road vehicles and mobile machinery are reported.

NFR-Code	Source category	Method	AD	EF	Key Category Analysis
1.A.4.c ii (a)	Off-road Vehicles and Other Machinery: Agriculture	T1, T2	NS, M	CS, D, M	see superordinate chapter



Methodology

Activity data

Subsector-specific consumption data is included in the primary fuel-delivery data are available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2024) [1)].

Table 1: Sources for primary fuel-delivery data

through 1994	**AGEB** - National Energy Balance, line 79: 'Haushalte und Kleinverbraucher insgesamt'
as of 1995	**AGEB** - National Energy Balance, line 67: 'Gewerbe, Handel, Dienstleistungen u. übrige Verbraucher'

Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2024) [2)], the remaining amounts of gasoline and diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and off-road vehicles in commercial/institutional use (1.A.4. ii) as well as agriculture and forestry (NFR 1.A.4.c ii) based upon annual shares derived from TREMOD-MM (Knörr et al. (2024b) [3)] (cf. NFR 1.A.4 - mobile).

Table 2: Annual contribution of agricultural vehicles and mobile machinery to the primary diesel[1] fuels delivery data provided in NEB line 67

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
62.4%	76.6%	78.5%	79.6%	71.8%	67.4%	66.9%	66.7%	69.2%	68.1%	67.8%	69.5%	71.8%	74.0%

[1] no gasoline used in agricultural vehicles and mobile machinery

Table 3: Annual mobile fuel consumption in agriculture, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel Oil	69,792	74,870	74,621	65,319	63,679	69,643	70,365	70,986	71,462	72,029	70,729	73,892	73,534	74,627
Biodiesel	0	0	0	4,344	4,981	3,869	3,814	3,870	4,032	4,086	5,785	5,182	5,101	5,531

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Σ 1.A.4.c ii (i)	**69,792**	**74,870**	**74,621**	**69,662**	**68,660**	**73,512**	**74,178**	**74,856**	**75,495**	**76,115**	**76,515**	**79,073**	**78,635**	**80,158**

Emission factors

The emission factors applied here are of rather different quality: For all **main pollutants**, **carbon monoxide** and **particulate matter**, annual IEF modelled within TREMOD MM [4)] are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

Table 4: Annual country-specific emission factors[1], in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
NH_3	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
NMVOC	237	216	191	155	119	90.8	85.4	80.3	75.5	70.9	66.6	62.1	57.6	52.9
NO_x	889	897	924	836	684	560	538	517	497	479	460	440	420	399
SO_x	79.6	60.5	14.0	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
PM^2	119	105	88.9	71.7	55.7	43.7	41.2	38.8	36.6	34.5	32.4	30.4	28.4	26.1
BC^3	218	192	163	128	94.4	69.9	65.3	61.1	57.2	53.6	50.2	46.8	43.7	40.3
CO	834	792	738	643	535	446	425	404	383	363	343	322	300	277

[1] due to lack of better information: similar EF are applied for fossil and biofuels
[2] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP consists of $PM_{2.5}$)
[3] estimated via a f-BCs as provided in [5)], Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery

> **NOTE:** With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.
>
> For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Recalculations

Revisions in **activity data** result from slightly revised annual shares adapted EBZ 67 shares as well as the implementation of primary activity data from the now finalised NEB 2022.

Table 5: Revised annual shares of NEB line 67, in %

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
current submission	0.624	0.766	0.785	0.796	0.718	0.674	0.669	0.667	0.692	0.681	0.678	0.695	0.718
previous submission	0.615	0.764	0.785	0.796	0.719	0.662	0.652	0.647	0.669	0.655	0.651	0.653	0.688
absolute change	0.008	0.002	0.000	0.000	-0.001	0.012	0.017	0.020	0.023	0.026	0.027	0.042	0.031
relative change	1.35%	0.22%	0.00%	0.00%	-0.14%	1.86%	2.59%	3.03%	3.48%	3.89%	4.09%	6.49%	4.46%

Table 6: Revised activity data, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
current submission	69,792	74,870	74,621	69,662	68,660	73,512	74,178	74,856	75,495	76,115	76,515	79,073	78,635
previous submission	68,861	74,708	74,621	69,662	68,754	72,167	72,309	72,651	72,952	73,264	73,509	74,252	75,439
absolute change	931	162	0	0	-94.9	1,345	1,870	2,205	2,542	2,851	3,005	4,821	3,196
relative change	1.35%	0.22%	0.00%	0.00%	-0.14%	1.86%	2.59%	3.04%	3.48%	3.89%	4.09%	6.49%	4.24%

For **pollutant-specific information on recalculated emission estimates reported for Base Year and 2022**, please see the recalculation tables following chapter 8.1 - Recalculations.

Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

[1)] AGEB, 2024: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

[2)] BAFA, 2024: Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.

[3), 4)] Knörr et al. (2024b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2024, Heidelberg, 2024.

[5)] EMEP/EEA, 2023: EMEP/EEA air pollutant emission inventory guidebook – 2023, https://www.eea.europa.eu//publications/emep-eea-guidebook-2023, Copenhagen, 2023.

1.A.4.c ii (b) - Off-road Vehicles and other Machinery: Forestry

Short description

Under sub-category *1.A.4.c ii (b)* fuel combustion activities and resulting emissions from off-road vehicles and mobile machinery used in forestry are reported.



NFR-Code	Source category	Method	AD	EF	Key Category Analysis
1.A.4.c ii (b)	Off-road Vehicles and Other Machinery: Forestry	T1, T2	NS, M	CS, D, M	see superordinate chapter

Methodology

Activity data

Primary activity data (PAD) are taken from National Energy Balances (NEBs) line 67: 'Commercial, trade, services and other consumers' (AGEB, 2024) [1)].

Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2024) [2)], the remaining amounts of gasoline and diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and off-road vehicles in commercial/institutional use (1.A.4. ii) as well as agriculture and forestry (NFR 1.A.4.c ii) based upon annual shares derived from TREMOD MM (Knörr et al. (2024b) [3)] (cf. NFR 1.A.4 - mobile).

Table 1: Annual contribution of forestry vehicles and mobile machinery to the primary fuel delivery data provided in NEB line 67

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
DIESEL FUELS	1.91%	0.63%	0.87%	1.13%	1.56%	1.70%	1.54%	1.57%	1.70%	1.86%	2.21%	2.14%	1.97%	1.68%
GASOLINE FUELS	68.5%	40.3%	44.9%	41.4%	35.5%	32.0%	29.1%	28.9%	32.1%	32.9%	36.5%	36.6%	36.2%	33.8%

source: own estimates based on TREMOD MM

Table 2: Annual mobile fuel consumption in forestry, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel Oil	2,134	615	831	923	1,381	1,753	1,624	1,674	1,760	1,969	2,307	2,275	2,014	1,690
Gasoline	3,093	3,005	3,324	3,029	3,600	2,855	2,506	2,439	2,731	2,886	3,181	3,265	3,184	2,937
Biodiesel				61.4	108	97.4	88.0	91.2	99.3	112	189	160	140	125
Biogasoline				21.0	60.9	116	102	98.6	118	119	143	154	148	139
Σ 1.A.4.c ii (ii)	**5,227**	**3,620**	**4,155**	**4,035**	**5,150**	**4,822**	**4,319**	**4,303**	**4,708**	**5,086**	**5,819**	**5,853**	**5,485**	**4,892**

Emission factors

The emission factors used here are of rather different quality: For all **main pollutants**, **carbon monoxide** and **particulate matter**, annually changing values computed within TREMOD MM (Knörr et al. (2024b)) [4)] are used, representing the development of mitigation technologies and th effect of fuel-quality legislation.

Table 3: Annual coutry-specific emission factors from TREMOD MM[1]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL FUELS													
NH_3	0.16	0.17	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
NMVOC	191	156	130	80.2	46.5	27.7	24.1	20.6	17.5	14.7	12.2	10.1	8.3
NO_x	981	1,052	1,071	834	543	373	343	310	282	255	229	203	177
SO_x	79.6	60.5	14.0	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[5]	84.5	60.7	41.7	27.7	21.6	16.2	14.6	13.1	11.7	10.4	9.03	7.72	6.43
PM[4]	155	111	75.8	45.3	30.4	20.8	18.6	16.7	14.9	13.2	11.6	10.0	8.55
CO	688	618	554	395	282	214	194	173	153	134	116	99.4	84.1
GASOLINE FUELS													
NH_3	0.075	0.083	0.083	0.086	0.087	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092
NMVOC[2]	5,819	5,099	5,099	5,320	5,424	2,897	2,897	2,897	2,897	2,901	2,910	2,915	2,915
NMVOC[3]	3.04	6.37	4.67	4.56	4.83	5.00	5.32	5.19	4.30	4.03	3.46	3.35	3.53
NO_x	42.7	49.4	49.4	76.4	86.0	55.1	55.1	55.1	55.1	55.1	55.1	55.1	55.1
SO_x	10.1	8.27	3.22	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[5]	5.09	3.73	3.73	3.86	3.91	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13
PM[4]	102	74.6	74.6	77.2	78.1	82.7	82.7	82.7	82.7	82.7	82.7	82.7	82.7
TSP[6]	2.35	0.82	leaded gasoline banned as of 1997										
CO	16,824	14,796	14,796	15,371	15,609	16,514	16,514	16,514	16,514	16,514	16,514	16,514	16,514
Pb	1.47	0.52	leaded gasoline banned as of 1997										

[1] due to lack of better information: similar EF are applied for fossil and biofuels
[2] from fuel combustion
[3] from gasoline evaporation
[4] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP consists of $PM_{2.5}$)
[5] estimated via a f-BCs as provided in [5)], Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery
[6] from leaded gasoline (until 1997)

With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [10)]

> For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Recalculations

Revisions in **activity data** result from slightly revised annual shares adapted EBZ 67 shares as well as the implementation of primary activity data from the now finalised NEB 2022.

Table 6: Revised annual shares of NEB line 67, in %

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL FUELS													
currents submission	0.019	0.006	0.009	0.011	0.016	0.017	0.015	0.016	0.017	0.019	0.022	0.021	0.020

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
previous submission	0.019	0.006	0.009	0.011	0.016	0.019	0.018	0.019	0.021	0.023	0.027	0.028	0.025
absolute change	0.000	0.000	0.000	0.000	0.000	-0.002	-0.003	-0.003	-0.004	-0.005	-0.005	-0.007	-0.005
relative change	-2.16%	-0.70%	0.00%	0.00%	0.35%	-8.32%	-14.0%	-16.0%	-18.9%	-20.3%	-19.4%	-24.1%	-21.0%
GASOLINE FUELS													
currents submission	0.685	0.403	0.449	0.414	0.355	0.320	0.291	0.289	0.321	0.329	0.365	0.366	0.362
previous submission	0.685	0.403	0.449	0.414	0.355	0.333	0.316	0.319	0.358	0.368	0.403	0.408	0.404
absolute change	0.000	0.000	0.000	0.000	0.000	-0.013	-0.025	-0.029	-0.037	-0.038	-0.039	-0.041	-0.042
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	-3.91%	-8.04%	-9.21%	-10.2%	-10.4%	-9.6%	-10.2%	-10.3%

Table 5: Revised activity data, in terajoules [TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL FUELS													
current submission	2,134	615	831	985	1,489	1,851	1,712	1,765	1,859	2,081	2,496	2,435	2,153
previous submission	2,181	620	831	985	1,484	2,019	1,991	2,102	2,293	2,611	3,095	3,206	2,730
absolute change	-47.2	-4.34	0.00	-0.01	5.22	-168	-280	-337	-434	-530	-599	-771	-577
relative change	-2.16%	-0.70%	0.00%	0.00%	0.35%	-8.32%	-14.0%	-16.0%	-18.9%	-20.3%	-19.4%	-24.1%	-21.1%
GASOLINE FUELS													
current submission	3,093	3,005	3,324	3,050	3,661	2,971	2,608	2,538	2,849	3,005	3,323	3,418	3,331
previous submission	3,093	3,005	3,324	3,050	3,661	3,092	2,836	2,795	3,173	3,355	3,675	3,805	3,731
absolute change	0.00	0.00	0.00	0.00	-0.01	-121	-228	-257	-324	-350	-352	-387	-400
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	-3.91%	-8.04%	-9.21%	-10.2%	-10.4%	-9.6%	-10.2%	-10.7%
OVER-ALL FUEL CONSUMPTION													
current submission	5,227	3,620	4,155	4,035	5,150	4,822	4,319	4,303	4,708	5,086	5,819	5,853	5,485
previous submission	5,274	3,624	4,155	4,035	5,145	5,111	4,827	4,897	5,466	5,966	6,770	7,011	6,462
absolute change	-47.2	-4.34	0.00	-0.01	5.22	-289	-508	-594	-758	-880	-951	-1,158	-977
relative change	-0.89%	-0.12%	0.00%	0.00%	0.10%	-5.65%	-10.5%	-12.1%	-13.9%	-14.8%	-14.0%	-16.5%	-15.1%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 8.1 - Recalculations.

[1)] AGEB, 2024: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

[2)] BAFA, 2024: Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.

[3), 4)] Knörr et al. (2024b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2024, Heidelberg, 2024.

[5)] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019.

[10)]

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.A.4.c iii - Agriculture/Forestry/Fishing: National Fishing

Short description

In NFR sub-category *1.A.4.c iii* fuel consumption and emissions of Germany's maritime fishing fleet are reported.

Category Code	Method	AD	EF
1.A.4.c iii	T1, T2	NS, M	D, M, CS, T1, T2

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity Data

Primary fuel delivery data for national fishing is included in NEB lines 6 ('International Deep-Sea Bunkers') and 64 ('Coastal and Inland Navigation') for IMO-registered and unregistered ships respectively. (AGEB, 2024) [1)]

The actual annual amounts used are therefore calculated within (Deichnik (2024)), where ship movement data (AIS signal) allows for a bottom-up approach providing the needed differentiation.[2)]

Table 1: Annual fuel consumption, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel oil	305	240	238	226	227	284	298	293	267	NO	NO	NO	NO	NO
Light fuel oil	NO	NO	NO	NO	NO	NO	NO	NO	88.9	322	359	265	221	225
Heavy fuel oil	33.3	26.0	26.0	24.4	24.5	NO	NO	NO	NO	NO	NO	NO	NO	NO
Σ 1.A.4.c iii	**338**	**266**	**264**	**250**	**251**	**284**	**298**	**293**	**356**	**322**	**359**	**265**	**221**	**225**

The strong increase after 2015 cannot be conclusively explained at the moment. However, even if the over-all fuel quantities delivered to the navigation sector would be somehow misallocated between the specific nautical acitivities, there would be no over- or under-estimation of over-all emissions.

Emission factors

The emission factors applied here, are derived from different sources and therefore are of very different quality.

For the main pollutants, country-specific implied values are used, that are based on tier3 EF included in the BSH model [3)] which mainly relate on values from the EMEP/EEA guidebook 2019 [4)]. These modelled IEFs take into account the ship specific information derived from AIS data as well as the mix of fuel-qualities applied depending on the type of ship and the current state of activity.

Table 2: Annual country-specific emission factors, in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
DIESEL OIL & LIGHT FUEL OIL[1]														
NH_3	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
NMVOC	58.9	58.9	58.9	58.9	58.9	69.6	68.2	64.3	58.0	58.7	57.5	58.7	57.8	62.1
NO_x	1,124	1,124	1,124	1,124	1,124	1,120	1,126	1,114	1,103	1,109	1,117	1,113	1,108	1,110
SO_x	466	419	233	186	69.8	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
BC [2]	83.7	75.3	41.8	33.5	12.5	12.5	12.7	12.4	12.2	12.0	11.6	11.5	11.7	11.8
$PM_{2.5}$	270	243	135	108	40.5	40.4	41.1	40.0	39.4	38.8	37.5	37.2	37.6	38.2
PM_{10}	289	260	144	115	43.3	43.2	43.9	42.8	42.1	41.5	40.1	39.8	40.2	40.9
TSP	289	260	144	115	43.3	43.2	43.9	42.8	42.1	41.5	40.1	39.8	40.2	40.9
CO	102	102	102	102	102	110	112	109	107	106	103	103	103	100
HEAVY FUEL OIL														
NH_3	0.33	0.33	0.33	0.33	0.33	NA								
NMVOC	36.4	36.4	36.4	36.4	36.4	NA								
NO_x	1,258	1,258	1,258	1,258	1,258	NA								
SO_x	1,319	1,332	1,323	1,336	496	NA								
BC [22]	64.9	65.5	65.1	65.7	24.4	NA								
$PM_{2.5}$ [3]	541	546	542	548	203	NA								
PM_{10}	595	601	597	602	224	NA								
TSP	595	601	597	602	224	NA								
CO	200	200	200	200	200	NA								

[1] similar EF applied to diesel oil and light fuel oil
[2] estimated from f-BCs as provided in [5)]: f-BC (HFO) = 0.12, f-BC (MDO/MGO) = 0.31, chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii, Navigation, Table 3-2 and Table A1 - BC fractions of PM emissions from relevant studies
[3] ratios $PM_{2.5}$: PM_{10} : TSP derived from the tier1 default EF as provided in [6)]

> **NOTE:** For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.
>
> For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust

> emissions from mobile sources.

Trend discussion for Key Sources

> **NFR 1.A.4.c iii - National Fishing** is **no key source**.

Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Uncertainties

Uncertainty estimates for **emission factors** were adopted from NFR 1.A.3.d i as a comparable emission source.

Planned improvements

Besides a routine revision of the underlying BSH model, further focus will be put on the correct allocation of actvity data to the different navigation activities covered in different NFR sub-sectors.

With respect to the strong increase in activity data from 2015 to 2016: This issue is under discussion with the BSH Hamburg as the agency in charge of the underlying model. However, these activity data are based on ship movement data showing a correspondingly increasing trend. Nonetheless, the model is under steady revision and erroneous calculations and results will be corrected whenever they are determined.

[1)] AGEB, 2024: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

[2)] Deichnik (2024): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs. from Bundesamts für Seeschifffahrt und Hydrographie (BSH - Federal Maritime and Hydrographic Agency); Hamburg, 2024.

[4), 5), 6)] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook – 2019; Chapter 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation; URL: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-d-navigation

1.A.5 - Other (including Military) (OVERVIEW)

Short description

In category *1.A.5 - Other: Military* emissions from military fuel combustion (stationary and mobile) within Germany are reported.

NFR-Code	Source category
1.A.5.a	Other: Stationary (including Military)
1.A.5.b	Other: Mobile (including Military)

Within NFR sub-category *1.A.5.a*, emissions from **stationary fuel combustion in military facilities** are reported whereas within NFR sub-category *1.A.5.b*, emissions from **mobile military fuel combustion** in ground vehicles, aircraft and ships are reported.

> For further details on sub-scetor specific acitivity data, emission factors and emissions please see the sub-category chapters linked above.

1.A.5.a - Other, Stationary (including Military)

Short description

In sub-category *1.A.5.a - Other, Stationary (including Military)* emissions from stationary fuel combustion in military facilities are reported.

NFR Code	Method	AD	EF
1.A.5.a	T2, T3	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	Pb	Cd	**Hg**	As	Cr	Cu	Ni	Se	Zn	**PCDD/F**	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAHs**	**HCB**	**PCBs**
-/-	**L/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE	-/-	NE	NE	NE	NE	NE	NE	-/-	-/-	-/-	-/-	-/-	**-/-**	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity Data

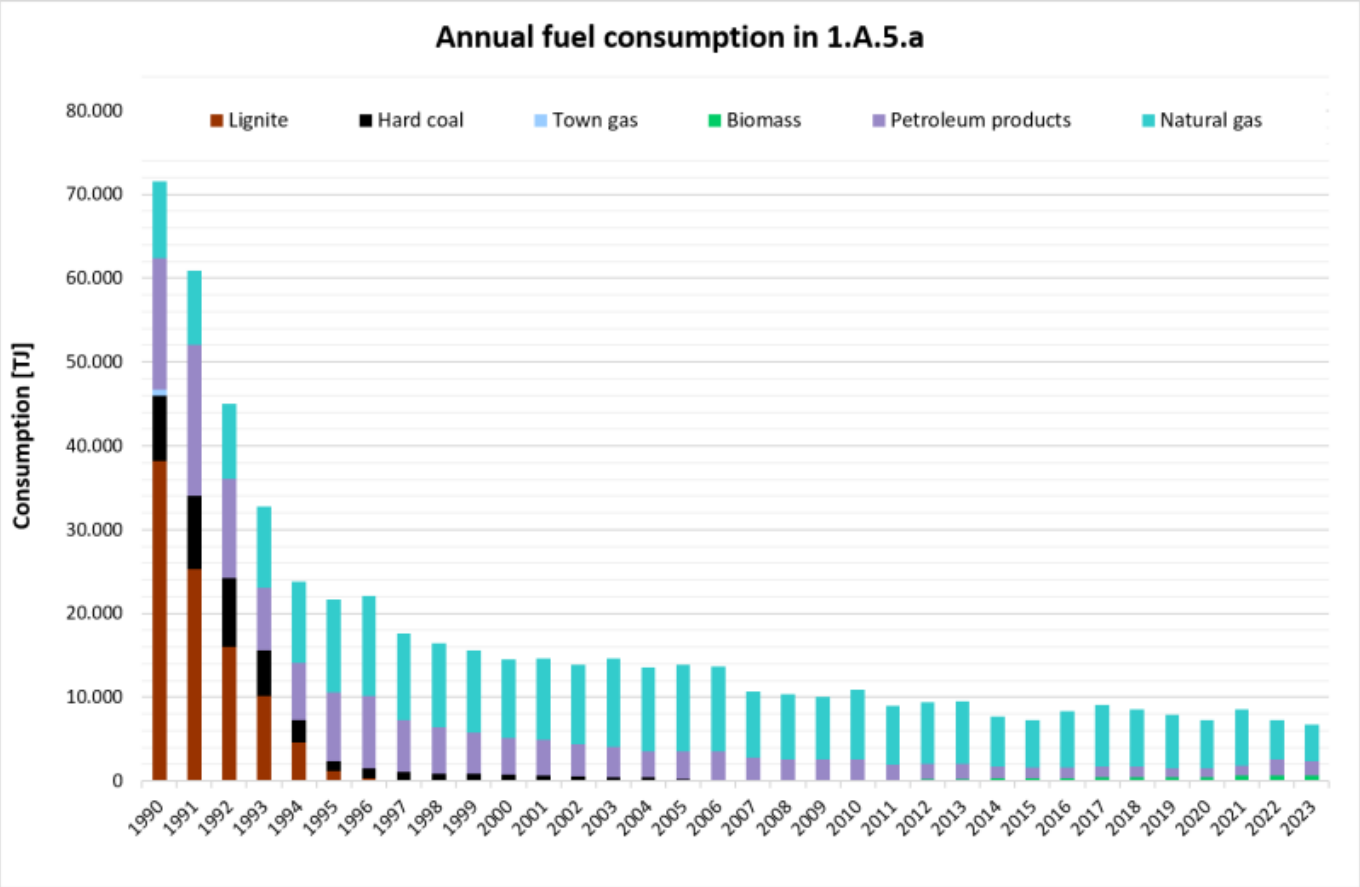
The National Energy Balance of the Federal Republic of Germany (NEB) provides the basis for the activity data used.

However, since 1995 the NEB does not provide separate listings of military agencies' final energy consumption. Instead, these data is included in NEB line 67: 'commerce, trade, services and other consumers'. Therefore, additional energy

statistics and fuel-specific data from the Federal Ministry of Defence (BMVg, 2020)[1)] is being used, providing the “Energy input for heat production in the German Federal Armed Forces” for all years as of 2000.

For liquid fuels, data is derived from the official mineral-oil data of the Federal Republic of Germany (Amtliche Mineralöldaten der Bundesrepublik Deutschland), compiled annually by the Federal Office of Economics and Export Control (BAFA, 2024) [2)]. The consumption figures given in units of [1000 t] are converted into [TJ] based on the relevant heating statistics published by the Working Group on Energy Balances.

All non-NEB figures are deducted from the figures in NEB line 67 (commerce, trade, services) and are reported in *1.A.5*, rather than in *1.A.4*.



Emission Factors

The database for the emission factors used for source category *1.A.5.a* consists of the results of a research project carried out by the University of Stuttgart, under commission to the Federal Environment Agency (Struschka et al., 2008)[3)]. Within this project, device-related and source-category-specific emission factors for combustion systems in military agencies were calculated, with a high level of detail, for all important emissions components for the reference year 2005. The method used to determine the factors conforms to that described for source category *1.A.4*. The following table shows the sectoral emission factors used.

Table 1: Emission factors for Military stationary combustion plants

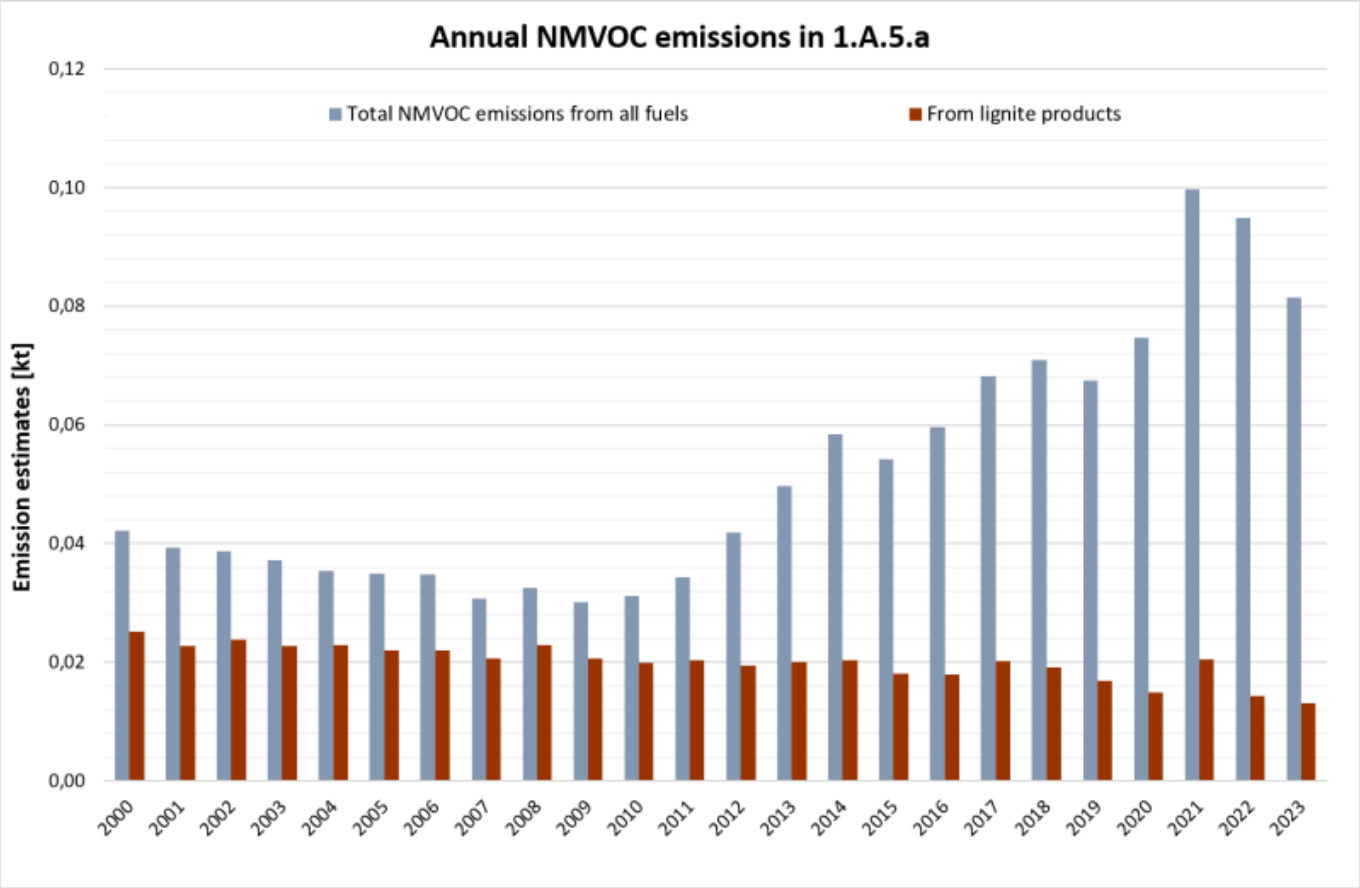
	NO_x	SO_x	NMVOC
	[kg/TJ]		
Hard coal	46	403	1
Brown coal briquettes	86	289	332
Light heating oil	46	77	2.8
Gaseous fuels	25	0.5	0.34

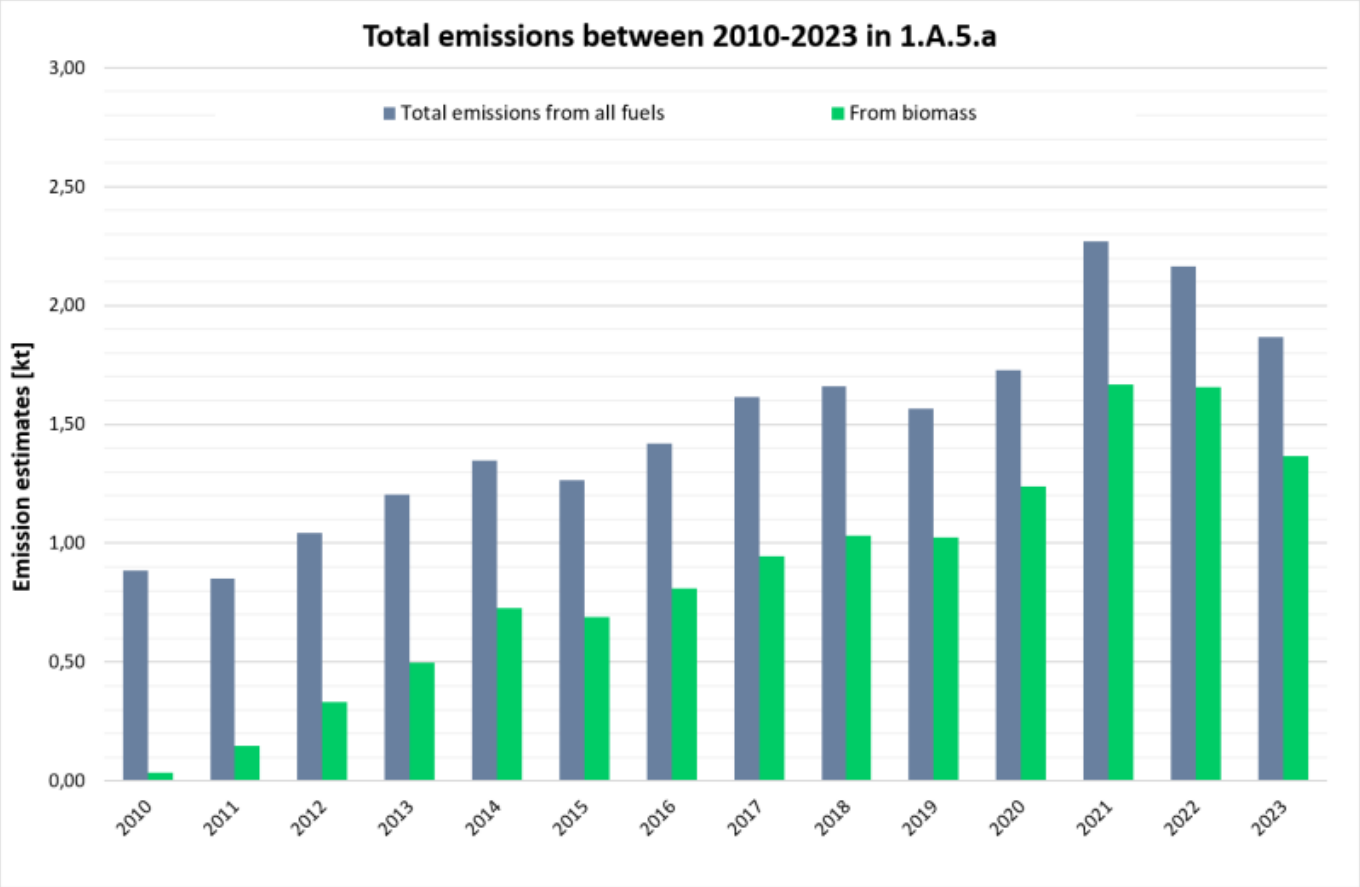
Trend discussion for key sources

NMVOC emissions show a remarkable declining trend with an overall reduction of 99.95% between 1990 and 2023 due to the closure of military agencies especially at the beginning of the 1990s as well as the reduced use of lignite for heating purposes (see activity data chart above).

However, since 2010, total emissions are increasing again on a very low level due to the increased use of biomass.

The following charts give an overview of the emission trends.





Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the energy balance for 2022 led to recalculations.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] BMVg (2020): Bundesministerium der Verteidigung: Energieeinsatz zur Wärmeversorgung der Bundeswehr, 2020 (unpublished).
[2)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.
[3)] Struschka et al. (2008): Struschka, Dr. M., Kilgus, D., Springmann, M.; Baumbach, Prof.Dr. Günter: Effiziente Bereitstellung aktueller Emissonsdaten für die Luftreinhaltung; UBA Forschungsbericht 205 42 322; https://www.umweltbundesamt.de/publikationen/effiziente-bereitstellung-aktueller-emissionsdaten; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008.

1.A.5.b - Other, Mobile (including Military)

Short description

In sub-category *1.A.5.b - Other, Mobile (including Military)* emissions from landbased, air- and waterborne military vehicles are reported.

NFR-Code	Name of Category	Method	AD	EF
1.A.5.b	**Other, Mobile (including Military)**	*see sub-category details*		
consisting of:				
1.A.5.b i	Land-based military transport and machinery	T1, T2	NS	CS, D
1.A.5.b ii	Military Aviation	T1, T2	NS	CS, D
1.A.5.b iii	Military Navigation	T1, T2, T3	NS, M	CS, D, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	PAHs	HCB	PCBs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	PAHs	HCB	PCBs

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

For further information on sub-sector specific consumption data, emission factors and emissions as well as further information on emission trends, recalculations and planned improvements, please follow the links above.

Methodology

Activity data

Basically, all fuel deliveries to the military are included in the primary fuel delivery data provided by the National Energy Balances (NEB) [1)]. As the NEB does not provide specific data for military use, the following additional sources are used:

Military land-based vehicles and aviation:

For the years as of 1995, the official mineral-oil data of the Federal Republic of Germany (Amtliche Mineralöldaten der Bundesrepublik Deutschland), prepared by the Federal Office of Economics and Export Control (BAFA), are used [2)]. Provided in units of [1000 t], these amounts have to be converted into [TJ] on the basis of the relevant net calorific values given by [3)].

As the official mineral-oil data does not distinguish into fossil and biofuels but does provide amounts for inland deliveries of total diesel and gasoline fuels, no data on the consumption of biodiesel and bioethanol is available directly at the moment. Therefore, activity data for biofuels used in military vehicles are calculated by applying Germany's official annual biofuel shares to the named total deliveries (see also: info on EF).

As there is no consistent NEB data availabe for aviation gasoline, delivery data from BAFA is applied for the entire time series.

Military navigation:

Primarilly, fuel deliveries to military navigation is included in the NEB data provided in NEB lines 6: 'International Deep-Sea Bunkers' and 64: 'Coastal and inland navigation' but cannot be derived directly. Therefore, starting with this submission, fuel

use in military navigation is estimated within a specific model used for estimating emissions from German maritime activities [4)].

Table 1: Sources for consumption data in 1.A.5.b

Mode of Military Transport	Specific AD included in:	Sources for specific data	Relevant years
Military ground vehicles and mobile machinery, military aviation	NEB line 67 - 'Commerce, Trade, Services and other Consumers'	Special evaluation 1990-1994 carried out by AGEB	1990 - 1994
		Official oil data, table 7j, column: 'An das Militär', [5)]	as of 1995
Military Navigation	NEB lines 6 - 'International Deep-Sea Bunkers' and 64 - 'Coastal and Inland Navigation'	AD estimated within [6)]	as of 1990

Table 2: Annual over-all fuel consumption in military vehicles and mobile equipment, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
DIESEL OIL	15,417	8,264	1,592	3,368	1,126	733	718	571	379	281	134	137	359	292
GASOLINE	21,508	9,800	7,477	6,838	4,790	3,300	2,969	2,464	2,305	2,273	1,771	1,923	2,082	2,076
BIODIESEL	NO	NO	NO	223	76.3	32.2	31.3	22.1	15.8	15.9	10.9	9.64	24.9	21.6
BIOGASOLINE	NO	NO	NO	47.4	186	133	121	104	100	93.7	79.4	90.6	96.5	98.0
JET KEROSENE	38,385	16,143	9,862	2,200	3,286	3,726	3,845	1,507	1,025	3,746	2,904	4,810	3,551	3,369
AVGAS	15.2	6.35	1.09	0.26	0.17	0.00	0.13	0.00	0.17	0.04	0.00	0.09	0,30	0.00
HEAVY FUEL OIL	152	104	90.4	67.4	59.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LIGHT FUEL OIL*	NO	NO	NO	NO	NO	NO	NO	NO	33.2	164	390	118	131	135
Σ 1.A.5.b	**75,477**	**34,317**	**19,022**	**12,743**	**9,524**	**7,925**	**7,685**	**4,667**	**3,858**	**6,574**	**5,289**	**7,089**	**6,244**	**5,991**
data sources: (BAFA, 2024) [7)]: Table 7j: “an das Militär” (“to the military”), (AGEB, 2024) [8)]: NEB line 6, and own estimates for blended biofuels														
* as of 2018: replacing diesel oil used in navigation (source: National Energy Balances)														

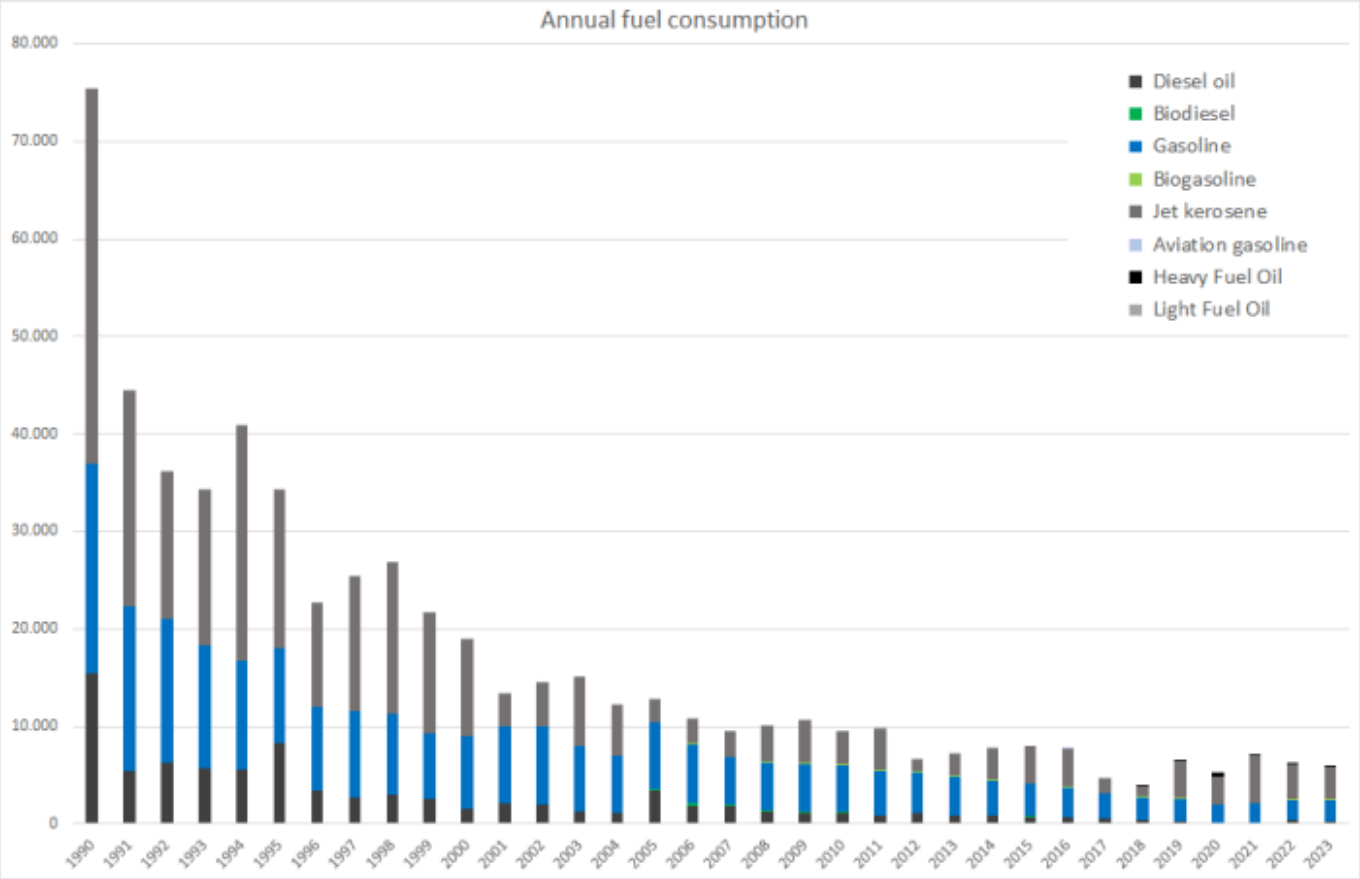
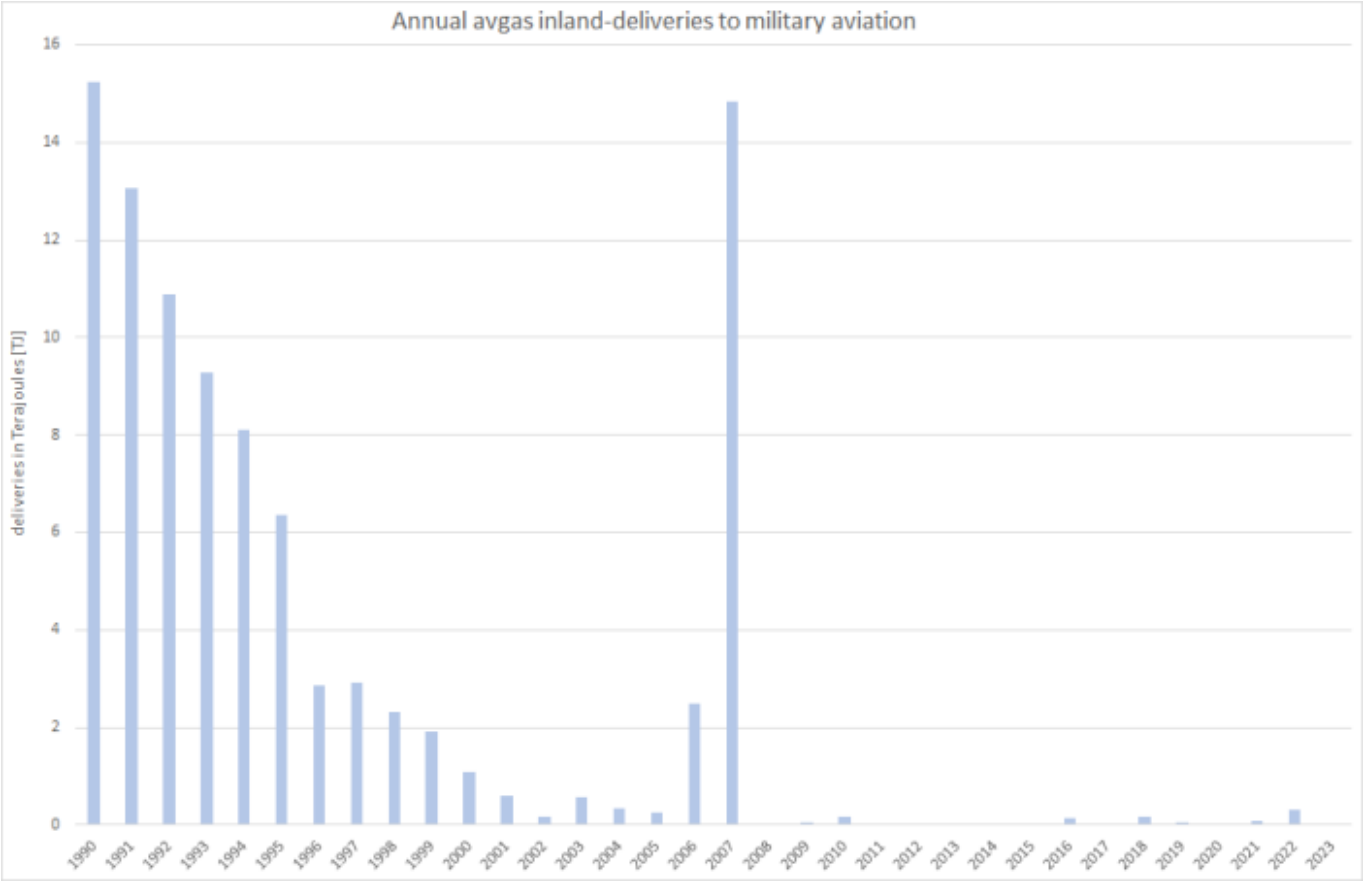


Table 3: Further break-down of annual military fuel consumption, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
used in military ground vehicles and machinery														
Diesel Oil	15,037	8,001	1,364	3,196	976	579	577	415	279	281	134	137	359	292
Biodiesel	NO	NO	NO	223	76.3	32.2	31.3	22.1	15.8	15.9	10.9	9.64	24.9	21.6
Gasoline	21,508	9,800	7,477	6,838	4,790	3,300	2,969	2,464	2,305	2,273	1,771	1,923	2,082	2,076
Biogasoline	NO	NO	NO	47.4	186	133	121	104	100	93.7	79.4	90.6	96.5	98.0
used in military aircraft														
Jet Kerosene	38,385	16,143	9,862	2,200	3,286	3,726	3,845	1,507	1,025	3,746	2,904	4,810	3,551	3,369
Aviation Gasoline	15.2	6.35	1.09	0.26	0.17	0.00	0.13	0.00	0.17	0.04	0.00	0.09	0.30	0.00
used in military navigation														
Diesel Oil	380	263	228	171	150	154	141	156	99.5	NO	NO	NO	NO	NO
Light Fuel Oil*	NO	NO	NO	NO	NO	NO	NO	NO	33.2	164	390	118	131	135
Heavy Fuel Oil	152	104	90.4	67.4	59.0	NO	NO	NO	NO	NO	NO	NO	NO	NO
Σ 1.A.5.b														
all types of fuels applied	**75,477**	**34,317**	**19,022**	**12,743**	**9,524**	**7,925**	**7,685**	**4,667**	**3,858**	**6,574**	**5,289**	**7,089**	**6,244**	**5,991**
data sources: (BAFA, 2024) [9]: Table 7j: “an das Militär” (“to the military”), (AGEB, 2024) [10]: NEB line 6, and own estimates for blended biofuels														
* as of 2018: replacing diesel oil used in navigation (source: National Energy Balances)														

As the “consumption data” provided here originally represents fuel delivery data, some trends in “annual consumption” are influenced by stock-keeping activities. Here, a clear impact of storage effects can be observed for avgas, where a significantly high amount of 15 TJ was purchased in 2007 followed by zero or very small deliveries.



Furthermore, based upon expert information, no biodiesel or heavy fuel oil is used in national military navigation.

Emission factors

For further information on sub-sector specific emission factors, please refer to the sub-chapters on ground-based , airborne and naval military activities.

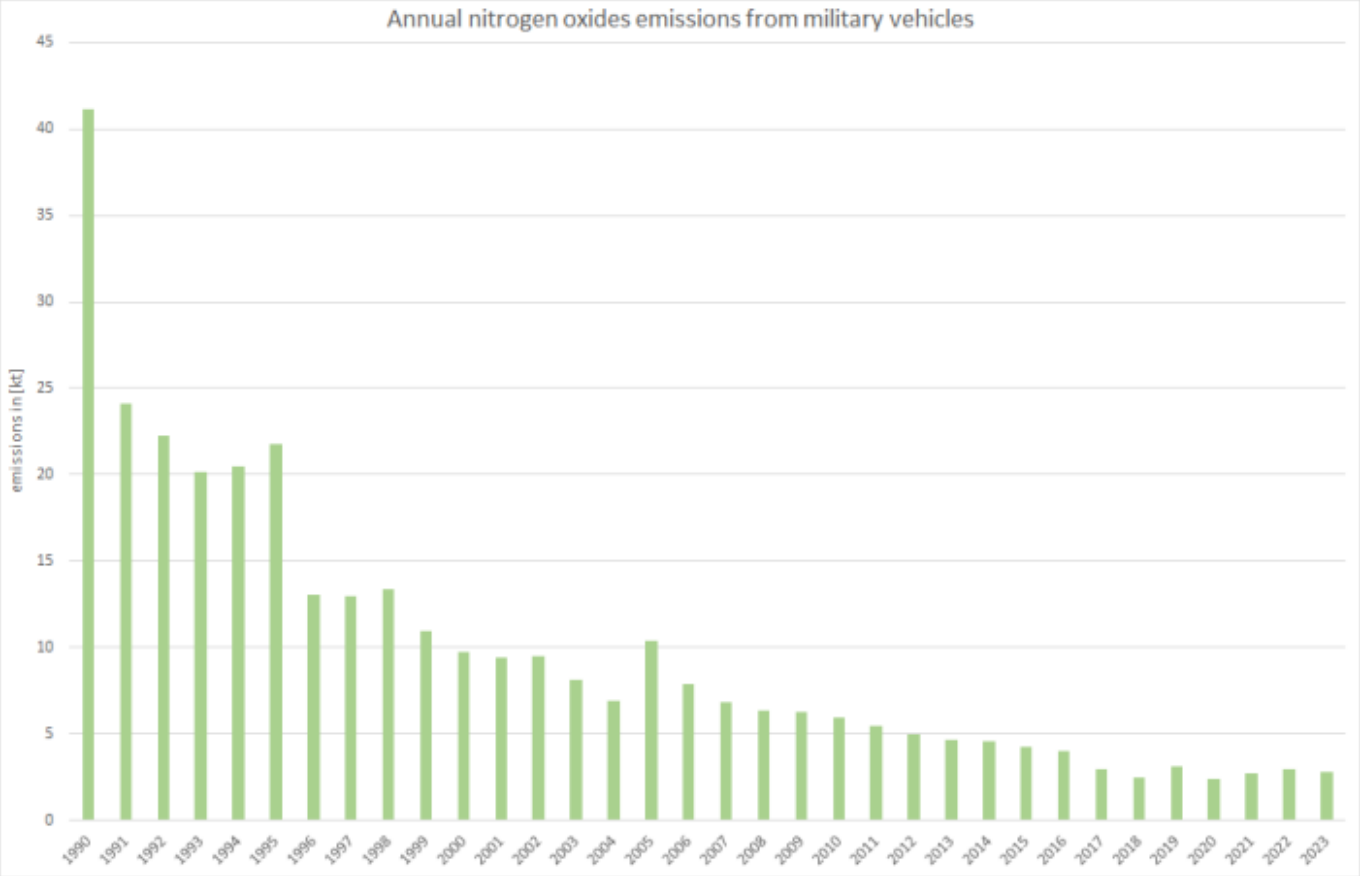
Discussion of emission trends

Table: Outcome of Key Category Analysis

for:	**NO_x**
by:	Trend

Here, due to the tier1 emission factors applied, annual emissions strongly correspond with activity data, therefore showing strong decline after 1990 and an ongoing downward trend.

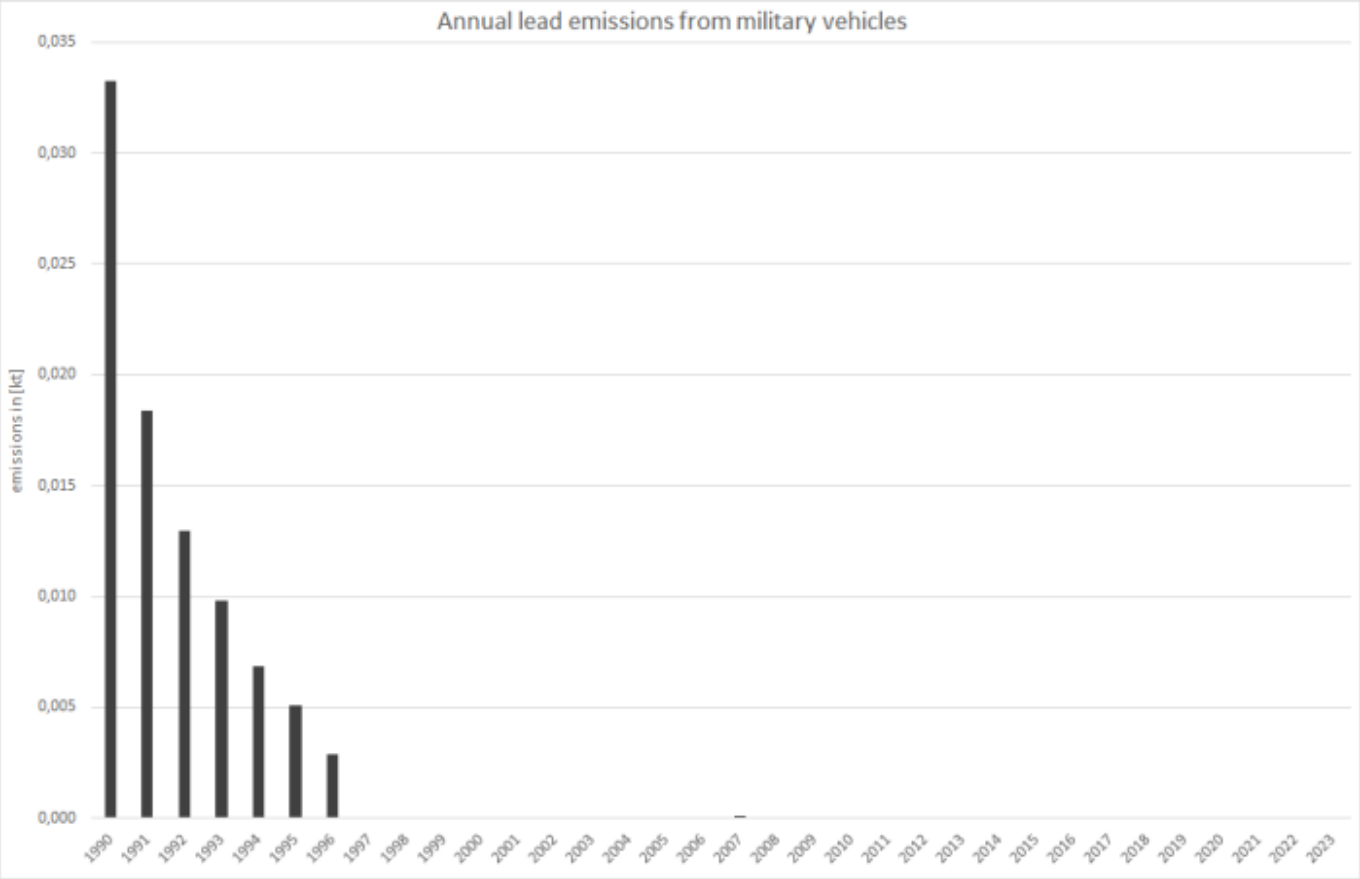
Regarding the peak in NO_x emissions 2005: The dominating source of NO_x (and PM) emissions is the use of diesel oil in militar ground vehicles and machinery as well as military vessels. Here, the underlying activity data (annual diesel oil inland deliveries) for 2005 are well above the values of previous and following years but cannot be revised in a sensible way.



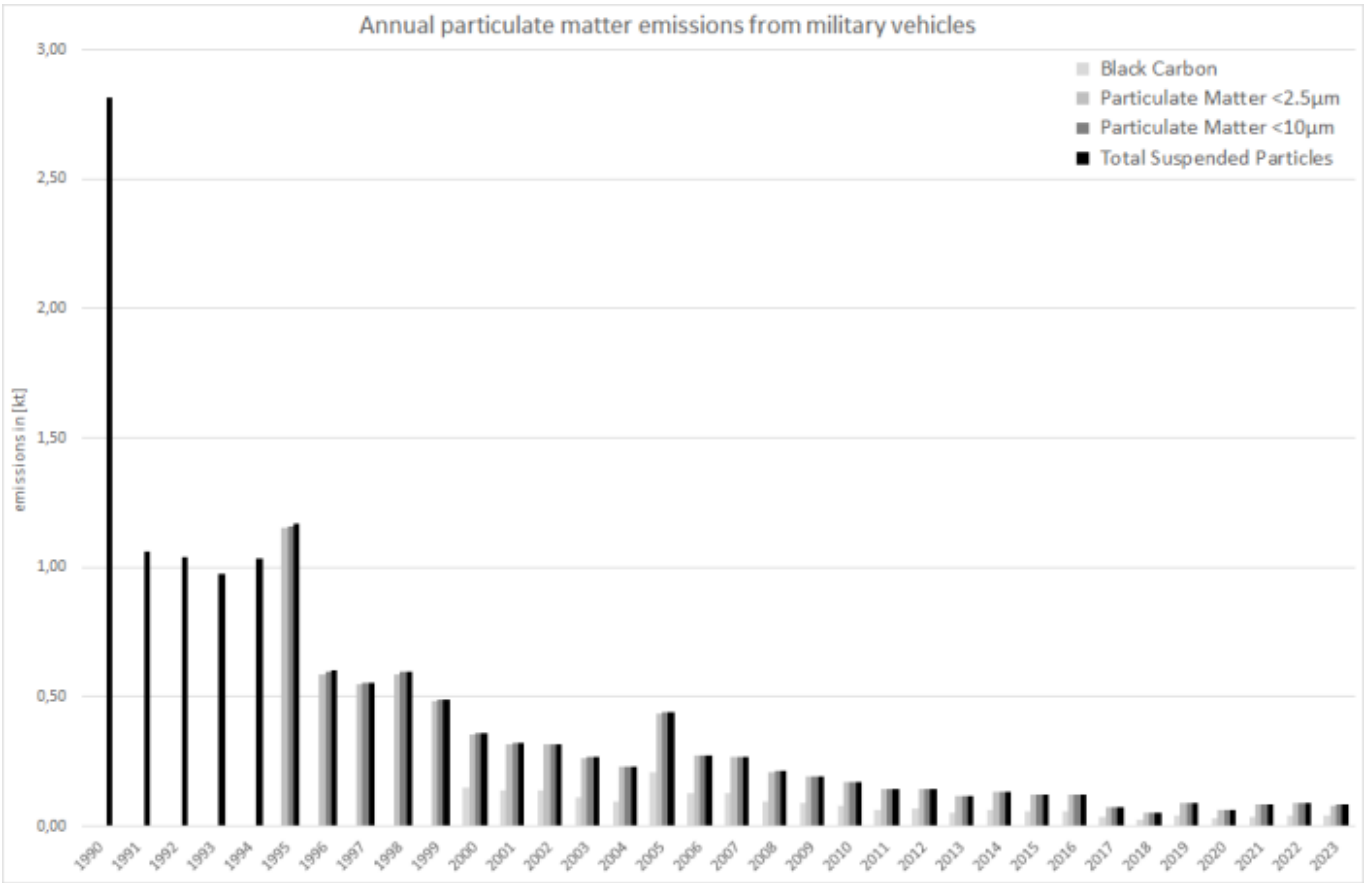
Furthermore, this NFR category shows interesting trends for emissions of **Lead (Pb)** from leaded gasoline (until 1997) and aviation gasoline:

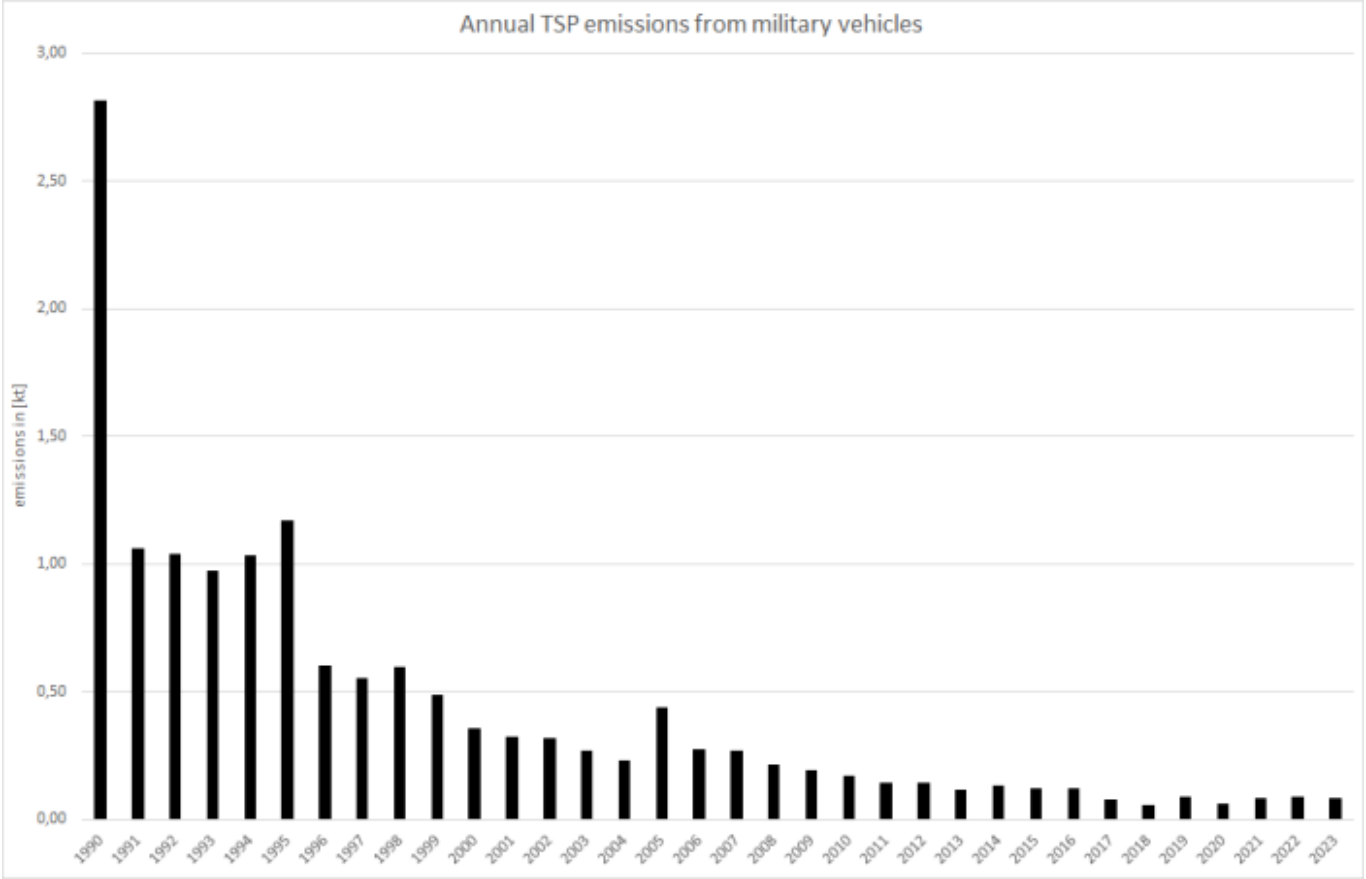
Until 1997, lead emissions were dominated by the combustion of leaded gasoline in military ground-based vehicles. Therefore, the over-all trend for lead emissions from military vehicles and aircraft is driven mostly by the abolition of leaded gasoline in 1997. Towards this date, the amount of leaded gasoline decreased significantly. After 1997, the only source for

lead from mobile fuel combustion is avgas used in military aircraft. As for avgas, the trend of consumption is more or less drecreasing steadily until 2005 but then shows a strong increase for 2006 and '07 (!), followed by no or very small deliveries. As mentioned above, there are no real consumption data available: AD is based on fuel deliveries to the military only. Thus, especially the trends for the use of aviation gasoline and the resulting emissions show this siginificant jumps in 2006 and 07. The party is aware of this issue and will try to solve it as soon as data allows. (see also: FAQ)

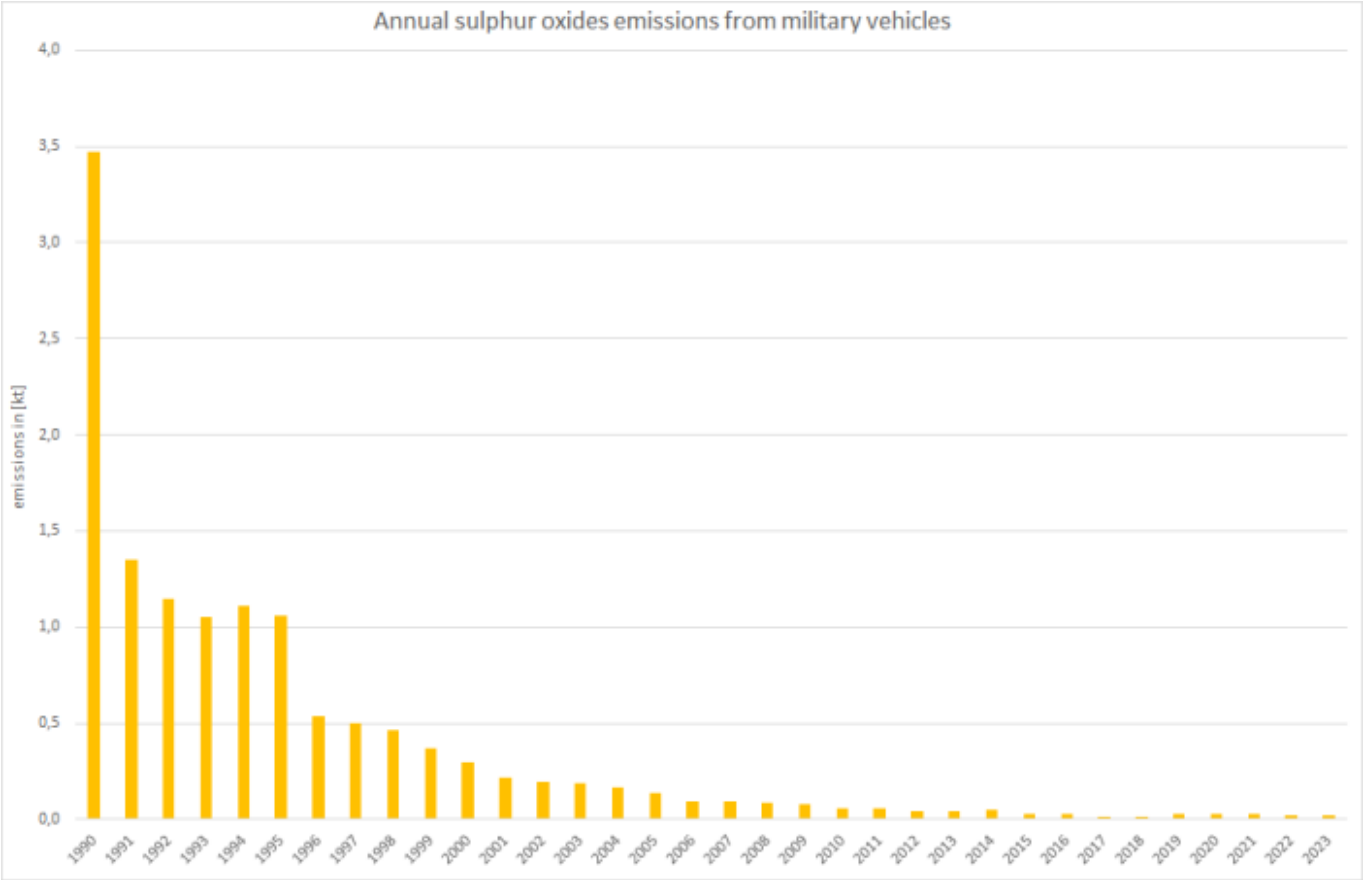


The trend for **TSP** emissions reflects the impact of leaded gasoline at least for 1990 to 1997. For all other years, **particulate matter** emissions simply follow the trend in over-all fuel consumption. Here, as already explained for NO_x, the increased 2005 emissions result form a corresponding jump in inland diesel-oil deliveries (see information on annual activity data above).





Regarding **sulphur dioxide**, emssions not only reflect the trend of fuel consumption but also the impact of fuel-sulphur legislation.



For all other reported pollutants, due to the application of tier1 emission factors, emission trends reported for this sub-category only reflect the trend in fuel deliveries.

Recalculations

Recalculations against last year's submission occur mainly due to the revision of the underlying National Energy Balances (NEB) 2003 to 2021 and here especially the heating values for gasoline fuels and the inland deliveries of diesel oil to maritime shipping as provided in line 6 of the NEB.

Furthermore, but with no impact on emission estimates, diesel oil and light fuel oil used in maritime shipping is reported separately for the first time.

Table: Revised activity data 2022, in terajoules [TJ]

	Diesel Oil	Biodiesel	Gasoline	Biogasoline	Jet Kerosene	AvGas	Heavy Fuel Oil	Light Fuel Oil	Σ 1.A.5.b
current submission	359	24.9	2,082	96.5	3,551	0,30	0.00	131	**6,244**
previous submission	148	10.3	2,042	94.6	3,551	0,30	0.00	131	**5,976**
absolute change	211	14.6	39.9	1.85	0.00	0.00	0.00	0.00	**268**
relative change	143%	143%	1.95%	1.95%	0.00%	0.00%		0.00%	**4.48%**

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by Knörr et al. (2009) [11)].

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

Planned improvements

With respect to NFR 1.A.5.b as such, no overarching improvements are planned. For further information on possible sub-sector specific improvements, please follow the links above.

[1), 3), 8), 10)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-1990-bis-2030/?wpv-jahresbereich-bilanz=2021-2030, (Aufruf: 12.12.2024), Köln & Berlin, 2024

[2), 5), 7), 9)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2022_12.xlsx?__blob=publicationFile&v=4, Eschborn, 2024.

[6)] Deichnik (2024): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs. from Bundesamts für Seeschifffahrt und Hydrographie (BSH); on behalf of the Umweltbundesamt, Hamburg / Dessau-Roßlau, 2024.

[11)] Knörr et al.(2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

1.A.5.b i - Military Ground Vehicles and Vehicles

Short description

In sub-category *1.A.5.b i - Other, Mobile (including Military)* emissions from military ground-vehicles and mobile machinery are reported.

Method	AD	EF	Key Category Analysis
T1, T2	NS	CS, D	see superordinate chapter

Methodology

Activity data

Basically, all fuel consumption in military vehicles is included in the primary acitivity data provided by the National Energy Balances (NEB) (AGEB, 2024) [1)].

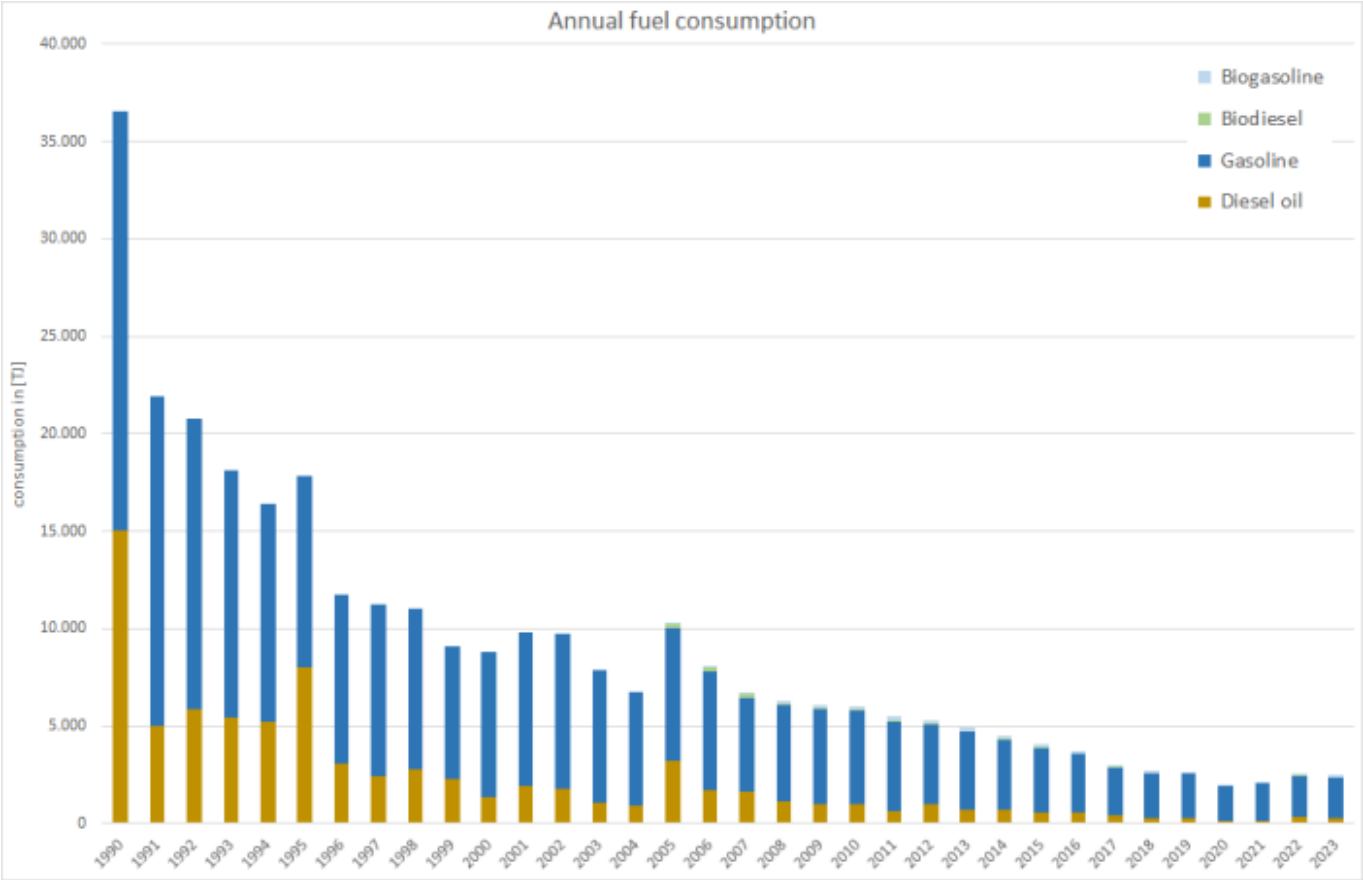
As the NEB does not provide specific data for military use, the following additional sources are used:

For the years as of 1995, the official mineral-oil data of the Federal Republic of Germany (Amtliche Mineralöldaten der Bundesrepublik Deutschland), prepared by the Federal Office of Economics and Export Control (BAFA), are used (BAFA, 2024) [2)]. Provided in units of [1,000 t], these amounts have to be converted into [TJ] on the basis of the relevant net calorific values given by [3)].

As the official mineral-oil data does not distinguish into fossil and biofuels but does provide amounts for inland deliveries of total diesel and gasoline fuels, no data on the consumption of biodiesel and bioethanol is available directly at the moment. Therefore, activity data for biofuels used in military vehicles are calculated by applying Germany's official annual biofuel shares to the named total deliveries (see also: info on EF).

Table 1: Annual fuel deliveries to the military for ground-vehicles and machinery, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel Oil	15,037	8,001	1,364	3,196	976	579	577	415	279	281	134	137	359	292
Biodiesel	21,508	9,800	7,477	6,838	4,790	3,300	2,969	2,464	2,305	2,273	1,771	1,923	2,082	2,076
Gasoline	0	0	0	223	76	32.2	31.3	22.1	15.8	15.9	10.9	9.64	24.9	21.6
Biogasoline	0	0	0	47.4	186	133	121	104	100	93.7	79.4	90.6	96.5	98.0
Σ 1.A.5.b i	**36,545**	**17,801**	**8,841**	**10,304**	**6,028**	**4,044**	**3,699**	**3,005**	**2,700**	**2,663**	**1,995**	**2,160**	**2,562**	**2,487**



Emission factors

Table 2: Annual country-specific emission factors[1], in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
DIESEL FUELS														
NH_3	4.00													
NMVOC	316	274	274	274	274	274	274	274	274	274	274	274	274	274
NO_x	1,195	1,360	1,360	1,360	1,360	1,360	1,360	1,360	1,360	1,360	1,360	1,360	1,360	1,360
SO_x	125	60.5	14.0	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
PM^2	53.0	53.0	53.0	53.0	53.0	53.0	53.0	53.0	53.0	53.0	53.0	53.0	53.0	53.0
BC^3	134	100	100	100	100	100	100	100	100	100	100	100	100	100
CO	515	350	350	350	350	350	350	350	350	350	350	350	350	350
GASOLINE FUELS														
NH_3	4.00													
NMVOC	594	373	373	373	373	373	373	373	373	373	373	373	373	373
NO_x	682	725	725	725	725	725	725	725	725	725	725	725	725	725
SO_x	11.8	8.30	3.20	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
PM^2	3.63	3.55	3.13	2.66	2.14	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91
BC^3	0.44	0.43	0.38	0.32	0.26	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
CO	4,199	4,010	4,010	4,010	4,010	4,010	4,010	4,010	4,010	4,010	4,010	4,010	4,010	4,010
TSP^4	2.46	0.82	NA											
Pb^4	1.54	0.52	NA											

[1] Due to lack of better information: similar EF are applied for fossil fuels and biofuels.
[2] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP from diesel oil combustion consists of $PM_{2.5}$)
[3] EF(BC) estimated from tier1 default f-BC values provided in [4], chapter 1.A.3.b, table 3-11 for gasoline passenger cars (f-BC: 0.12) and diesel heavy duty vehicles (f-BC: 0.53)
[4] from leaded gasoline (until 1997), based on country-specific emission factors from TREMOD [5]

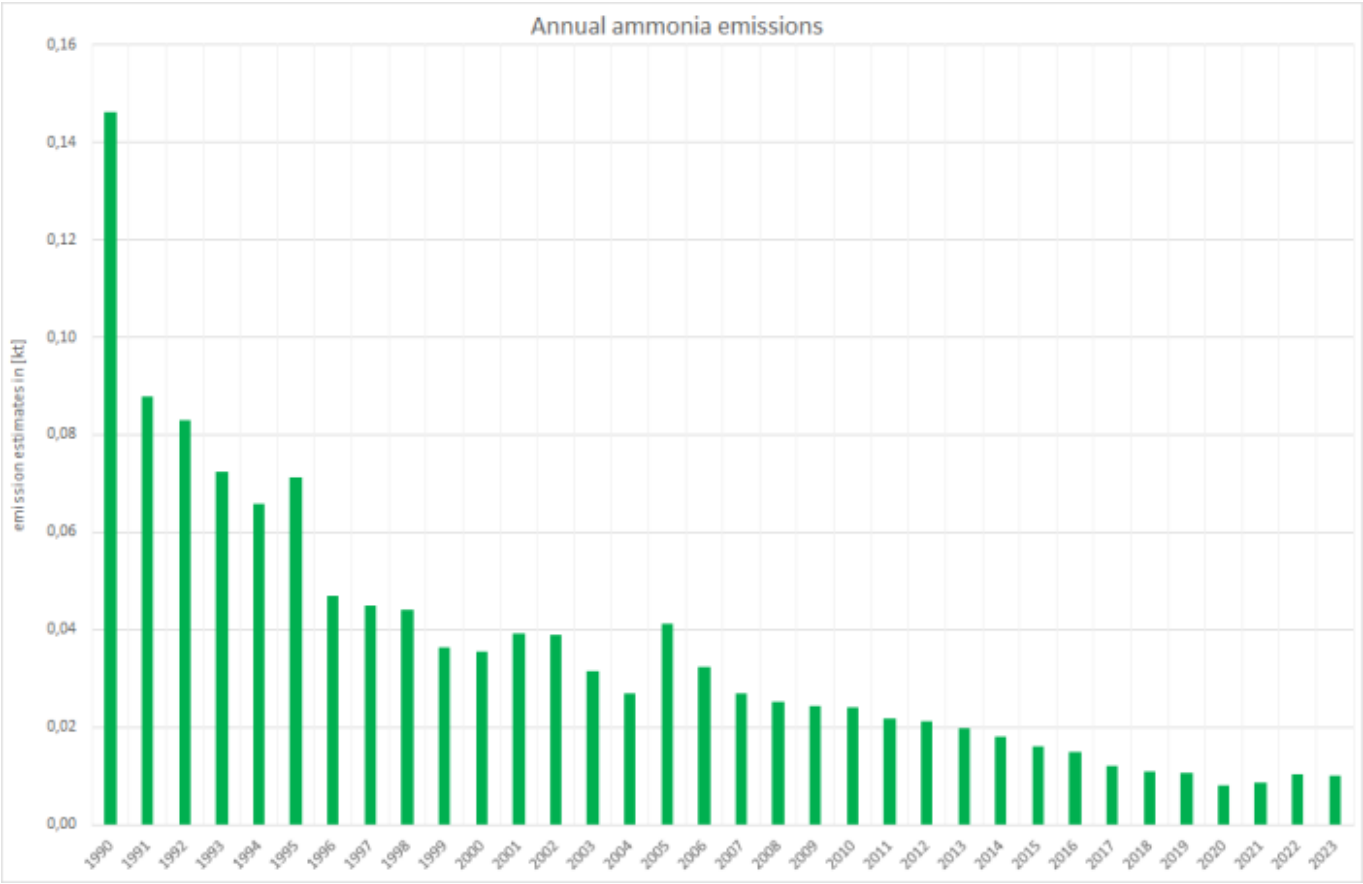
With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [11)]

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Discussion of emission trends

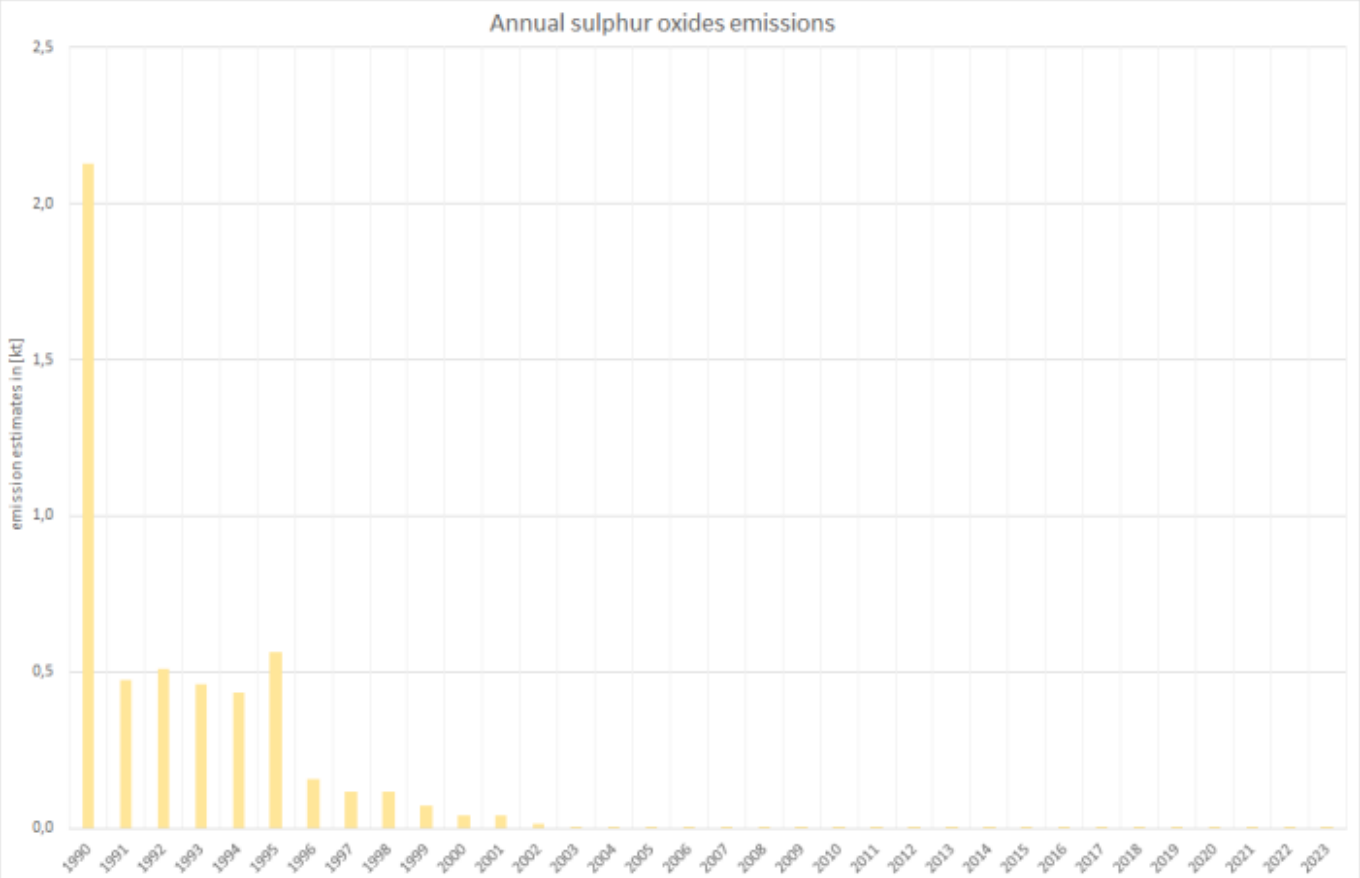
As only NFR 1.A.5.b as a whole is taken into account within the key category analysis, this country-specific sub-sector is not considered separately.

Due to the application of very several tier1 emission factors, most emission trends reported for this sub-category only reflect the trend in fuel deliveries. Therefore, the fuel-consumption dependend trends in emission estimates are only influenced by the annual fuel mix.



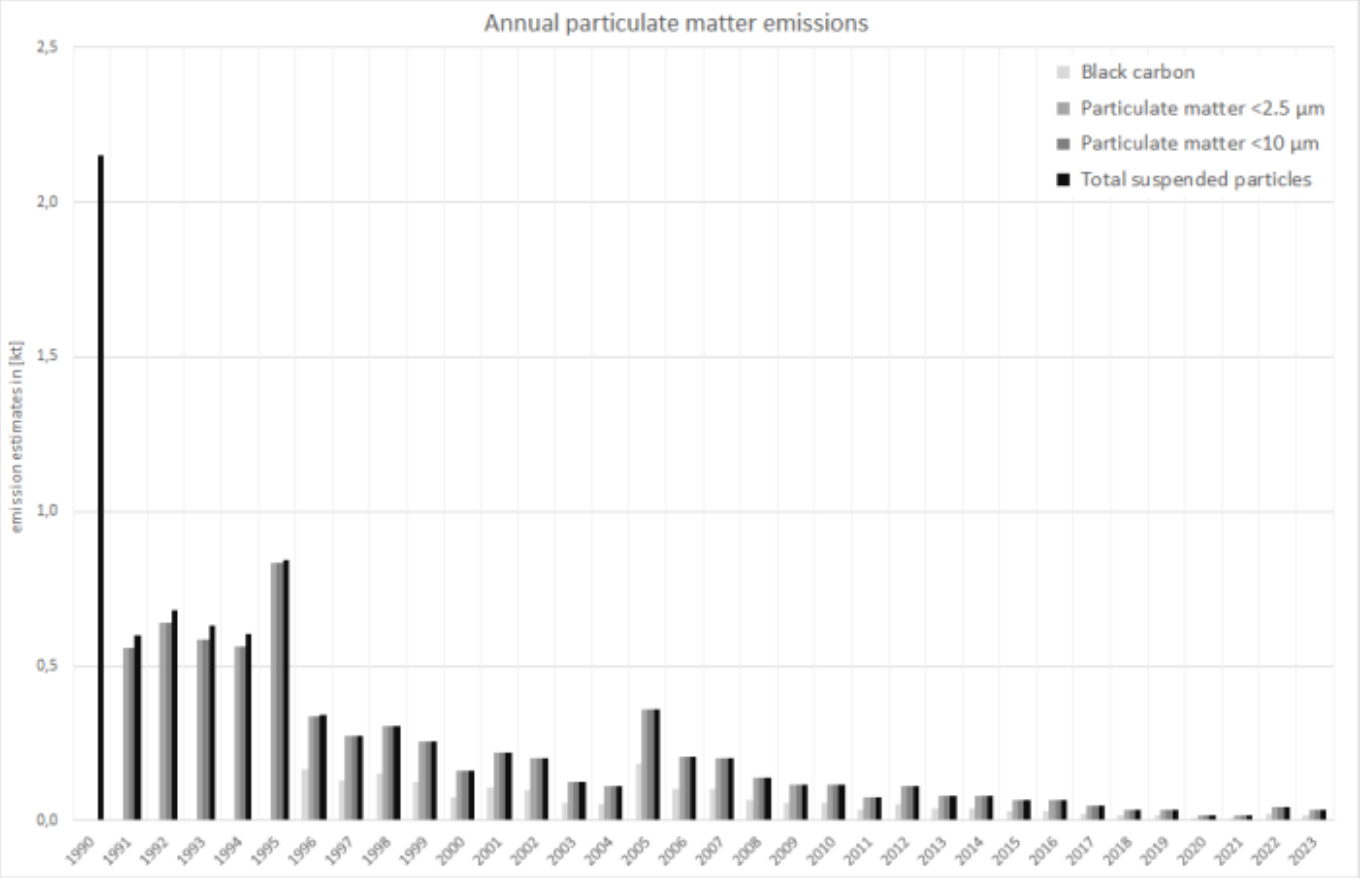
Here, diesel oil deliveries data show a peak in 2005 resulting in emission estimates well above the values of previous and following years. Due to the applied approach, the resulting outliers especially for NO_x and PM emissions have already been looked into in several NEC and CLRTAP Reviews. However, given the underlying activity data, the noticeable emission estimates cannot be revised in a sensible way.

Here, for **sulphur dioxide**, this consumption-based falling trend is intensified by the impact of fuel-sulphur legislation.



Over-all **particulate matter** emissions are dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption. Here, until 1997, the emission values reported for **total suspended particles (TSP)** are slightly higher than those reported for $PM_{2.5}$ and PM_{10} due to the additional TSP emissions from leaded gasoline that was banned in 1997.

Regarding the peak in PM emissions 2005: The dominating source of particulate matter (and NO_x) emissions is the use of diesel oil in militar ground vehicles and machinery as well as military vessels. Here, the underlying activity data (annual diesel oil inland deliveries) for 2005 are well above the values of previous and following years but cannot be revised in a sensible way.



Recalculations

For information on revised inventory data, please see the superordinate chapter.

Planned improvements

Given the limited quality of the emission factors applied, the inventory compiler will check a possible revision at least for the main pollutants.

FAQs

[1)] AGEB (2024): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

[2)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.

[3)] AGEB (2022b): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Zusatzinformationen - Heizwerte der Energieträger und Faktoren für die Umrechnung von spezifischen Mengeneinheiten in Wärmeinheiten (2005-2020); URL: https://ag-energiebilanzen.de/wp-content/uploads/2022/04/Heizwerte2005bis2020.pdf, (Aufruf: 13.03.2023) Köln & Berlin, 2022.

[4)] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019.

[5)] Knörr et al. (2022b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery

(TREMOD MM) 2024, Heidelberg, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2024.

[11)]

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.A.5.b ii - Military Aviation

Short description

In sub-category *1.A.5.b ii - Other, Mobile (including Military)* emissions from military aviation are reported.

Method	AD	EF	Key Category Analysis
T1	NS	CS, D	see superordinate chapter

Methodology

Activity data

The Energy Balance of the Federal Republic of Germany (AGEB) provides the basis for the activity data used. Since the Energy Balance does not provide separate listings of military agencies' final energy consumption as of 1995 – and includes this consumption in line 67, under “commerce, trade, services and other consumers” – additional sources of energy statistics had to be found for source category 1.A.5.

For source category 1.A.5.b, consumption data for **kerosene**, until 1995, were drawn from a special analysis of the Working Group on Energy Balances (AGEB).

For the years as of 1995, the official mineral-oil data of the Federal Republic of Germany (Amtliche Mineralöldaten der Bundesrepublik Deutschland 2012), prepared by the Federal Office of Economics and Export Control (BAFA), are used (BAFA, 2024) [1)]. Provided in units of 1,000 tonnes [kt], these amounts have to be converted into terajoules [TJ] on the basis of the relevant net calorific values given by (AGEB, 2022b) [2)].

As there is no consistent AGEB data availabe for **aviation gasoline**, delivery data from BAFA is used.

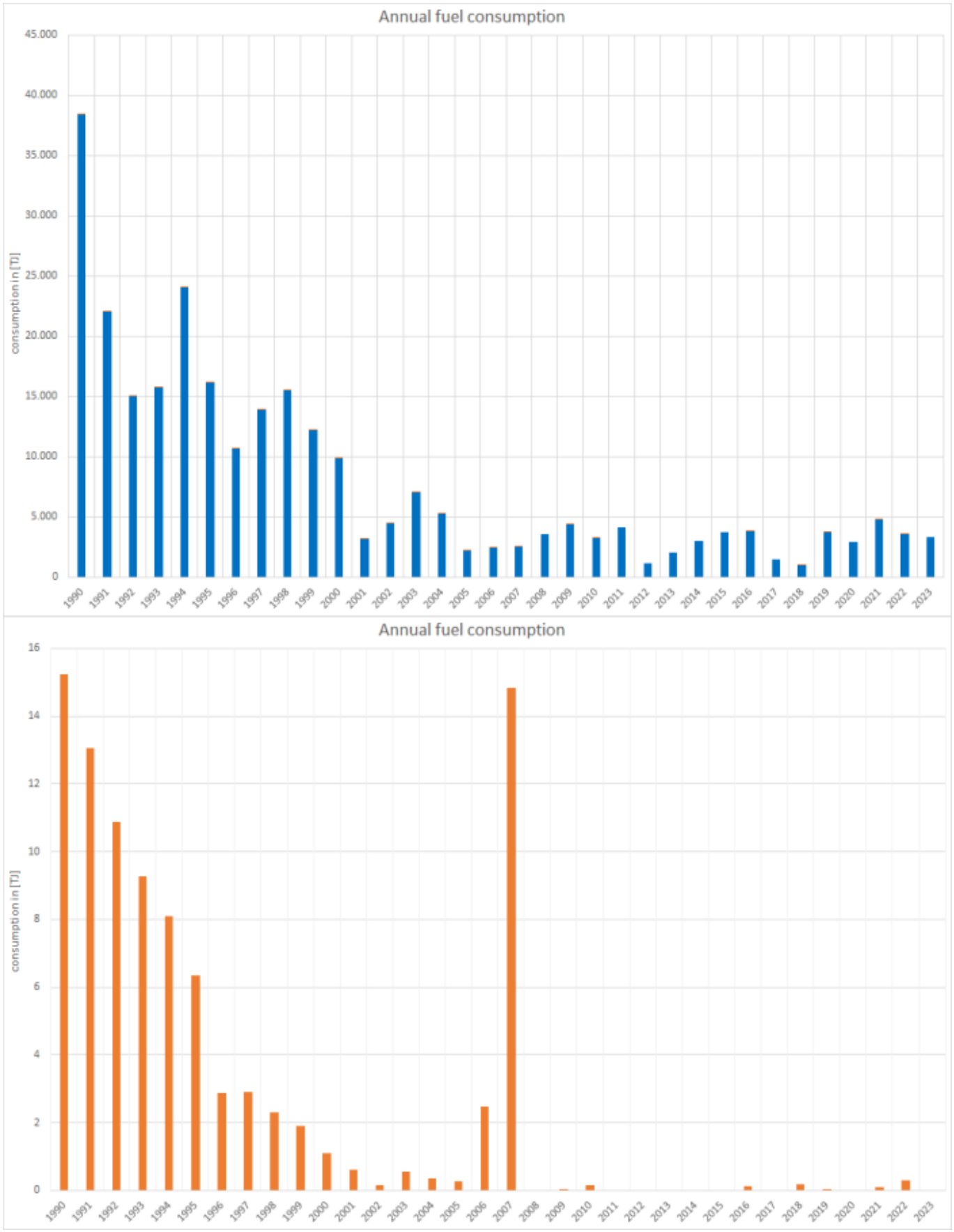
Table 1: Sources for consumption data in 1.A.5.b

Relevant years	Data Source
through 1994	**AGEB** - Special evaluation 1990-1994
since 1995	**BAFA** - Official oil data, table 7j, column: 'An das Militär'

Table 2: Annual fuel consumption in military aviation, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jet Kerosene	38,385	16,143	9,862	2,200	3,286	3,726	3,845	1,507	1,025	3,746	2,904	4,810	3,551	3,369
Aviation Gasoline	15.2	6.35	1.09	0.26	0.17	0.00	0.13	0.00	0.17	0.04	0.00	0.09	0.30	0.00
Σ 1.A.5.b ii	**38,400**	**16,149**	**9,863**	**2,200**	**3,286**	**3,726**	**3,845**	**1,507**	**1,025**	**3,746**	**2,904**	**4,810**	**3,551**	**3,369**

[1] possible reason for jumps in delivered amounts: storage (resulting in no (2008, 2011+) or very small deliveries (2009) (see also: FAQs)



Emission factors

Without better information, constant tier1 values are used mainly (see table below).

NOTE: As the aircraft used for military purposes differ strongly from those used in civil aviation, the country specific EF used for kerosene in 1.A.3.a could not be used for reporting emissions from 1.A.5.b as well. Therefore, and due to missing

information on the technical developments within the military aircraft fleet, the EF values applied show no trend.

Table 3: Country-specific emission factors, in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
JET KEROSENE														
NH_3	4.00													
NMVOC	98.0													
NO_x	205													
SO_x	25.1	15.2	8.46	6.34	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65	4.65
BC[1]	5.76													
PM[2]	12.0													
CO	485													
AVIATION GASOLINE														
NH_3	NE													
NMVOC	300													
NO_x	302													
SO_x	0.51													
BC[1]	1.10													
PM[2]	7.50													
TSP[3]	22.7													
CO	15,000													

[1] estimated via a f-BCs (avgas: 0.15, jet kerosene: 0.48) as provided in the EMEP/EEA GB 2023 in Table A3.2 - Tables in this chapter of the guidebook that contain f-BC fraction data [3)]
[2] EF($PM_{2.5}$) also applied for PM_{10}, and TSP (assumption: > 99% of TSP from diesel oil combustion consists of $PM_{2.5}$)
[3] TSP from leaded aviation gasoline = EF(Pb) x 1.6 (see also: FAQs)

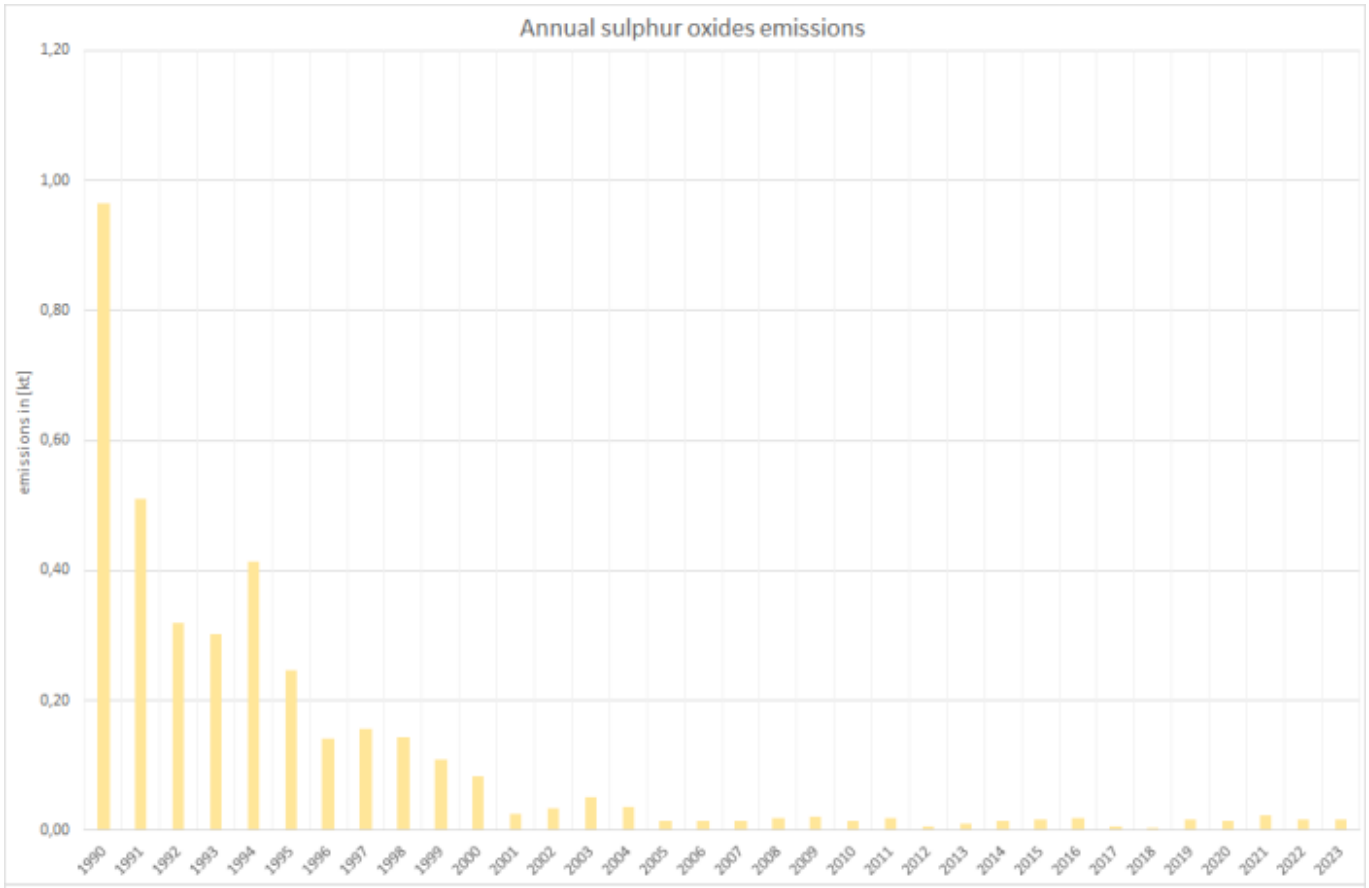
For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

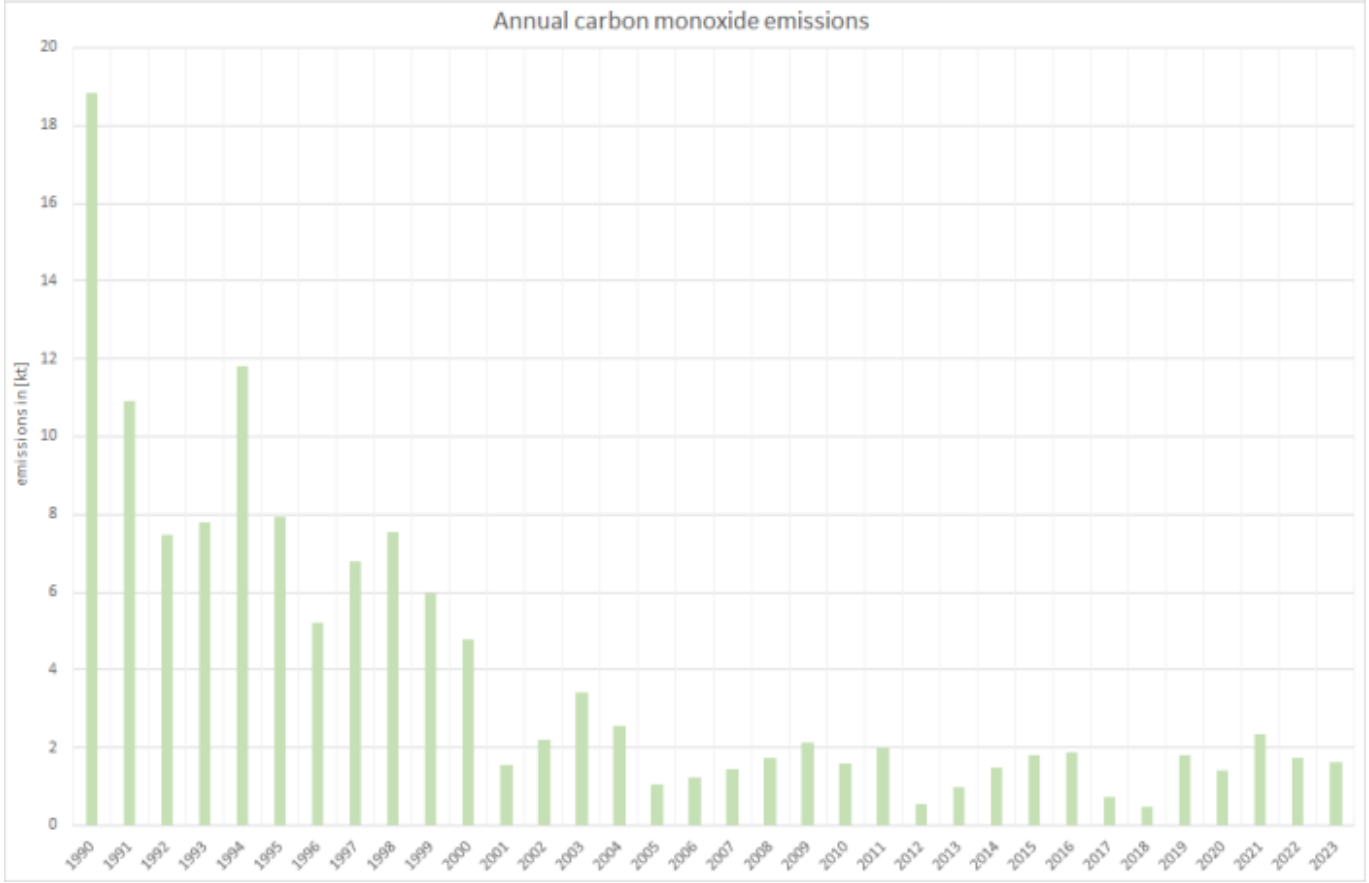
For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources. - Here, regarding lead and TSP from leaded avgas, constant tier1 EFs based on the average lead content of AvGas 100 LL are used.

Discussion of emission trends

As only NFR 1.A.5.b as a whole is taken into account within the key category analysis, this country-specific sub-sector is not considered separately.

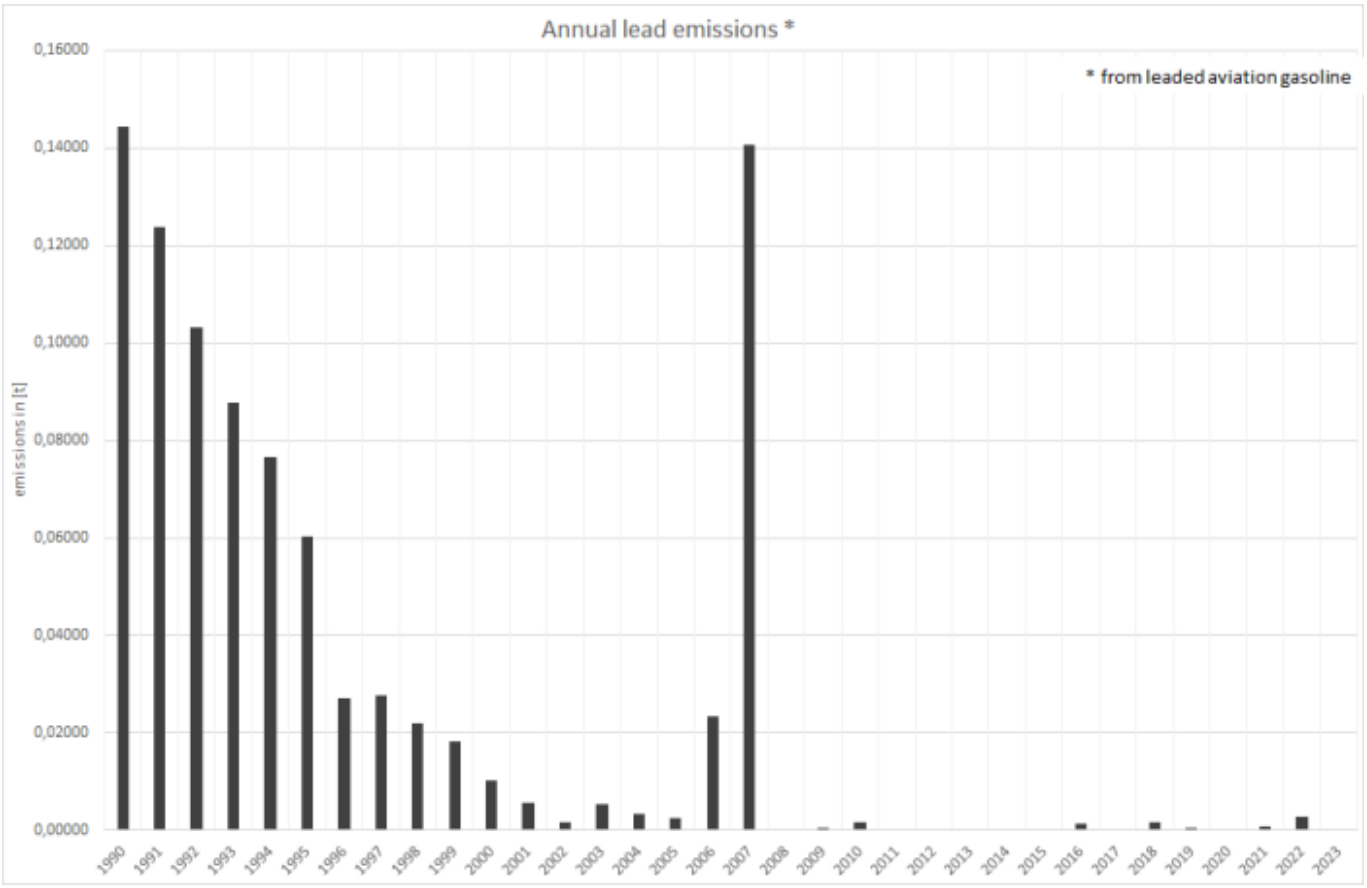
Due to the application of very several tier1 emission factors, most emission trends reported for this sub-category only reflect the trend in fuel deliveries. Therefore, the fuel-consumption dependend trends in emission estimates are only influenced by the annual fuel mix.





Here, as the EF(BC) are estimated via fractions provided in [4], black carbon emissions follow the corresponding emissions of $PM_{2.5}$.

Nonetheless, this NFR category shows interesting trends for emissions of **Lead (Pb)** from leaded gasoline (until 1997) and aviation gasoline:



Until 1997, lead emissions were dominated by the combustion of leaded gasoline in military ground-based vehicles. Therefore, the over-all trend for lead emissions from military vehicles and aircraft is driven mostly by the abolition of leaded gasoline in 1997. Towards this date, the amount of leaded gasoline decreased significantly. After 1997, the only source for lead from mobile fuel combustion is avgas used in military aircraft. As for avgas, the trend of consumption is more or less drecreasing steadily until 2005 but then shows a strong increase for 2006 and '07 (!), followed by no (2008 and 2011) or very small deliveris (2009, 2010). As mentioned above, there are no real consumption data available: AD is based on fuel deliveries to the military only. Thus, especially the trends for the use of aviation gasoline and the resulting emissions show this siginificant jumps in 2006 and 07, falling back to zero in 2008 and 2011ff. The party is aware of this issue and will try to solve it as soon as data allows. (see also: FAQ)

Recalculations

For information on revised inventory data, please see the superordinate chapter.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland”. For detailled information, please refer to the project's final report [https://www.umweltbundesamt.de/publikationen/ermittlung-unsicherheiten-den-modellen-tremod here] (German version only!).

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

Planned improvements

There are no specific improvements planned at the moment.

FAQs

What is the reason for the big jumps in the consumption of aviation gasoline in 2006 & '07 and the zero-consumption in 2008?

As mentioned above, consumption is deducted from AGEB and BAFA data on the amounts of fuels delivered to the sector. Therefore, the big jumps reported for 2006 & '07 might result from the storage of aviation gasoline in military stocks. Consequentially, the 0.00 TJ reported for 2008 show the missing of any deliveries to the military and should not be misunderstood as a non-use. The party is aware of this issue and will try to solve it as soon as data allows.

On which basis does the party estimate the reported lead emissions from aviation gasoline?

assumption by party: aviation gasoline = AvGas 100 LL (AvGas 100 LL is the predominant sort of aviation gasoline in Western Europe) [5)] (Wikipedia: "...Common in North America and western Europe, limited availability elsewhere worldwide.")

lead content of AvGas 100 LL: 0.56 g lead/liter (as tetra ethyl lead) ("Thus, general emission factors for the stationary combustion of kerosene and the combustion of gasoline in cars may be applied. The only exception is lead. Lead is added to aviation gasoline to increase the octane number. The lead content is higher than in leaded car gasoline, and the maximum permitted levels in the UK are shown below. A value of 0.6 g of lead per litre of gasoline should be used as the default value if there is an absence of more accurate information. Actual data may be obtained from oil companies.") [6)]

The applied procedure is similar to the one used for calculating lead emissions from leaded gasoline used in road transport. (There, in contrast to aviation gasoline, the lead content constantly declined resulting in a ban of leaded gasoline in 1997.)

What is the country-specific methododlogy for estimating the reported TSP emissions from aviation gasoline?

The TSP emissions calculated depend directly on the reported lead emissions: The emission factor for TSP is 1.6 times the emission factor used for lead: EF(TSP) = 1.6 x EF(Pb). - The applied procedure is similar to the one used for calculating TSP emissions from leaded gasoline used in road transport.

Why does the party report TSP emissions from leaded avgas, but no such $PM_{2.5}$ or PM_{10} emissions?

The EF(TSP) is estimated from the EF(Pb) which has been calculated from the lead content of Avgas 100 LL. There is no information on the percetual shares of $PM_{2.5}$ & PM_{10} in the reported TSP and therefore no EF($PM_{2.5}$) & EF(PM_{10}) were deducted.

Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?

The EF provided in [7)] represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained the biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel and bioethanol.

[1)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.
[2)] AGEB (2022b): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Zusatzinformationen - Heizwerte der Energieträger und Faktoren für die Umrechnung von spezifischen Mengeneinheiten in Wärmeeinheiten (aktuelle Bilanz) - 2022; URL: https://ag-energiebilanzen.de/wp-content/uploads/2023/12/Heizwerte_2022e.xlsx, (Aufruf: 09.12.2024) Köln & Berlin, 2022.
[3), 6)] EMEP/EEA (2023): EMEP/EEA EMEP/EEA air pollutant emission inventory guidebook 2023; Chapter 1.A.3.a, 1.A.5.b Aviation, Annex 2, page 44, Table A2.1; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023/@@download/file, Copenhagen, 2023
[4), 7)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019.
[5)] https://en.wikipedia.org/wiki/Avgas

1.A.5.b iii - Military Navigation

Short description

In sub-category *1.A.5.b iii - Other, Mobile (including Military)* emissions from military navigation are reported.

Method	AD	EF	Key Category Analysis
T1, T2	NS, M	D, M, CS, T1, T3	see superordinate chapter

Methodology

Activity Data

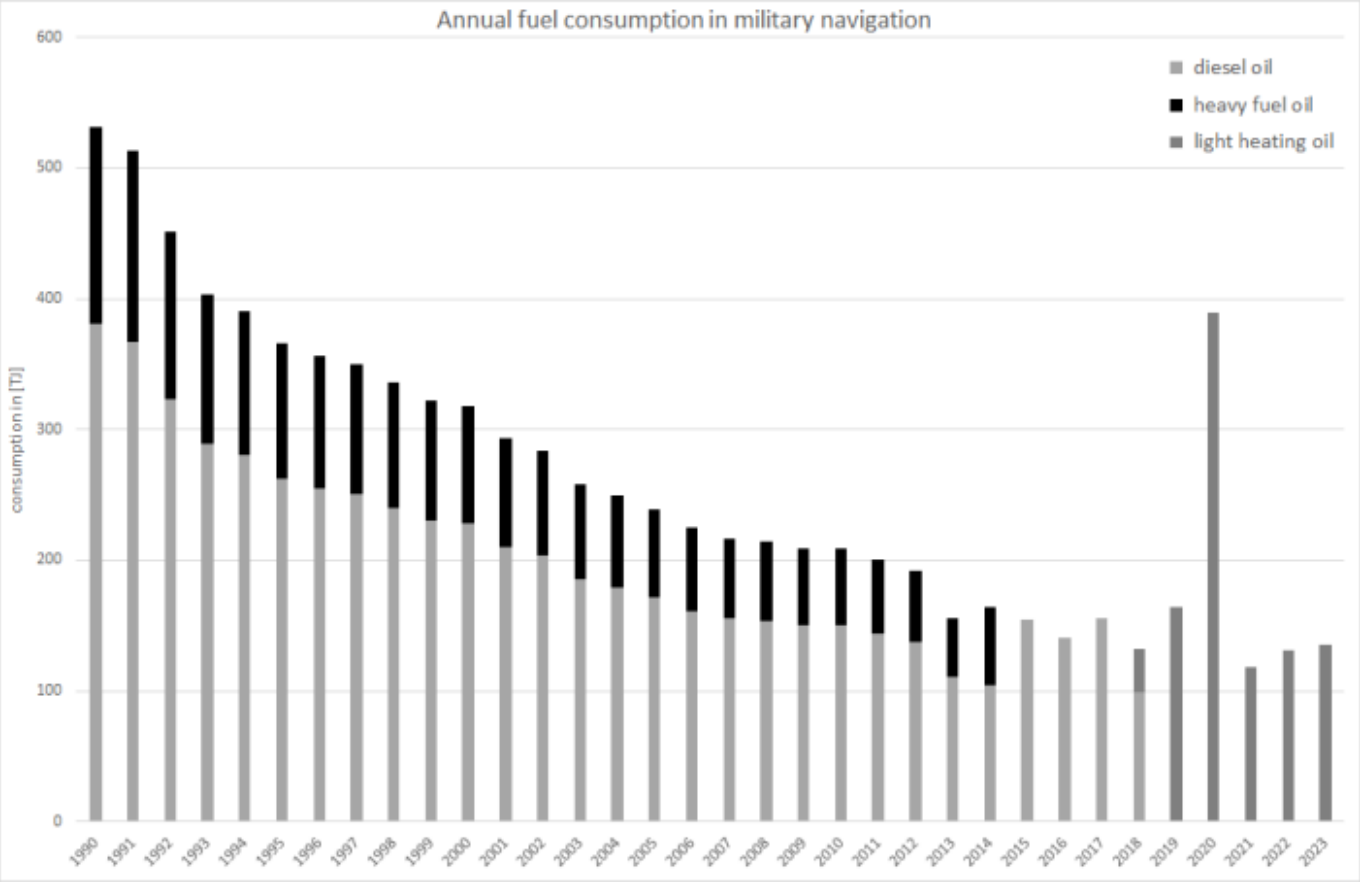
Primary fuel data for national military waterborne activities is included in NEB lines 6 ('International Deep-Sea Bunkers') and 64 ('Coastal and Inland Navigation') for IMO-registered and not registered ships respectively. (AGEB, 2024) [1)]

The annual shares used within NFR 1.A.5.b iii are therefore calculated within (Deichnik, K. (2024)) [2)], where ship movement data (AIS signal) allows for a bottom-up approach providing the needed differentiation.

Table 1: Annual fuel consumption, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel Oil	380	263	228	171	150	154	141	156	99.5	NO				
Light Fuel Oil	NO								33.2	164	390	118	131	135
Heavy Fuel Oil	152	104	90.4	67.4	59.0	NO								
Σ 1.A.5.b iii	**532**	**366**	**318**	**239**	**209**	**154**	**141**	**156**	**133**	**164**	**390**	**118**	**131**	**135**

source: Deichnik, K. (2024): BSH model 2024



PLEASE NOTE: For the time being, there is no explanation for the jump in fuel consumption reported for 2020. However, as this data is calculated based on actual ship movement data, there should be no statistical or methodological error. On the other hand, if there is indeed an error, it should automatically be corrected with the current and fundamental revision of the model.

Emission factors

The emission factors applied here, are derived from different sources and therefore are of very different quality.

For the main pollutants, country-specific implied values are used, that are based on tier3 EF included in (Deichnik (2024)) which mainly relate on values from the EMEP/EEA guidebook 2019 [3)]. These modelled IEFs take into account the ship specific information derived from AIS data as well as the mix of fuel-qualities applied depending on the type of ship and the current state of activity.

Table 2: Annual country-specific implied emission factors, in kg/TJ

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
DIESEL OIL & LIGHT FUEL OIL[1]														
NH_3	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.17	0.33	0.22	0.27
NMVOC	80.1	80.1	80.1	80.1	80.1	86.6	84.0	79.6	69.1	79.3	38.9	30.7	35.8	45.7
NO_x	1,176	1,176	1,176	1,176	1,176	1,214	1,228	1,236	1,085	1,206	682	570	680	820
SO_x	466	419	233	186	69.8	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
BC	111	99.8	55.4	44.3	16.6	15.9	15.2	14.8	16.1	15.3	7.3	13.1	8.9	11.0
$PM_{2.5}$	358	322	179	143	53.6	51.2	49.1	47.8	51.9	49.3	23.4	42.2	28.6	35.6
PM_{10}	383	344	191	153	57.4	54.8	52.5	51.1	55.5	52.7	25.1	45.1	30.6	38.0
TSP	383	344	191	153	57.4	54.8	52.5	51.1	55.5	52.7	25.1	45.1	30.6	38.0
CO	140	140	140	140	140	148	144	141	148	142	63	127	76.9	75.9
HEAVY FUEL OIL														
NH_3	0.34	0.34	0.34	0.34	0.34	NA								
NMVOC	28.0	28.0	28.0	28.0	28.0	NA								
NO_x	1,468	1,468	1,468	1,468	1,468	NA								
SO_x	1,319	1,332	1,323	1,336	496	NA								
BC	42.3	42.7	42.4	42.9	15.9	NA								
$PM_{2.5}$	353	356,0	354	357	132	NA								
PM_{10}	388	392	389	393	146	NA								
TSP	388	392	389	393	146	NA								
CO	154	154	154	154	154	NA								
[1] similar EF are applied for diesel oil and light fuel oil (as of 2018)														
[2] ratio $PM_{2.5}$: PM_{10} : TSP derived from the tier1 default EF as provided in [4)]														
[3] estimated from a BC-fraction of 0.31 as provided in [5)], chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Table 3-2														

With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [12)]

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Discussion of emission trends

As only NFR 1.A.5.b as a whole is taken into account within the key category analysis, this country-specific sub-sector is not considered separately.

Recalculations

For information on revised inventory data, please see the superordinate chapter.

Uncertainties

For uncertainty information, please see the superordinate chapter.

Planned improvements

A **routine revision** of the underlying model is planned for the next annual submission.

[1)] AGEB (20249: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024

[2)] Deichnik (2024): Deichnik, K.: Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs. from Bundesamts für Seeschifffahrt und Hydrographie (BSH); Hamburg, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2024.

[3)], [4)], [5)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, Copenhagen, 2019.

[12)]

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

1.B - Fugitive Emissions from fossil fuels

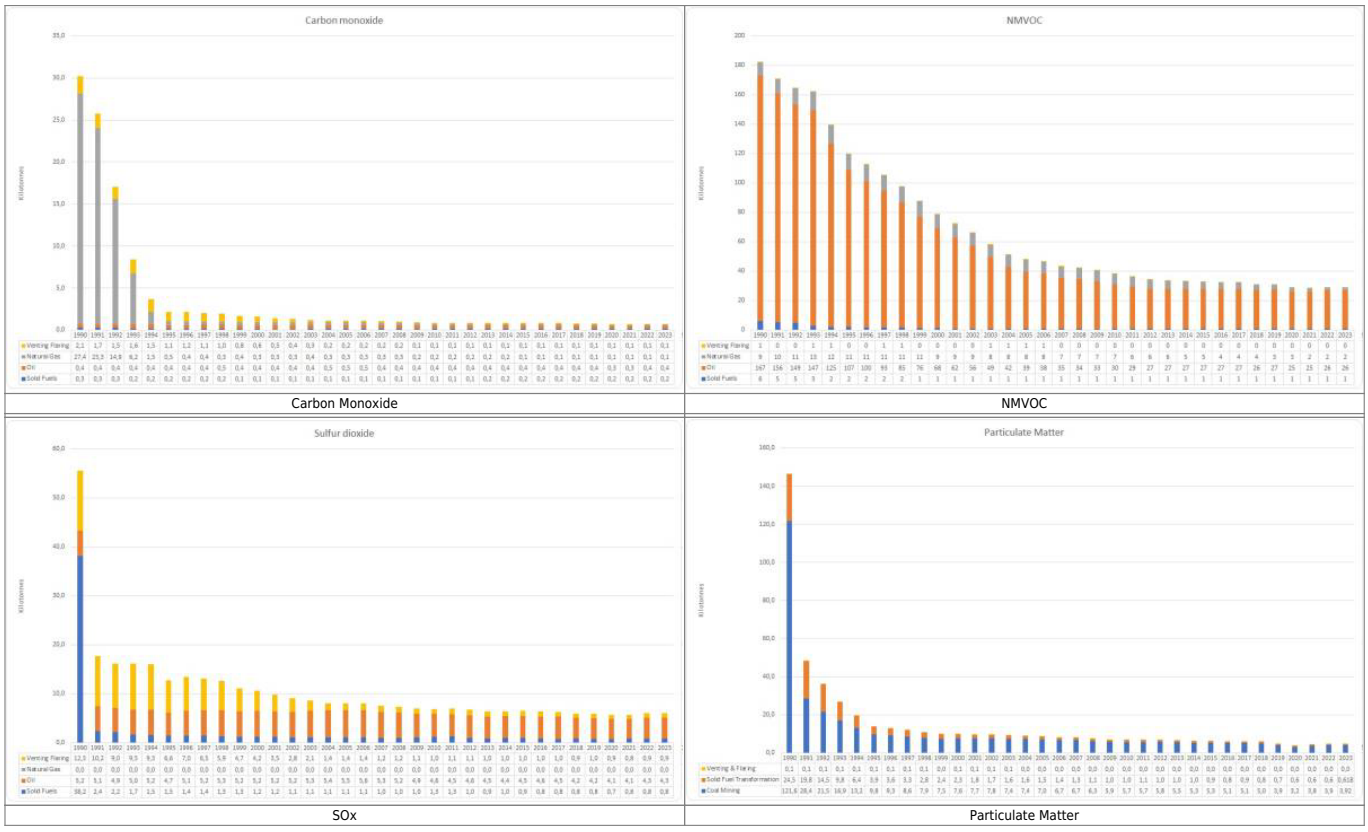
During all stages of fuel production and use, from extraction of fossil fuels to their final use, fuel components can escape or be released as fugitive emissions.

While NMVOC, TSP and SO_x are the most important emissions within the source category *solid fuels*, fugitive emissions of oil and natural gas include substantial amounts of NMVOC and SO_x.

1.B - “Fugitive emission from fuels” consist of following sub-categories:

NFR-Code	Name of category
1.B.1	Solid Fuels
1.B.2.a	Oil
1.B.2.b	Gas
1.B.2.c	Venting and Flaring
1.B.3	Geothermal Energy

Trends in emissions



Carbon Monoxide | NMVOC

SOx | Particulate Matter

Sulphur Dioxide emissions occur during the production of hard-coal coke. The value of the year 1990 is partly based on the GDR’s emission report, chapter “Produktion” (=production) which has no clear differentiation between mining, transformation and handling of coal. The total emission as reported in the emission report is allocated in the NFR categories 1.B.1 and 2. The split factor is based on estimation of experts.

The apparently steep decline from 2007 to 2008 is the result of a research project in 2010, where new emission factors were determined for coke production for the years 2008. In sub-category 1.B.2, one main driver of shrinking SO_2 emission is the decreasing amount of flared natural gas. The shrinking emissions are also attributed to the declining emissions from desulphurisation, that are a result of the implementation of modern technology.

Particulate matter emissions occur during the transformation of lignite and hard coal. The very steep decline of the emissions in the early 1990s is due to the shrinking production of lignite briquettes (almost 90% in the first five years). The value of the year 1990 is partly based on the GDR’s emission report, chapter “Produktion” (=production) which has no clear differentiation between mining, transformation and handling of lignite. The total emission as reported in the emission report is allocated in the NFR categories 1.B.1 and 2. The split factor is based on estimation of experts.

NMVOC emission occur during the production of hard-coal coke. The shrinking emissions are mainly attributed to the hard-coal coke production and the decommissioning of outdated plants. The main sources of NMVOC emissions from total petrol distribution (1.B.2.a.v) were fugitive emissions from handling and transfer (filling/unloading) and container losses (tank breathing). These emissions have decreased by round about 65 % since 1990. The decrease in fugitive emissions during this period is the result of implementation of the Technical Instructions on Air Quality Control (TA-Luft 2002) and of the 20th and 21st Ordinance on the Execution of the Federal Immission Control Act (20. and 21. BImSchV), involving introduction of vapour recovery systems. It is also the result of reduced petrol consumption.

Currently, about 13 million m^3 of petrol fuels are transported in Germany via railway tank cars. This transport volume entails a maximum of 300,000 handling processes (loading and unloading). Some 5,000 to 6,000 railway tank cars for transport of petrol are in service. Transfer/handling (filling/unloading) and tank losses result in emissions of only 1.4 kt VOC per year. The emissions situation points to the high technical standards that have been attained in railway tank cars and pertinent handling facilities. On the whole, oil consumption is expected to stagnate or decrease. As a result, numbers of oil storage facilities can be expected to decrease as well.

Carbon monoxide emissions occur during the production of coke. A trend-reversing issue was the decommissioning of outdated plants in the 1990s. Flaring in oil refineries is the main source for carbon monoxide emission in category 1.B.2. In the early 1990s, emissions from distribution of town gas were also taken into account in calculations. In 1990, the town-gas distribution network accounted for a total of 16 % of the entire gas network. Of that share, 15 % consisted of grey cast iron lines and 84 % consisted of steel and ductile cast iron lines. Since 1997 no town gas has been distributed in Germany's gas mains. Town-gas was the only known source of CO emissions in category 1.B.2.b.

Recalculations

Recalculations covering the past two years have been carried out as a result of the provisional nature of a number of statistics in this area.



For **pollutant-specific information on recalculated emission estimates reported for Base Year and 2023**, please see the recalculation tables following chapter Chapter 9.1 - Recalculations.

Improvements planned for future submissions

- an ongoing research project estimates emissions from storage and cleaning of tanks for oil and oil products - results are planned to be implemented into the inventory in 2026

1.B.1 - Solid Fuels



Short description

Category Code	Method	AD	EF
1.B.1.a	T2, M	AS	CS
1.B.1.b	T2, T3	AS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

Key Category	NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAHs	HCB
1.B.1.a	NA	-/-	NA	NA	-/-	**-/T**	-/-	NA	NA	NA	NA	NA	-/-	-/-	-/-	-/-	-/-	-/-	NA	-	-	-	-	NA	NA
1.B.1.b	-/-	-/-	-/-	-/-	-/-	-/-	**L/T**	-/-	-/-	NA	NA	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	**L/T**	**-/T**	**-/T**	**-/T**	**-/T**	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Source category **1.B.1 - Solid fuels** consists of two sub-source subcategories – the source subcategory Coal mining (1.B.1.a) and the source subcategory Coal transformation (1.B.1.b). This chapter discusses fugitive emissions from coal mining, coal handling, including door leakages from coke ovens and quenching (emissions from the furnace are covered by category 1.A.1.c), and emissions from the beneficiation of solid fuels. In the mining sector, a distinction is made between open-pit mines, in which raw materials are extracted from pits open to the surface, and closed-pit mines, in which seams are mined underground. In Germany, hard coal used to be mined in closed-pits only (until 2018), while lignite is mined in four coal fields since 2003 with the open-pit method only.

> Unitil 2018 Germany produced significant amounts of hard coal in underground mines. Since 2019, hard coal has been imported exclusively. NMVOC emissions are considered insignificant as the coal outgased along the import route. Particle emissions from loading and unloading as well as storage are reported under 2.L(a) - Handling of Bulk Products“

Methodology

Lignite production



Activity data for lignite production have been taken from the *Statistik der Kohlenwirtschaft*'s website (in German only) [1)]. Extracted coal is moved directly to processing and to power stations.

The emission factors used for calculating emissions from lignite production (TSP, PM_{10} and $PM_{2.5}$) already include possible emissions from transport and storage. The PM_{10} factor is taken from a 2021 research project [2)]. TSP and $PM_{2.5}$ have been reduced the same way on the basis of the previous values[3)].

Table 1: Annual amounts of extracted raw lignite, in [Mt]

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
357	193	168	178	169	178	172	171	166	131	107	126	131	102

Table 2: Emission factors applied for lignite extraction, in [kg/t]

Pollutant	Value
TSP	0.03
PM_{10}	0.015
$PM_{2.5}$	0.002

Lignite coke production

Table 3: Annual amounts of lignite coke produced, in [Mt]

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
3.36	0.19	0.18	0.17	0.18	0.17	0.16	0.15	0.16	0.16	0.15	0.16	0.14	0.16

Emissions from lignite production other than listed below are reported by plant operator. Particle emission factors were verified in a research project (Emissionen und Maßnahmenanalyse Feinstaub 2000-2020) by Jörß et al. (2007)[4)].

Table 4: Emission factors applied for lignite-coke production

Pollutant	Unit	Value
TSP	kg/t	0.1
PM_{10}	kg/t	0.048
$PM_{2.5}$	kg/t	0.013
PAH	mg/t	55
PCDD/F	µg/t	0.03

Hard coal coke production

The activity rates for hard coal coke production have been taken from the *Statistik der Kohlenwirtschafts*'s website (in German only) [5)].

Table 5: Annual amounts of hard coal coke produced, in [Mt]

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
18.5	11.1	9.12	8.40	8.15	8.80	9.39	9.34	9.36	8.91	7.94	8.25	8.27	8.03

The emission factors for hard coal coke production have been obtained from the research project "Emission factors for the iron and steel industry, for purposes of emissions reporting" ("Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichterstattung") by Hensmann et al. (2011) [6)].

Table 6: Emission factors for hard coal coke production

Pollutant	Unit	Value
CO	kg/t	0.015
NH_3	kg/t	0.000243
NMVOC	kg/t	0.096
SO_2	kg/t	0.004
TSP	kg/t	0.011
PM_{10}	kg/t	0.004
$PM_{2.5}$	kg/t	0.004
PAH	mg/t	55
PCDD/F	µg/t	0.0015

There are many potential sources of PAH emissions from coking plants. The dominant emission sources are leakages from coke oven doors and from charging operations. As there is limited data available on PAH emissions, the uncertainties of the estimated emission factors are very high. It should also be taken into account that emissions from coke production greatly

vary between different coke production plants. The emission factors for benzo[a]pyrene and mixed PAH have been revised by research projects in 2010 [7)8)]. Split factors for Black Carbon (BC) are based on the EMEP Guidebook 2016 [9)].

Decommissioned hard-coal mines

NMVOC Emissions from decommissioned hard-coal mines play a role in this sub- source category. When a hard-coal mine is decommissioned, mine gas can escape from neighbouring rock, and from coal remaining in the mine, into the mine's network of shafts and passageways. Since the mine is no longer artificially ventilated, the mine gas collects and can then reach the surface via gas pathways in the overlying rock or via the mine's own shafts and passageways. Such mine gas was long seen primarily as a negative environmental factor. Recently, increasing attention has been given to the gas' positive characteristics as a fuel (due to its high methane content, it is used for energy recovery). In the past, use of mine gas was rarely cost-effective. This situation changed fundamentally in 2000 with the Renewable Energy Sources Act (EEG). Although mine gas is a fossil fuel in finite supply, its use supports climate protection, and thus the gas was included in the EEG. The Act requires network operators to accept, and provide specified compensation for, electricity generated with mine gas and fed into the grid.

The NMVOC emissions from decommissioned hard-coal mines have been calculated in the research project “Potential for release and utilisation of mine gas” (“Potential zur Freisetzung und Verwertung von Grubengas”) [10)]. The relevant calculations were carried out for all mining-relevant deposits in Germany.

Table 7: NMVOC emission factor for decommissioned hard-coal mines, in [kg/m^{13}]

EF
0.001599

Recalculations

For more details please refer to the super-ordinate chapter 1.B - Fugitive Emissions from fossil fuels

Planned improvements

At the moment, no further category-specific improvements are planned.

[1)] Statistik der Kohlenwirtschaft (2019) External Link (last pageview: March 2025)
[2)] Dokumentation zur Berechnung des PM10-Austrags aus dem Tagebau Hambach im Jahr 2013 und Ableitung eines Emissionsfaktors (2021) External Link (last pageview: March 2025)
[3)] Co-ordinated European Programme on Particulate Matter Emission Inventories, Projections and Guidance (CEPMEIP) External Link
[4)] Jörß et al. (2007): Jörß, W.; Handke, V. (Institut für Zukunftsstudien und Technologiebewertung (IZT), Berlin) mit Beiträgen von Lambrecht, U., Dünnebeil, Fr. (Institut für Energie und Umweltforschung Heidelberg (ifeu)): Emissionen und Maßnahmenanalyse Feinstaub 2000–2020. UBA-TEXTE Nr. 38/200; URL: https://www.umweltbundesamt.de/publikationen/emissionen-massnahmenanalyse-feinstaub-2000-2020; on behalf of the Umweltbundesamt; Dessau-Roßlau, 2007.
[6)] Hensmann et al. (2011): Hensmann, M., Haardt, S., Ebert, D.: Emission factors for the iron and steel industry, for purposes of emissions reporting” (“Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichterstattung”; https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/4362.pdf; on behalf of the Umweltbundesamt, Dessau-Roßlau, October 2012
[7)] Federal Environment Agency and DFIU research project “Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationale Richtlinien, Teilbericht Prioritäre Quellen”, on behalf of the Umweltbundesamt, 2010 (not available online)

[8)] Federal Environment Agency and BFI research project No. 3707 42 301 “Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichterstattung“, 2011 External Link
[9)] EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016; https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/1-energy/1-b-fugitives, Copenhagen, 2016
[10)] Meiners, H. (2014): Potential zur Freisetzung und Verwertung von Grubengas

1.B.2 - Oil And Natural Gas

1.B.2.a - Oil



Category Code	Method	AD	EF
1.B.2.a.i	T2	AS	CS
1.B.2.a.iv	T2	AS	CS
1.B.2.a.v	T2	AS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

Key Category	**NO_x**	**NMVOC**	**SO_2**	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	**Hg**	Additional HM	POPs
1.B.2.a.i	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	-/-	NA	NA
1.B.2.a.iv	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.a.v	NA	**-/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

1.B.2.a.i - Exploration, production, transport

Emissions from exploration consist of emissions from activities of drilling companies and other actors in the exploration sector. Gas and oil exploration takes place in Germany. According to the BVEG (former WEG) [1)], virtually no fugitive emissions occur in connection with drilling operations, since relevant measurements are regularly carried out at well sites (with use of methane sensors in wellhead-protection structures, ultrasound measurements and annulus manometers) and old / decommissioned wells are backfilled and normally covered with concrete caps.

Table 1: Activity data applied for emissions from oil exploration

	Unit	1990	1995	2000	2005	2010	2015	2020	2023
number of wells	No.	12	17	15	23	16	18	12	7
total of drilling meter	m	50,140	109,187	41,378	63,994	51,411	32,773	6,220	29.380

Since pertinent measurements are not available for the individual wells involved, a conservative approach is used whereby VOC emissions for wells are calculated on the basis of the share ratio of VOC = 9 NMVOC : 1 CH4, using the default methane factor of the IPCC Guidelines 2006 [2)].

Table 2: NMVOC emission factor applied for emissions from oil exploration, in [kg/No.]

Value
576

Emissions from extraction (crude oil) and first treatment of raw materials (petroleum) in the petroleum industry are included in 1.B.2.a.i as well. Because Germany's oil fields are old, oil production in Germany is highly energy-intensive (thermal extraction, operation of pumps to inject water into oil-bearing layers). The first treatment that extracted petroleum (crude oil) undergoes in processing facilities serves the purpose of removing gases, water and salt from the oil. Crude oil in the form present at wellheads contains impurities, gases and water and thus, does not conform to requirements for safe, easy transport in pipelines. No substance transformations take place. Impurities – especially gases (petroleum gas), salts and water – are removed in order to yield crude oil of suitable quality for transport in pipelines.

Table 3: Annual amounts of oil produced, in [kt]

1990	1995	2000	2005	2010	2015	2020	2023
3,606	2,959	3,123	3,573	2,516	2,414	1,907	1,620

The emissions from production and processing are measured or calculated by the operators, and the pertinent data is published in the annual reports of the Federal association of the natural gas, oil and geothermal energy industries (BVEG) [3)]. The emission factors are determined from the reported emissions and the activity data.

Table 4: NMVOC emission factor applied for emissions from oil production, in [g/m³]

Substance	Emission Factor
NMVOC	63
Mercury	0,001

Transport emissions are tied to activities of logistics companies and of pipeline operators and pipeline networks. After the first treatment, crude oil is transported to refineries. Almost all transport of crude oil takes place via pipelines. Pipelines are stationary and, normally, run underground. In contrast to other types of transport, petroleum transport is not interrupted by handling processes.

Table 5: Activity data applied for emissions from oil transportation, in [kt]

Activity	1990	1995	2000	2005	2010	2015	2020	2023
Transport of domestically produced crude oil	3,660	2,940	3,123	3,572	2,516	2,414	1,907	1,620
Transport of imported crude oil	84,043	86,063	89,280	97,474	93,270	91,275	83,049	77,171
Transport via inland-waterway tankers	89	67	112	176	6	43	46	44

For pipelines, the emission factor for inland-waterway tankers has been estimated by experts. The pertinent emission factors have been confirmed by the research project “Determination of emission factors and activity data in areas 1.B.2.a.i through vi” [4)]. Since long-distance pipelines are continually monitored and disruptive incidents in such pipelines are very rare [5)], emissions occur – in small quantities – only at their transfer points. The emission factor is thus highly conservative. The emission factor covers the areas of transfer / injection into pipelines at pumping stations, all infrastructure along pipelines (connections, control units, measuring devices), and transfer at refineries, and it has been determined on the basis of conservative assumptions. For imported quantities, only one transfer point (the withdrawal station) is assumed, since the station for input into the pipeline network does not lie on Germany's national territory.

Table 6: NMVOC emission factor applied for emissions from oil transportation, in [kg/t]

Activity	Value
Transports of domestically produced crude oil	0.13
Transports of imported crude oil	0.064
Transports via inland-waterway tankers	0.34

1.B.2.a.iv- Refining / storage



Emissions in category 1.B.2.a.iv - Refining / storage consist of emissions from activities of refineries and of refining companies in the petroleum industry. Crude oil and intermediate petroleum products are processed in Germany. For the most part, the companies concerned receive crude oil for refining and processing. To some extent, intermediate petroleum products undergo further processing outside of refineries in processing networks. Such processing takes place in state-of-the-art plants.

Refinery tank storage systems are used to store both crude oil and intermediate and finished petroleum products. They thus differ from non-refinery tank storage systems in terms of both the products they store and the quantities they handle. Tank-storage facilities outside of refineries are used especially for interim storage of heating oil, gasoline and diesel fuel. The storage capacities of storage caverns for petroleum products are listed separately. In light of the ways in which storage caverns are structured, it may be assumed that no emissions of volatile compounds occur. This is taken into account in the emissions calculation.

Tanks are emptied and cleaned routinely before tank inspections and repairs. In tank cleaning, a distinction is made between crude-oil tanks and product tanks. Because sediments accumulate in crude oil tanks, cleaning these tanks, in comparison to cleaning product tanks, is a considerably more laborious process. The substances in product tanks produce no sediments and thus are cleaned only when the products they contain are changed. In keeping with an assessment of Müller-BBM (2010)[6)], the emission factors for storage of crude oil and of petroleum products may be assumed to take the cleaning processes into account.

Table 8: Activity data applied for emissions from oil refinement and storage

Activity	unit	1990	1995	2000	2005	2010	2015	2020	2023
Quantity of crude oil refined	kt	107,058	96,475	107,632	114,589	95,378	93,391	83,990	79,153
Capacity utilisation in refineries	%	106	92	95	99	81	91	82	76
Crude-oil-refining capacity in refineries	kt	100,765	104,750	112,940	115,630	117,630	103,080	105,655	104.086
Tank-storage capacity in refineries and pipeline terminals	Mill m³	27,1	28,4	24,9	24	22,5	22	20,7	21,1
Storage capacity of tank-storage facilities outside of refineries	Mill m³	15,4	15,9	18,1	17	15,9	15,3	15,3	15
Storage capacity of caverns	Mill m³	26,6	25,3	27,9	27,2	27,2	25,5	25,5	28,3

Processing The emission factors used for NMVOC, CO, NO_x and SO_2 were determined by evaluating the emission declarations of the period 2004 through 2016 in the framework of a research project (Bender & von Müller, 2020) [7)].

Tank-storage facilities in refineries

In keeping with the results of the research project “Processing of data of emissions declarations pursuant to the 11th Ordinance Implementing the Federal Immission Control Act – the area of storage facilities” (Müller-BBM, 2010) [8)], the crude-oil-distillation capacity is used as the activity data for estimating emissions from storage in refineries. The fugitive VOC emissions value specified in the VDI Guideline 2440 [9)], 0.16 kg/t, may be used as the emission factor. The EF for methane was derived from it (5-10 % of 0.16 kg) and then suitably deducted.

Tank-storage facilities outside of refineries

According to Müller-BBM (2010) [10)], no emission factors could be derived by evaluating emission declarations for storage systems, which would be representative of individual systems. This is due, according to the same source, to the widely differing emission behaviours of different individual systems. It was possible, however, to form aggregated emission factors. For each relevant group of data, this was done by correlating the sums of all emissions with the sums of all capacities. For non-refinery tank-storage systems, storage of liquid petroleum products can be differentiated from storage of gaseous petroleum products, since the relevant data is suitably differentiated.

Claus plants

The emission factors used for NMVOC, CO, NO_x und SO_2 were determined by evaluating emission declarations from refineries for the period 2004 through 2016, in the framework of a research project (Bender & von Müller, 2020)[11)]. Since no data was available for earlier years, the data obtained this way was used for all years as of 1990.

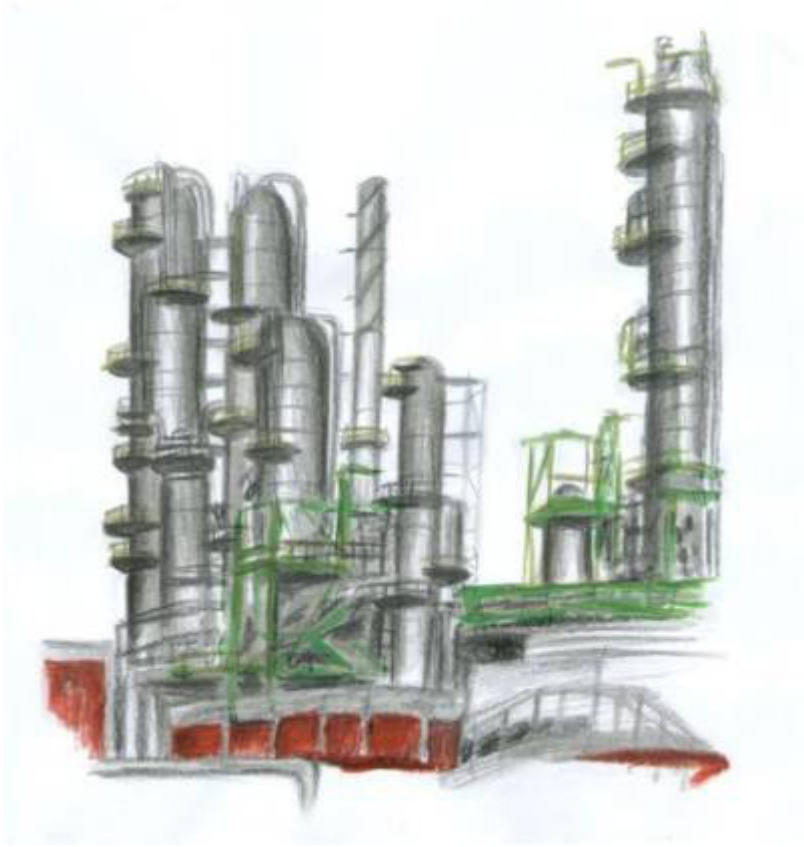


Table 9: Emission factors applied for emissions from oil refinement and storage

Activity	Substance	Unit	Value
Fugitive emissions at refineries	NMVOC	kg/t	0.0072
Fugitive emissions at refineries	NO_x	kg/t	0.00602
Fugitive emissions at refineries	SO_2	kg/t	0.00085
Fugitive emissions at refineries	CO	kg/t	0.000494
Storage and cleaning of crude oil in tank-storage facilities of refineries	NMVOC	kg/t	0.0227
Storage of liquid petroleum products in tank-storage facilities outside of refineries	NMVOC	g/m³	100
Storage of gaseous petroleum products in tank-storage facilities outside of refineries	NMVOC	g/m³	500
Claus Plants	NMVOC	kg/t	0.000025
Claus Plants	NO_x	kg/t	0.0022
Claus Plants	SO_2	kg/t	0.048
Claus Plants	CO	kg/t	0.0036

Emissions from storage consider all refinery products. According to the EMEP guidebook, fuel-related emissions are reported under 1.B.2. Emissions other than fuels (like naphtha, methanol etc.) are reported under 2.B.10.b - Storage, Handling and Transport of Chemical Products.

1.B.2.a.v- Distribution of oil products

In category 1.B.2.a.v - Distribution of oil products, the emissions from distribution of oil products are described. Petroleum products are transported by ship, product pipelines, railway tanker cars and tanker trucks, and they are transferred from tank to tank. The main sources of NMVOC emissions from petrol distribution as a whole were fugitive emissions from handling and transfer (filling/unloading) and container losses (tank breathing). Experts consider the emissions from aircraft refuelling to be non-existent, since the equipment used for such refuelling is fitted with dry couplings. The emissions from filling private heating-oil tanks are also very low thanks to high safety standards. In this category, petroleum products that have undergone fractional distillation in refineries are handled and distributed, i.e. processes in which gaseous products are separated out. For this reason, no significant methane emissions are expected. Only in storage of certain petroleum products can small quantities of methane escape.

Table 10: Annual activity data for the distribution of oil products

Activity	Unit	1990	1995	2000	2005	2010	2015	2020	2023
number of petrol stations	No	19,317	17,957	16,324	15,187	14,744	14,531	14,459	14,442
distribution of diesel	kt	21,817	26,208	28,922	28,531	32,128	36,756	35,163	33,380
distribution of jet fuel	kt	4,584	5,455	6,939	8,049	8,465	8,550	4,725	9,466
distribution of light heating oil	kt	31,803	34,785	27,875	25,380	21,005	16,127	15,558	11,537
distribution of domestic petrol	kt	31,257	30,333	28,833	23,431	19,634	18,226	16,218	17,472

Transport

Inland-waterway gasoline tankers retain considerable quantities of gasoline vapours in their tanks after their gasoline has been unloaded. When the ships change loads or spend time in port, their tanks have to be ventilated. With such ships being ventilated on average 277 times per year, the quantity of NMVOC emitted in these operations amounts to 336 to 650 t [12)]. The highest value in the range is used to calculate the relevant emissions.

About 13 million m^3 of gasoline fuel are transported annually in Germany via railway tank cars. Transfer/handling (filling/unloading) and tank losses result in annual emissions of only 1,400 t VOC [13)]. The emissions situation points to the high technical standards that have been attained in railway tank cars and pertinent handling facilities.

Filling stations

Significant quantities of fugitive VOC emissions are released into the environment during transfers from tanker vehicles to storage facilities and during refuelling of vehicles. To determine emissions, a standardised emission factor of 1.4 kg/t is used. This value refers to the saturation concentration for hydrocarbon vapours and thus, corresponds to the maximum possible emissions level in the absence of reduction measures.

The immission-control regulations issued in 1992 and 1993 (20th BImSchV [14)]; 21st BImSchV, [15)]) that required filling stations to limit such emissions promoted a range of reduction measures. The relevant reductions affect both the area of gasoline transfer and storage (20th BImSchV) and the area of fuelling of vehicles with gasoline at filling stations (21st BImSchV). The use of required emissions-control equipment, such as vapour-balancing (20th BImSchV) and vapour-recovery (21st BImSchV) systems, along with the use of automatic monitoring systems (via the amendment of the 21st BImSchV on 6 May 2002), have brought about continual reductions of VOC emissions; the relevant high levels of use of such equipment are shown in the table below (Table 151). In emissions calculation, the two ordinances' utilisation and efficiency requirements for filling stations in service are taken into account. The following assumptions, based on the technical options currently available, are applied:

Ordinance	Factor		
20th BImSchV	Vapour balancing	Degree of utilisation	98 %
20th BImSchV	Vapour balancing	Efficiency	98 %
21st BImSchV	Vapour recovery	Degree of utilisation	98 %
21st BImSchV	Vapour recovery	Efficiency	85 %

In addition, permeation of hydrocarbons occurs in tank hoses. The DIN EN 1360 standard sets a limit of 12 ml / hose meter per day for such permeation. From analysis of measurements, UBA experts have adopted a conservative factor of 10ml/m per day. That factor is used to determine the NMVOC emissions. The calculation is carried out in accordance with the pertinent formula of the University of Stuttgart's Institute for Machine Components [16)]:

> Number of service stations * number of fuel pumps per service station * number of hoses per fuel pump * hose length * emission factor.

Cleaning of transport vehicles

Tank interiors are cleaned prior to tank repairs and safety inspections, in connection with product changes and with lease changes. The inventory currently covers cleaning of railway tank cars. The residual amounts remaining in railway car tanks after these have been emptied – normally, between 0 and 30 litres (up to several hundred litres in exceptional cases) – are not normally able to evaporate completely. They thus produce emissions when the insides of tanks are cleaned.

Each year, some 2,500 cleaning operations are carried out on railway tank cars that transport gasoline. The emissions released, via exhaust air, in connection with cleaning tank cars' interiors amount to about 40,000 kg/a VOC (Joas et al.,

2004), p. 34. [17)].

Any additional prevention and reduction measures could affect emissions in this category only slightly. At the same time, emissions can be somewhat further reduced from their current levels via a combination of various technical and organizational measures. Emissions during handling – for example, during transfer to railway tank cars – are produced especially by residual amounts of gasoline that remain after tanks have been emptied. Such left-over quantities in tanks can release emissions via manholes the next time the tanks are filled. A study is thus underway to determine the extent to which “best practice” is being followed at all handling stations, and whether this extent has to be taken into account in emissions determination. In addition, improvements of fill nozzles enhance efficiency in prevention of VOC emissions during refuelling.

Pursuant to the UBA text (Joas et al., 2004), [18)] a total of 1/3 of all relevant transports are carried out with railway tank cars. The remaining 2/3 of all transports are carried out by other means – primarily with road tankers.

The 1/3 to 2/3 relationship given by the report is assumed to be also applicable to the emissions occurring in connection with cleaning. Currently, the inventory includes 36,000 kg of NMVOC emissions from cleaning of railway tank cars. Emissions from cleaning of other transport equipment – primarily road tankers – are derived from that figure; they amount to about 70,000 kg NMVOC.

More-thorough emissions collection upon opening of manholes of railway tank cars (a volume of about 14.6 m^3 escapes), along with more thorough treatment of exhaust from cleaning tank interiors, could further reduce VOC emissions. Exhaust cleansing is assumed to be carried out via one-stage active-charcoal adsorption. For an initial load of 1 kg/m^3, exhaust concentration levels can be reduced by 99.5 %, to less than 5 g/m^3. As a result, the remaining emissions amount to only 1.1 t. This is equivalent to a reduction of about 97 % from the determined level of 36.5 t/a (without adsorption) (Joas et al. (2004), p. 34) [19)].

Generally, the emission factors listed below have been verified by the study [20)].

Process responsible for NMVOC emissions		**Emission factor [kg/t]**
Drip losses in refuelling at filling stations	gasoline	0.117
Transfers from road tankers to filling stations (20th Ordinance Implementing the Federal Immission Control Act – vapour displacement)	gasoline	1.4
Ventilation in connection with transports with inland-waterway tankers	gasoline	0.025
Transfers from filling station tanks to vehicle tanks (21st Ordinance Implementing the Federal Immission Control Act – vapour recovery)	gasoline	1.4
Drip losses in refuelling at filling stations	diesel	0.1
Transports from refineries to transport vehicles	diesel	0.008
Transfers from filling-station tanks to vehicle tanks	diesel	0.003
Drip losses in refuelling at transfer stations	light heating oil	0.0011
Transports from refineries to transport vehicles	light heating oil	0.0053
Transfers from filling-station tanks to vehicle tanks	light heating oil	0.0063

Recalculations



For more details please refer to the super-ordinate chapter 1.B - Fugitive Emissions from fossil fuels

Planned improvements

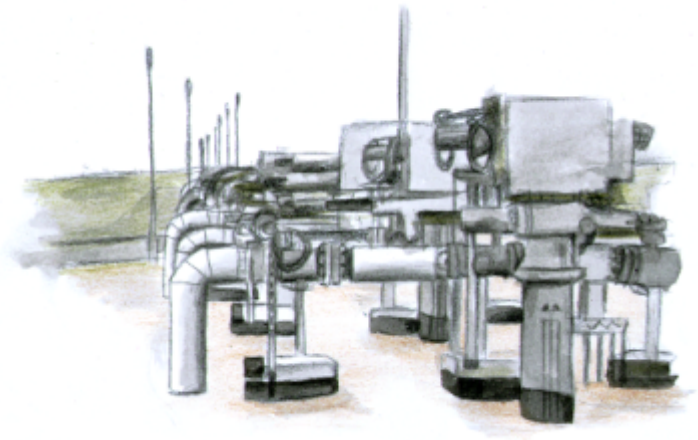
* an ongoing research project estimate emissions from storage and cleaning of tanks for oil and oil products - results are planned to be implemented into the inventory in 2025/26

[1)] WEG (2008). Report of the Association of Oil and Gas Producing “Erdgas – Erdöl. Entstehung-Suche-Förderung”, Hannover, 34 S. External Link, PDF

[2)] IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. External

Link
[3)] BVEG (2019). Annual report of the Association of Oil and Gas Producing “Die E&P-Industrie in Zahlen. Statistischer Bericht 2019: Zahlen”. External Link
[4), 20)] Theloke, J., Kampffmeyer, T., Kugler, U., Friedrich, R., Schilling, S., Wolf, L., & Springwald, T. (2013). Ermittlung von Emissionsfaktoren und Aktivitätsraten im Bereich IPCC (1996) 1.B.2.a. i-vi - Diffuse Emissionen aus Mineralöl und Mineralölprodukten (Förderkennzeichen 360 16 033), on behalf of the Umweltbundesamt, Stuttgart, 2013.
[5)] Cech, M., Davis, P., Gambardella, F., Haskamp, A., González, P. H., Spence, M., & Larivé, J.-F. (2017). Performance of European cross-country oil pipelines - Statistical summary of reported spillages in 2015 and since 1971 External Link
[6), 8), 10)] Müller-BBM (2010). UBA research project No. 3707 42 103/ 01, Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV aus dem Jahre 2004 für die Verwendung bei der UNFCC- und UNECE-Berichterstattung - Bereich Lageranlagen (Bericht Nr. M74 244/7, UBA FKZ 3707 42 103/01). External Link
[7), 11)] Bender, M., & von Müller, G. (2020). Emissionsfaktoren zu Raffinerien für die nationale Emissionsberichterstattung (FKZ 3716 41 107 0).
[9)] VDI (2000). VDI-Richtlinie 2440: Emissionsminderung - Mineralölraffinerien, published by V. D. I.
[12)] Bauer, S., Polcher, D. A., & Greßmann, A. (2010). Evaluierung der Anforderungen der 20. BImSchV für Binnentankschiffe im Hinblick auf die Wirksamkeit der Emissionsminderung klimarelevanter Gase (FKZ 3709 45 326). München.
[13), 17), 18), 19)] Dr. R. Joas; A. Potrykus; R. Schott; S. Wenzel (2004). “VOC-Minderungspotenzial beim Transport und Umschlag von Mineralölprodukten mittels Kesselwagen”, FKZ 202 44 372, UBA-Texte 12/2004, Dessau. External Link
[14)] 20. BImSchV - Zwanzigste Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung zur Begrenzung der Emissionen flüchtiger organischer Verbindungen beim Umfüllen oder Lagern von Ottokraftstoffen, Kraftstoffgemischen oder Rohbenzin) in der Fassung der Bekanntmachung vom 18. August 2014(BGBl. I S. 1447), die durch Artikel 2 der Verordnung vom 24. März 2017 (BGBl. I S. 656) geändert worden ist, published by BGBl (2017).
[15)] 21. BImSchV - Verordnung zur Begrenzung der Kohlenwasserstoffemissionen bei der Betankung von Kraftfahrzeugen in der Fassung der Bekanntmachung vom 18. August 2014 (BGBl. I S. 1453), die zuletzt durch Artikel 3 der Verordnung vom 24. März 2017 (BGBl. I S. 656) geändert worden ist, published by BGBl. (2017).
[16)] Haas, W. (2015). Kraftstoffpermeation an Zapfsäulen.

1.B.2.b - Natural Gas



Category Code	Method	AD	EF
1.B.2.b	T2, T3, M	AS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	**CO**	Pb	Cd	**Hg**	Additional HM	POPs
-/-	-/-	-/-	NA	NA	NA	NA	NA	-/-	NA	NA	-/-	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

1.B.2.b.i - Exploration

Source category 1.B.2.b.i is considered together with source category 1.B.2.a.i (Oil, exploration). Consequently, the aggregated, non-subdivided data of 1.B.2.b.i are included in source category 1.B.2.a.i.

1.B.2.b.ii - Production

The emissions of source category 1.B.2.b.ii consist of emissions related to production. Since 1998, the Federal Association of the Natural gas, Oil and Geothermal Energy Industries (BVEG) has determined the emissions from production and published the relevant data in its statistical report.

Table 1: Produced quantities of natural gas, in [Billion m^3]

1990	1995	2000	2005	2010	2015	2020	2023
15.3	19.1	20.1	18.8	12.7	8.6	5.2	4.3

Table 2: Emission factors for Natural gas production, in [g/ 1000 m^3]

Substance	Emission Factor
NMVOC	2
Mercury	0.0007

1.B.2.b.iii - Processing

The emissions of this category consist of emissions from the activities of pretreatment and processing. After being brought up from underground reserves, natural gas is first treated in drying and processing plants. As a rule, such pretreatment of the natural gas takes place in facilities located directly at the pumping stations. Such processes separate out associated water from reserves, along with liquid hydrocarbons and various solids. Glycol is then used to remove the water vapour remaining in the gas (p. 25)[1)]. Natural gas dehydration systems are closed systems. For safety reasons, all of such a system's overpressure protection devices are integrated within a flare system. When such protection devices are triggered, the surplus gas is guided to a flarehead, where it can be safely burned. After drying, the natural gas is ready for sale and can be delivered to customers directly, via pipelines [2)]. The relevant quantities of flared gas are reported under 1.B.2.c. The natural gas drawn from Germany's Zechstein geological formation contains hydrogen sulphide. In this original state, the gas – known as “sour gas” – has to be subjected to special treatment. Due to the hazardousness of hydrogen sulphide, this gas is transported via separate, specially protected pipelines to German processing plants that wash out its hydrogen sulphide via chemical and physical processes. About 40 % of the natural gas extracted in Germany is sour gas [3)]. The natural gas that leaves processing plants is ready for use. The hydrogen sulphide is converted into elementary sulphur and is used primarily by the chemical industry, as a basic raw material.

Table 3: Sulphur production from natural gas production, in [kt]

1990	1995	2000	2005	2010	2015	2020	2023
915	1,053	1,100	1,050	832	628	353	277

For processing of sour gas, data of the BVEG (the former WEG) for the period since 2000 are used. This data is the result of the BVEG members' own measurements and calculations. For calculation of emissions from sour-gas processing, a split factor of 0.4 relative to the activity data is applied. That split factor is based on the BVEG report [4)] on sour-gas processing.

Table 4: Emission factors for emissions from treatment of natural gas, in [kg/ 1000 m^3]

	Value
NMVOC	0.005
CO	0.043
NO_x	0.011
SO_2	0.140

1.B.2.b.iv - Transmission

This source category's emissions consist of emissions from activities of gas producers and suppliers. In Germany, natural gas is transported from production and processing companies/plants to gas suppliers and other processors. In addition, natural gas is imported and transmitted via long-distance pipelines. Almost all of the pipelines used to transmit natural gas are steel pipelines [5)].

One important emissions pathway consists of the compressors that are used to maintain pressure in pipelines. They are spaced at intervals of about 100 km along lines [6)]. At present, the compressors involved have a total power output of about 2,585 MW [7)]. The pipelines are also fitted with shut-off devices (sliding sleeves), which are safety mechanisms located at intervals of about 30 km along high-pressure pipelines, and with systems for regulating and measuring gas pressure.

In pipeline inspection and cleaning, tools known as pipeline inspection gauges (“pigs”) are used. In a pipeline system, a pig moves, driven by the gas flow, from a launching station to a receiving station (pig trap). Systems for launching and catching pigs can be either fixed or portable. Small quantities of methane are emitted in both insertion and removal of pigs. In addition, pig traps can develop leaks. Normally, however, such traps are regularly monitored for leaks and repaired as necessary. Not all types of pipelines can be pigged; diameter reductions, isolation valves, bends, etc. in pipelines can block pigs. These emissions have been estimated in the framework of a study carried out by the firm of DBI Gas- und Umwelttechnik GmbH [8)].

Table 5: Activity data applied for NFR 1.B.2.b.iv

	Unit	1990	1995	2000	2005	2010	2015	2020	2023
Length of transmission pipelines	km	22,696	28,671	32,214	34,086	35,503	34,270	33,809	34,035
Cavern reservoirs	Billion m³	2.8	4.8	6.1	6.8	9.2	14.3	15.1	14.3
Porous-rock reservoirs	Billion m³	5.2	8.5	12.5	12.4	12.1	9.8	8.6	8.6

Most of the gas extracted in Germany is moved via pipelines from gas fields and their pumping stations (either on land or off the coast). Imported gas is also transported mainly via pipelines.

The emission factor for underground natural gas storage was derived via surveys of operators and analysis of statistics on accidents / incidents [9)], and it is valid for porous storage and cavern-storage facilities. The NMVOC split factor have been obtained from the research project [10)] described on chapter 6.

Table 6: NMVOC content of natural gas, mean values from [11)]

1990	2000	2010	2020
2,57%	2,87%	3,43%	3,50%

1.B.2.b.v - Distribution

The emissions caused by gas distribution have decreased slightly, even though gas throughput has increased considerably and the distribution network has been enlarged considerably with respect to its size in 1990. One important reason for this improvement is that the gas-distribution network has been modernised, especially in eastern Germany. In particular, the share of grey cast-iron lines in the low-pressure network has been reduced, with such lines being supplanted by low-emissions plastic pipelines. Another reason for the reduction is that fugitive losses in distribution have been reduced through a range of technical improvements (tightly sealing fittings such as flanges, valves, pumps, compressors) undertaken in keeping with emissions-control provisions in relevant regulations (TA Luft (1986) and TA Luft (2002)).

Table 7: Length of natural gas distribution network, in [km]

1990	1995	2000	2005	2010	2015	2020	2023
282,612	366,987	362,388	402,391	471,886	474,570	503,543	529,000

Pipeline network

The calculation was carried out using the Tier 3 method, on the basis of the available network statistics of the German Association of Energy and Water Industries (BDEW) [12)] and of own surveys. In the early 1990s, emissions from distribution of town gas were also taken into account in calculations. In 1990, the town gas distribution network accounted for a total of 16 % of the entire gas network. Of that share, 15 % consisted of grey cast-iron lines and 85 % consisted of steel and ductile cast-iron lines. The emission factors have been obtained from the research project [13)] with using the split factor described on chapter 6..

Storage reservoirs

Man-made above-ground storage facilities, for storage of medium-sized quantities of natural gas, help meet and balance rapid fluctuations in demand. In Germany, spherical and pipe storage tanks, and other types of low-pressure containers, are used for this purpose. Results from a relevant research project [14)] have made it possible to derive new country-specific emission factors for this area. The emissions have been calculated in accordance with the Tier 2 method.

Liquefied natural gas (LNG)

Natural gas can be liquefied, at a temperature of -161°C, for ease of transport. The liquefaction process is highly energy-intensive, however, and is normally used only in connection with long-distance transports. Germany did not have LNG terminals before 2022. Gas imports arrive mostly in gaseous form, via long-distance pipelines, and they are included in 1.B.2.b.iv. Germany now has one natural gas liquefaction facility and two satellite LNG storage facilities. Since the storage and transfer processes at those facilities are subject to the most stringent standards possible, emissions there can be ruled out. Gas can escape only in connection with maintenance work, and the gas quantities involved are extremely small. The quantities do not exceed more than a few hundred kilograms [15)].



In the 1990s, town gas (=coal gas) was supplied to households via distribution systems in East Germany and West-Berlin. The composition of coal gas varied in the different regions, consisting of hydrogen, carbon monoxide, methane and nitrogene.

1.B.2.b.vi - Post-Meter Emissions

The category describes emissions from leakage in the industrial sector and in the residential and institutional/commercial sectors as well as from natural gas-powered vehicles.

Leakage in the industrial sector and in the residential and institutional/commercial sectors

The activity data is based on own surveys.

Table 8: Number of gas meters in the residential and institutional / commercial sector, in Millions

1990	1995	2000	2005	2010	2015	2020	2023
10.3	12.7	12.8	13.3	12.9	13.0	13.1	13.1

The emission factors are country-specific, and they were determined via the research project by DVGW and GWI [16)]. They include start-stopp loses at all enduser devices. The study covers methane only. The appropriate NMVOC factor was derived from the publication [17)] (refer to chapter 6).

Natural-gas-powered vehicles, and CNG fuelling stations

Use of vehicles running on natural gas continues to increase in Germany. Such vehicles are refuelled at CNG fuelling stations connected to the public gas network. In such refuelling, compressors move gas from high-pressure on-site tanks. Some 900 CNG fuelling stations are now in operation nationwide. In keeping with the stringent safety standards applying to refuelling operations and to the tanks themselves, the pertinent emissions are very low. In the main, emissions result via tank pressure tests and emptying processes.

Table 9: Number of natural-gas-powered vehicles

1990	1995	2000	2005	2010	2015	2020	2023
-.-	-.-	7,500	28,500	90,000	97,804	100,807	100,000

Recalculations

For more details please refer to the super-ordinate chapter 1.B - Fugitive Emissions from fossil fuels

Planned improvements

At the moment, no further category-specific improvements are planned.

[1), 3)] WEG (2008): Report of the Association of Oil and Gas Producing (WEG - Wirtschaftsverband Erdöl- und Erdgasgewinnung e.V.): “Erdgas – Erdöl. Entstehung-Suche-Förderung”, https://web.archive.org/web/20220119003912/https://www.bveg.de/content/download/1990/11317/file/Erdgas%20Erd%C3%B6l%20Entstehung%20Suche%20F%C3%B6rderung.pdf; Hannover, 2008
[2)] EXXON (2014): Förderung von Erdgas in Deutschland.
[4)] BVEG (2022). Statistischer Jahresbericht 2021 External Link
[5)] Zöllner, S. (2014): Überführung der Bestands- und Ereignisdaten des DVGW in die Emissionsdatenbank des Umweltbundesamts.
[6)] GASUNIE (2014). Verdichterstationen.
[7)] Ohlen, N. v. (2019): Umsetzungsbericht zum Netzentwicklungsplan Gas 2018-2028 der Fernleitungsnetzbetreiber; https://fnb-gas.de/wp-content/uploads/2021/09/2019_04_01_umsetzungsbericht_2019_1.pdf
[8)] Grosse, C. (2019). Qualitätsprüfung der Texte für den nationalen Inventarbericht und Datenerhebung in der Quellgruppe.1.B.2.b (PNr. 1252 30).
[9), 14), 15)] Langer, B. u. (2012). Ermittlung von Emissionsfaktoren und Aktivitätsraten im Bereich IPCC (1996) 1.B.2.b.iii (Bericht Nr. M96023/01, UBA FKZ 360 16 035).
[10), 11), 13), 17)] Boettcher, C. (2022) Aktualisierung der Emissionsfaktoren für Methan für die Erdgasbereitstellung, published by UBA External Link
[12)] German Association of Energy and Water Industries (BDEW) (2016). 2016 Gas Statistics “Gasstatistik 2016”.
[16)] Entwicklung der Methanemissionen in der Gasanwendung, published by DVGW and GWI (2022) External Link

1.B.2.c - Venting and Flaring

Category Code	Method	AD	EF
1.B.2.c	T2	AS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	Pb	Cd	**Hg**	Additional HM	POPs
-/-	-/-	-/-	NA	-/-	-/-	-/-	-/-	-/-	NA	NA	-/-	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Pursuant to general requirements of the Technical Instructions on Air Quality Control TA Luft (2002), gases, steam, hydrogen and hydrogen sulphide released from pressure valves and venting equipment must be collected in a gas-collection system. Wherever possible, gases so collected are burned in process combustion. Where such use is not possible, the gases are piped to a flare. Flares used for flaring of such gases must fulfill at least the requirements for flares for combustion of gases from operational disruptions and from safety valves. For refineries and other types of plants in categories 1.B.2, flares are indispensable safety components. In crude-oil refining, excessive pressures can build up in process systems, for various reasons.

Such excessive pressures have to be reduced via safety valves, to prevent tanks and pipelines from bursting. Safety valves release relevant products into pipelines that lead to flares. Flares carry out controlled burning of gases released via excessive pressures. When in place, flare-gas recovery systems liquify the majority of such gases and return them to refining processes or to refinery combustion systems. In the process, more than 99 % of the hydrocarbons in the gases are converted to CO_2 and H_2O. When a plant has such systems in operation, its flarehead will seldom show more than a small pilot flame.

Table 1: Activity data applied for 1.B.2.c

	Unit	1990	1995	2000	2005	2010	2015	2020	2023
Flared natural gas	millions of m³	36	33	36	18.7	12.1	10.5	14.1	10.8
Refined crude-oil quantity	millions of t	107	96.5	107.6	114.6	95.4	93.4	84.0	79.1

Flaring takes place in extraction and pumping systems and at refineries. In refineries, flaring operations are subdivided into regular operations and start-up / shut-down operations in connection with disruptions.

Table 2: Emission factors applied for flaring emissions in natural gas extraction, in [kg/ 1000 m^3]

	Value
NMVOC	0.005
NO_x	1.269
SO_2	8.885
CO	0.726

Table 3: Emission factors applied for flaring emissions at petroleum production facilities

	Unit	Value
NO_x	kg/t	0.008
SO_2	kg/t	0.010
CO	g/t	0.1

Table 4: Emission factors applied for flaring emissions at at refineries: normal flaring operations

	Unit	Value
NMVOC	kg/m³	0.004
CO	kg/m³	0.001
SO_2	kg/m³	0.003
NO_x	g/m³	0.4

Table 5: Emission factors applied for flaring emissions at at refineries: disruptions of flaring operations, in [kg/t]

	Value
NMVOC	0.001
CO	0.001
SO_2	0.007
NO_x	0.004

The emission factors have been derived from the 2004 and 2008 emissions declarations Theloke et al. 2013 [1)]. In 2019, they were updated for CH_4, N_2O, CO, NMVOC, NO_x and SO_2, on the basis of Bender & von Müller, 2019 [2)].

Venting emissions are taken into account in category 1.B.2.b.iii. The SO_2 emissions are obtained from the activity data for the flared natural gas (Table 178) and an emission factor of 0.140 kg / 1,000 m³, a factor which takes account of an average H_2S content of 5 % by volume. The emission factors are determined on the basis of emissions reports, crude-oil-refining capacity and total capacity utilisation at German refineries. The guide for this work consists of the evaluation assessment of Theloke et al. (2013) [3)].

Recalculations



For more details please refer to the super-ordinate chapter 1.B - Fugitive Emissions from fossil fuels

Planned improvements



At the moment, no further category-specific improvements are planned.

[1), 3)] Theloke et al. (2013): Theloke, J., Kampffmeyer, T., Kugler, U., Friedrich, R., Schilling, S., Wolf, L., & Springwald, T.: Ermittlung von Emissionsfaktoren und Aktivitätsraten im Bereich IPCC - Diffuse Emissionen aus Mineralöl und Mineralölprodukten; Institut für Energiewirtschaft und Rationelle Energieanwendung (IER) (University of Stuttgart) with Eurofins GfA GmbH (Mannheim) and Ökopol GmbH (Hamburg), on behalf of the Umweltbundesamt, Dessau-Roßlau, 2013 (not available online)

[2)] Bender, M., & von Müller, G. (2019). Konsolidierung der Treibhausgasemissionsberechnungen unter der 2. Verpflichtungsperiode des Kyoto-Protokolls und der neuen Klimaschutz-Berichterstattungs-pflichten an die EU (FKZ 3716 41 107 0).

1.B.3 - Geothermal Energy

Operation of geothermal power stations and heat stations in Germany produces no emissions. The thermal-water circuits of such installations are closed and airtight, both above and below ground level. As a result, no emissions occur during their operation. Even a release of the gases dissolved in the heat-carrying fluid – primarily, hydrogen (H_2), methane (CH_4), carbon dioxide (CO_2), and hydrogen sulphide (H_2S) – would not lead to concentrations worthy of reporting.

No emission factors for pollutants that could escape in connection with drilling for tapping of geothermal energy (both near-surface and deep energy) are known for Germany at present.

From a geoscientific standpoint, however, it is clear that virtually any drilling will lead to releases of gases bound in underground layers – and the gases involved can include H_2, CH_4, CO_2, H_2S and Rn [1)].

In many cases, and especially in drilling for tapping of geothermal energy near the surface, such emissions would be expected to be very low. “Blow-out preventers”, which are safety devices that guard against gas releases, are now used in connection with all deep drilling. In addition, specially modified drilling fluids are used that force gases that are released into the well back into the penetrated rock layers.

In drilling operations for near-surface geothermal energy, as in drilling of wells for drinking water, only low emissions levels are normally encountered, due to the low gas concentrations found near the surface. In the interest of preventing gas releases, drilling of deep geothermal wells is subject to the same safety regulations that apply to hydrocarbon exploration, including obligations to use Christmas trees and blowout preventers, to prevent accidents. A study by Frick et al. (2007)[2)] estimates that NMVOC emissions from geothermal drilling sum up to nearly 30 kg/a.

[1)] Theloke et al. (2013): Theloke, J., Kampffmeyer, T., Kugler, U., Friedrich, R., Schilling, S., Wolf, L., & Springwald, T.: Ermittlung von Emissionsfaktoren und Aktivitätsraten im Bereich IPCC - Diffuse Emissionen aus Mineralöl und Mineralölprodukten; Institut für Energiewirtschaft und Rationelle Energieanwendung (IER) (University of Stuttgart) with Eurofins GfA GmbH (Mannheim) and Ökopol GmbH (Hamburg), on behalf of the Umweltbundesamt, Dessau-Roßlau, 2013 (not available online)

[2)] Frick et al. (2007): Frick, St., Schröder, G., Rychtyk, M., and Bohnenschäfer, W.: Umwelteffekte einer geothermischen Stromerzeugung -Analyse und Bewertung der klein-und großräumigen Umwelteffekte der geothermischen Stromerzeugung (FKZ 205 421 10), Institute for Energy and Environment (Institut für Energetik und Umwelt gGmbH (IE)), on behalf of the Umweltbundesamt; https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/endbericht_fkz_205_42_110-gesamtausgabe.pdf; Leipzig, 2007

CHAPTER 4: NFR 2 - Industrial Processes and Product Use (IPPU)

Industrial processes are an important emission source for most pollutants. Due to Germany's high-level, differentiated industry featuring numerous companies and a large number of plants for each sector, emission estimation for industrial processes is very complex. Please refer to the sub-sections below for details.

In the area of industrial processes, production data from association statistics and of manufacturers' information is used. In the interest of the inventory's completeness and reliability, checking of source-category definitions and data-collection methods will stay a priority where emissions reporting is based on such sources. The inventory is considered complete for the main industrial processes. [!– (Should be described at the source category level) Nevertheless, there are still certain categories awaiting further examination, though only negligible contributions to the national total emissions are expected. –]

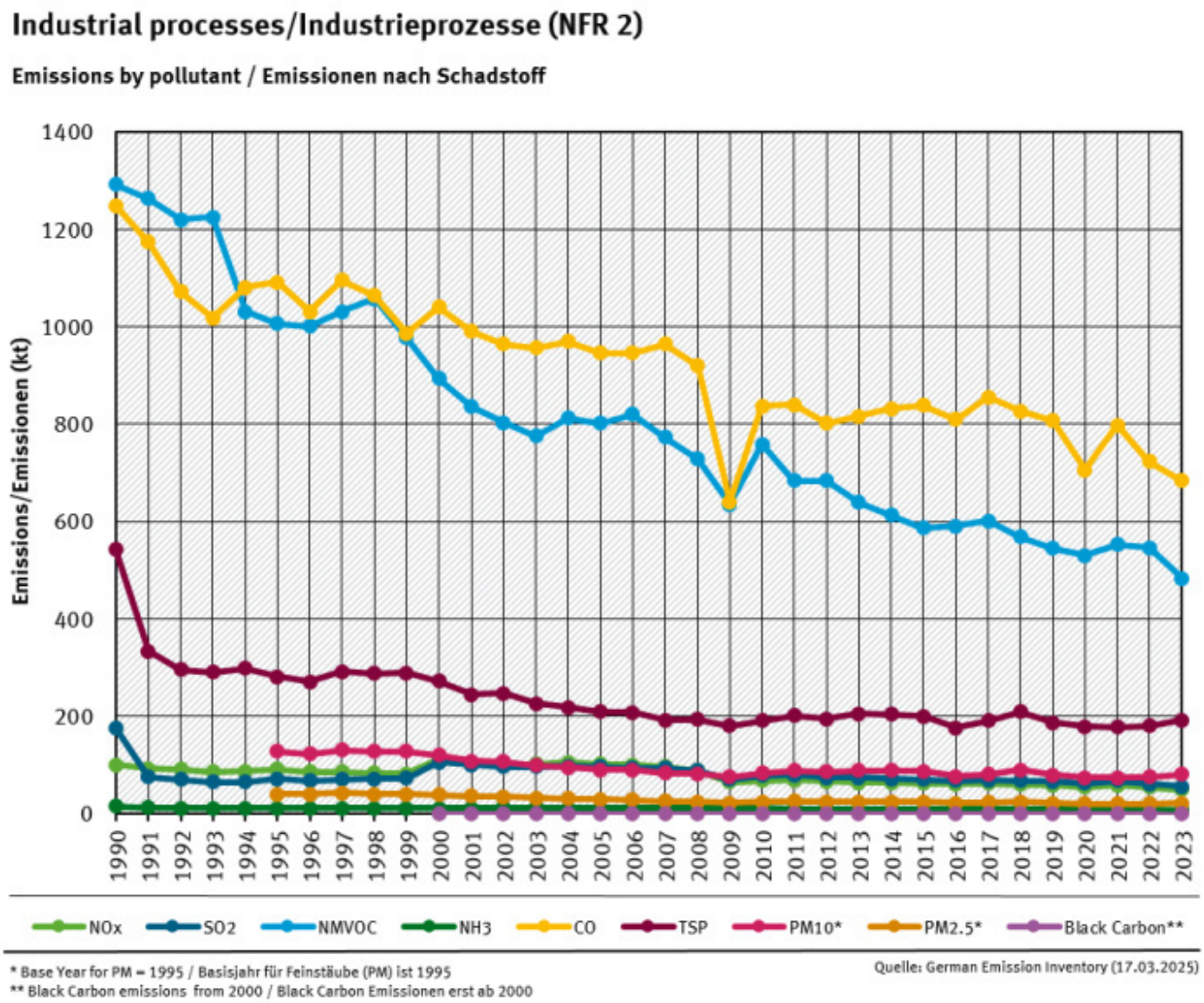
NFR 2 consists of the following and sub-categories:

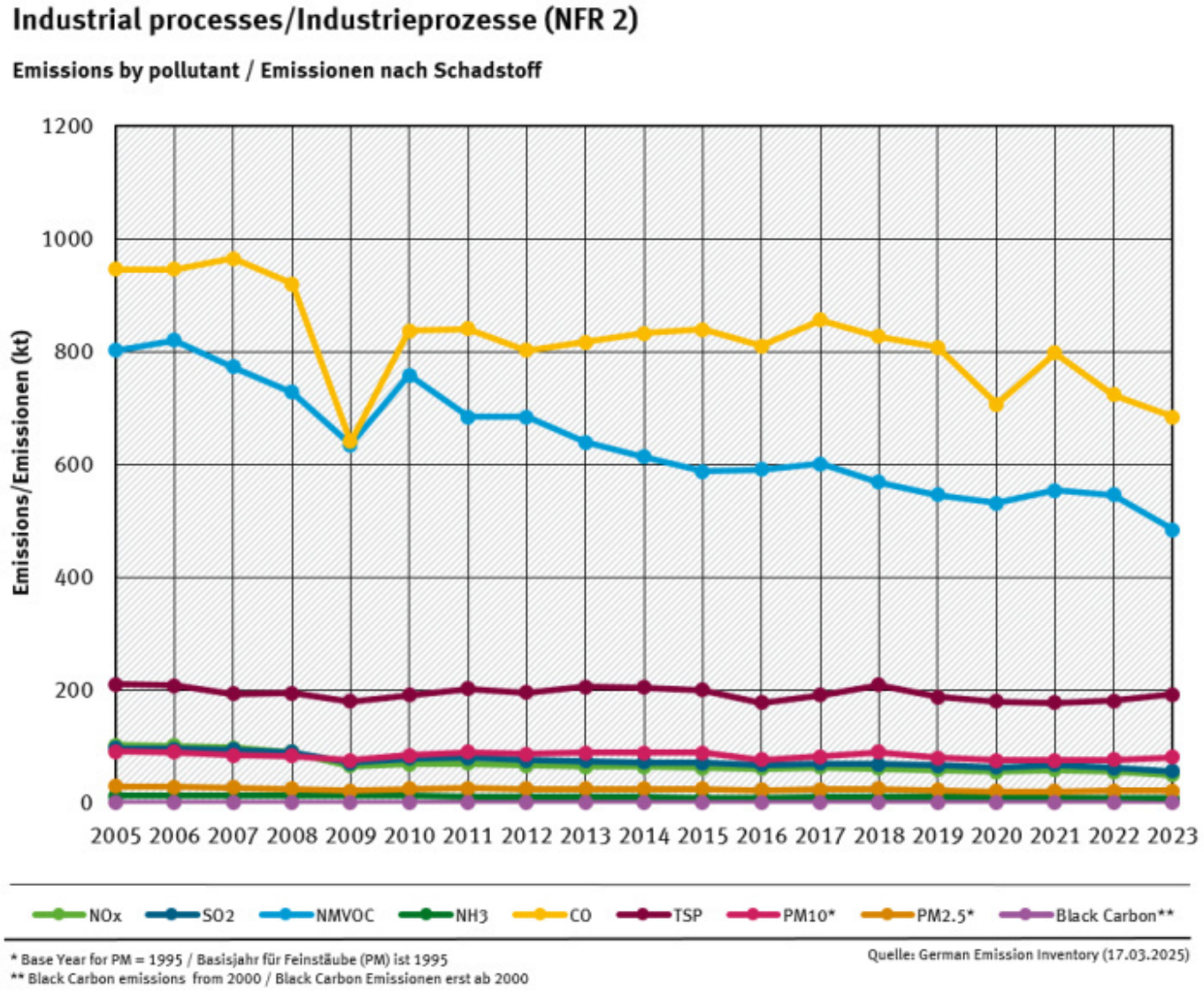
2.A Mineral Industry
2.A.1 Cement Production
2.A.2 Lime Production
2.A.3 Glass Production
2.A.5.a Quarrying and Mining of Minerals other than Coal
2.A.5.b Construction and Demolition
2.A.5.c Storage, Handling and Transport of Mineral Products
2.A.6 Other Mineral Products
2.B Chemical Industry
2.B.1 Ammonia Production
2.B.2 Nitric Acid Production
2.B.3 Adipic Acid Production
2.B.5 Carbide Production
2.B.6 Titanium Dioxide Production
2.B.7 Soda Ash Production
2.B.10.a Other
2.B.10.b Storage, Handling and Transport of Chemical Products
2.C Metal Industry
2.C.1 Iron and Steel Production
2.C.2 Ferroalloys Production
2.C.3 Aluminum Production
2.C.4 Magnesium Production
2.C.5 Lead Production
2.C.6 Zinc Production
2.C.7.a Copper Production
2.C.7.b Nickel Production
2.C.7.c Other Metal_Production
2.C.7.d Storage, Handling and Transport of Metal Products
2.D Other Solvent and Product Use
2.D.3.a Domestic Solvent Use including fungicides
2.D.3.b Road Paving with Asphalt
2.D.3.c Asphalt Roofing
2.D.3.d Coating Applications
2.D.3.e Degreasing
2.D.3.f Dry Cleaning
2.D.3.g Chemical Products
2.D.3.h Printing
2.D.3.i Other Solvent Use
2.G Other Product Use
2.G.4 Use of Fireworks

2.A Mineral Industry
2.G.4 Use of Tobacco
2.G.4 Use of Charcoal
2.G.4 Use of Lubricants
2.H Other (Pulp & Paper, Food)
2.H.1 Pulp and Paper Industry
2.H.2 Food and Beverages Industry
2.H.3 Other Industrial Processes
2.I Wood Processing
2.J Production of POPs
2.K Consumption of POPs and Heavy Metals
2.L Other Production, Consumption, Storage, Transportation or Handling of Bulk Products
2.L(a) Handling of Bulk Products
2.L(b) Diffuse Emissions From Industrial Establishments

Visual overview

Emission trends for main pollutants in *NFR 2 - Industrial Processes*:

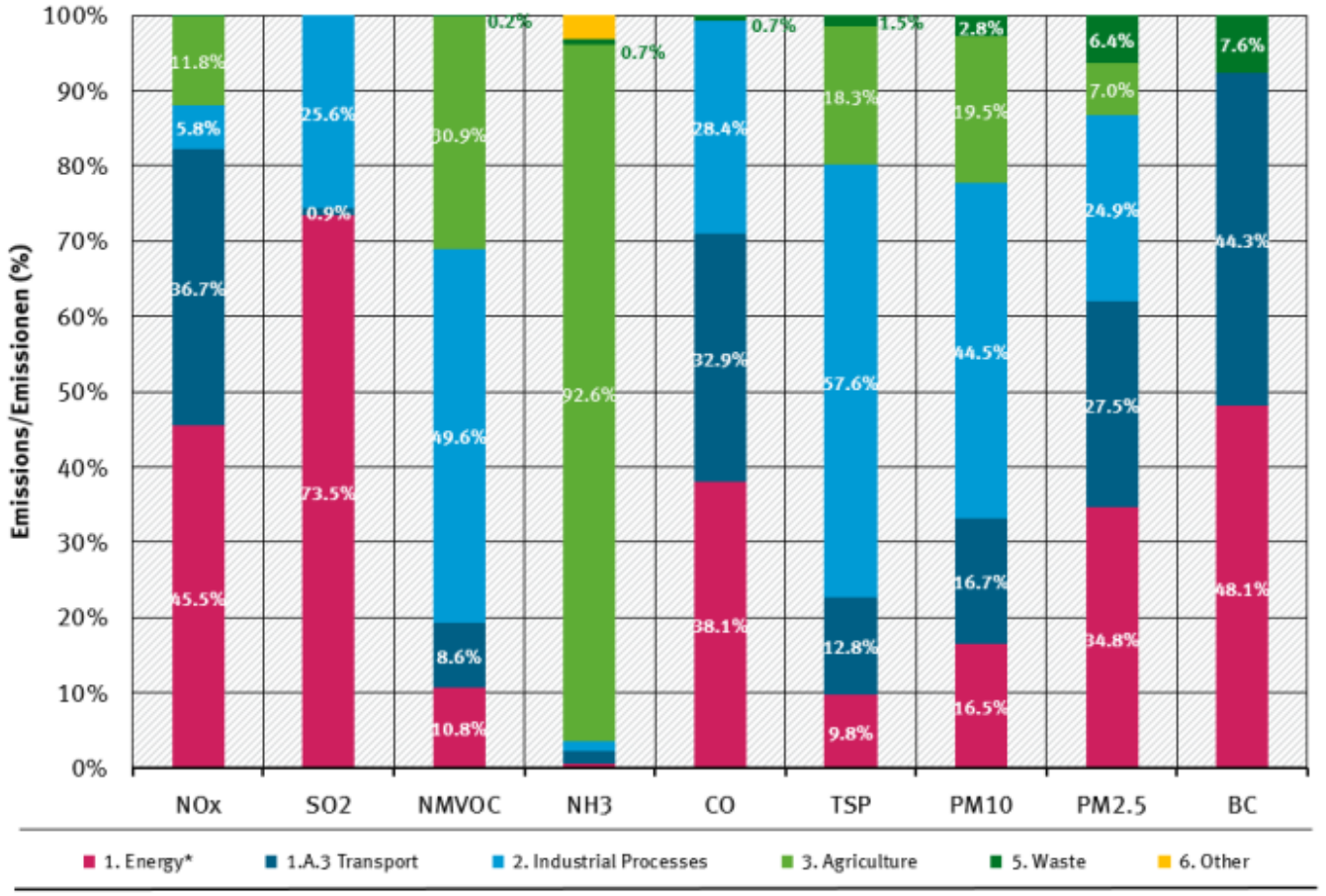




[Contribution of NFRs 1 to 6 to the National Totals, for 2021]

Contribution of NFR categories to the emissions

percentages per air pollutant, 2023



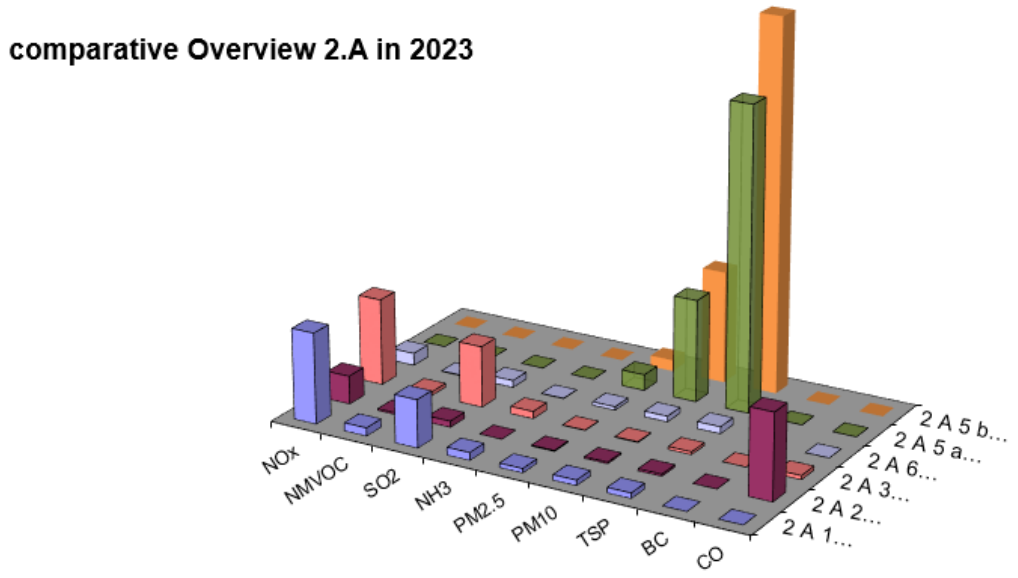
* w/o Transport / ohne Verkehr (1.A.3)

Quelle: German Emission Inventory (17.03.2025)

2.A - Mineral Industry (OVERVIEW)

2.A - Mineral Industry
2.A.1 Cement Production
2.A.2 Lime Production
2.A.3 Glass Production
2.A.5.a Quarrying and Mining of Minerals other than Coal
2.A.5.b Construction and Demolition
2.A.5.c Storage, Handling and Transport of Mineral Products
2.A.6 Other Mineral Products: Ceramics

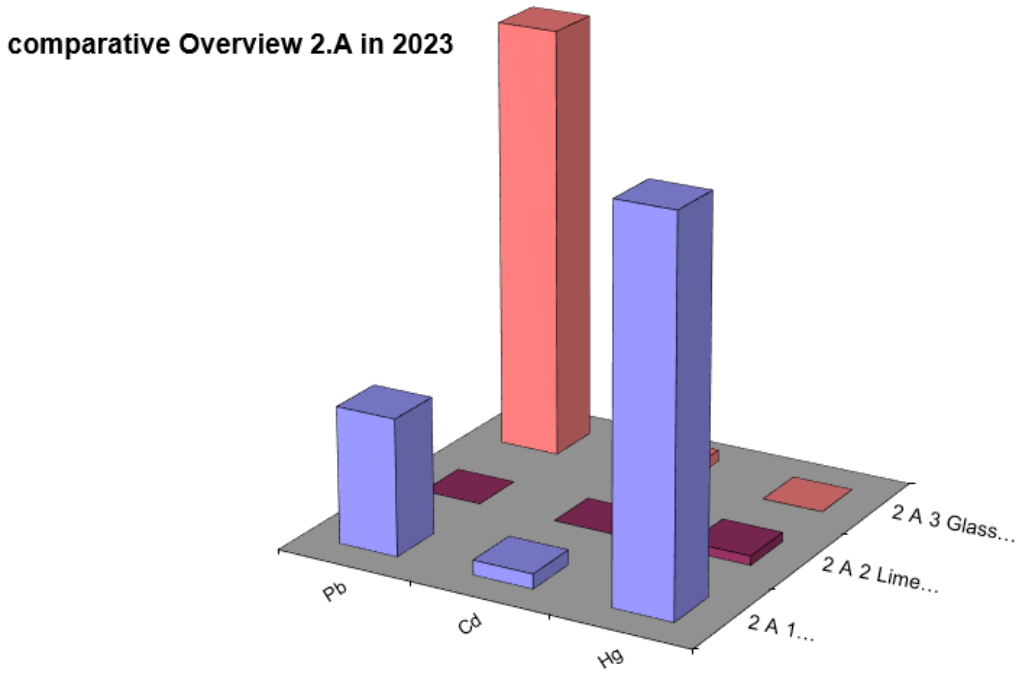
The Mineral Industry comprises six different sub-categories partly divergent to reporting format of Greenhouse Gases (CRF). The main categories are the Cement Production (2.A.1), Lime Production (2.A.2), Glass Production (2.A.3). But further mineral industries are important regarding other specific emissions, highlighted here: Mining other than coal (2.A.5.a), Construction (2.A.5.b) and Ceramics Production (2.A.6).



all values in Gg

	NOx	NMVOC	SO2	NH3	PM2.5	PM10	TSP	BC	CO
2 A 1 Cement Production	10,4	0,9	5,5	0,9	0,5	0,6	0,6	0,0	0,0
2 A 2 Lime Production	3,2	0,2	0,7	0,0	0,1	0,2	0,2	0,0	9,9
2 A 3 Glass Production	9,9	0,4	7,0	0,8	0,0	0,1	0,3	0,0	0,5
2 A 6 Ceramic Production	1,4	0,1	0,8	0,0	0,4	0,6	0,8	0,0	0,0
2 A 5 a Mining	0,0	0,0	0,0	0,0	1,8	11,7	34,9	0,0	0,0
2 A 5 b Construction	0,0	0,0	0,0	0,0	1,3	12,8	42,8	0,0	0,0

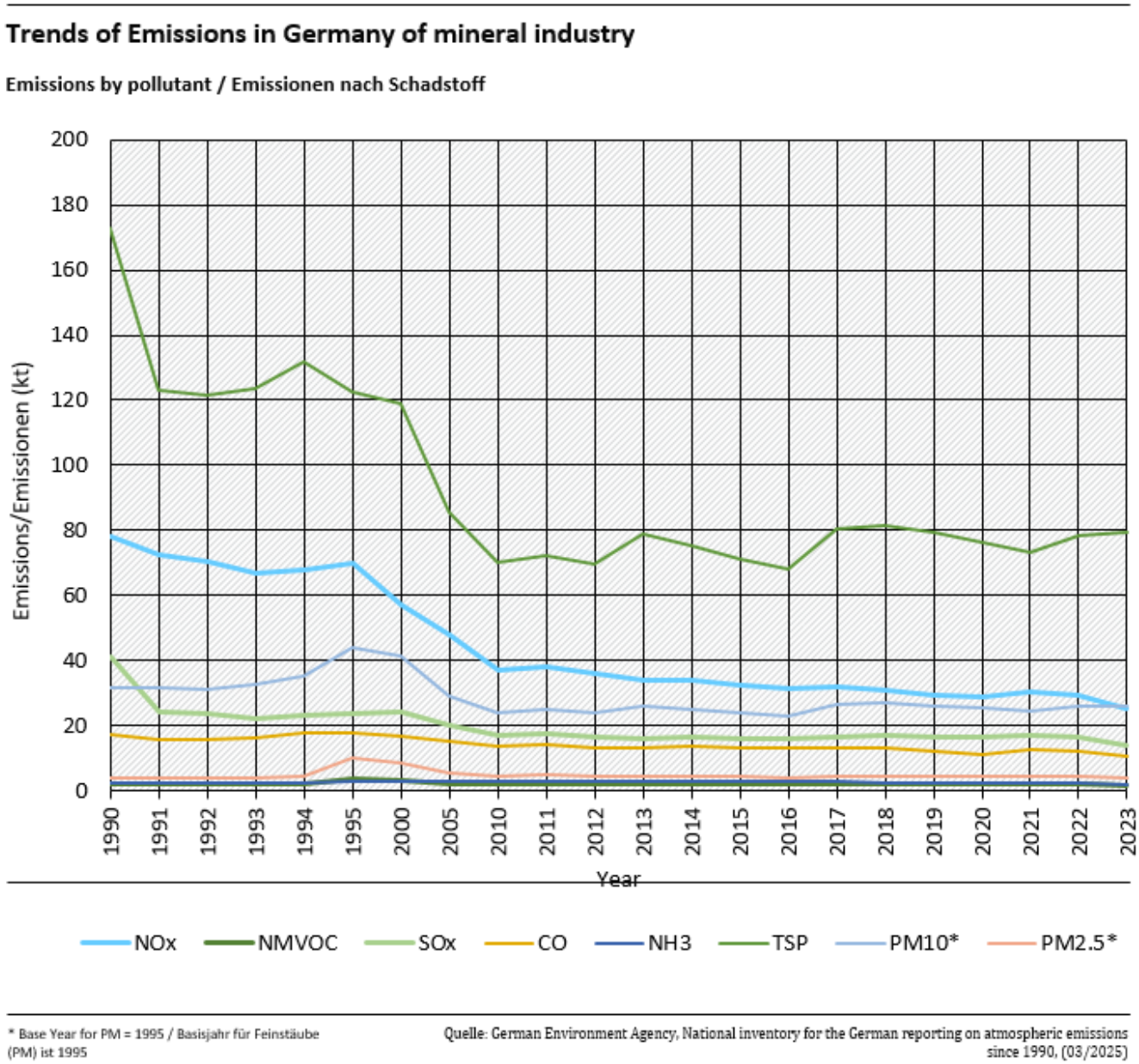
Emissions of air pollutants



all values in Mg	Pb	Cd	Hg
2 A 1 Cement Production	0,19	0,02	0,53
2 A 2 Lime Production	0,00	0,00	0,01
2 A 3 Glass Production	0,59	0,02	0,00

Emissions of heavy metals

Discussion of emission Trends



Emission trends in NFR 2.A

The steep reduction especially for TSP and SO_2 at the beginning of the 1990s was due especially to closures in the eastern German industrial sector. The last statistic of the GDR[1)] is the source for emissions data of year 1990 for eastern Germany in cases of TSP and SO_2, in principle absolut amounts of emissions not old emission factors within a calculation. These unusual emissions are allocated to 2.A.6 Other Mineral Products.

[1)] Emissionsberichte 1985 - 1989 / released by Statistischen Amt der DDR, not public, but existing copy in UBA-Library under signature LU350633/1989

2.A.1 - Cement Production

Short description

Category Code	Method	AD	EF
2.A.1	T1	AS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/F**	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAH1-4**	HCB	**PCBs**
-/-	-/-	-/-	-/-	**-/T**	**-/T**	-/-	NE	IE	-/-	-/-	**L/-**	NE	NE	NE	NE	NE	NE	-/-	-/-	IE	IE	IE	-/-	NA	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

The remarks below refer to production of cement clinkers and clinker grinding (only relevant as a source for particulate matter). The clinker-burning with intensive use of energy emits climate-relevant gases. CO_2 accounts for the great majority of these emissions, but heavy metals are important too.

Methodology

Activity data

cement clinker

Activity data are determined via summation of figures for individual plants (until 1994, activity data were determined on the

basis of data of the official member association BDZ). As of 1995, following optimisation of data collection within the association, activity data were compiled by the German Cement Works Association (VDZ), and by its VDZ research institute (located in Düsseldorf), via surveys of German cement plants. The data are supplemented with data for plants that are not BDZ members (in part, also VDZ estimates).

For internal reasons within the association, the data for the years from 2015 onwards is not available from the VDZ. Instead, the cement clinker specification is based on aggregated plant specific ETS-data of DEHSt. A comparison for the years 2005-2014 showed a good correlation between information of the European Emissions Trading (ETS) and the cement clinker production data of the VDZ. So, the cement clinker information from 2015 onwards is based on aggregated data of ETS. All companies are required to report production data within the framework of CO_2-ETS. The EU monitoring guidelines for emissions trading specify a maximum accuracy of 2.5%. Furthermore CKD was taken into account.

According to the VDZ, the share of bypass dust in clinker production was between 1% and 2% between 2009 and 2016. For the inclusion as an activity rate, it can be assumed that the share was 2 % from 2009 onwards, for time before only 1%.

grinded cement

The annual amount of grinded cement is provided by VDZ, too, but calculated based on statistical data [1)]

Emission factors

The emission factors used for emissions calculation are based on figures from research projects [2)3)] as well as from expert judgements.

In the German cement industry, dust separated from clinker burning exhaust gas is returned to the burning process. As a result, there is no need to take account of significant losses of particles via the exhaust-gas pathway. - On the other hand, particulate matter emissions occur during clinker grinding.

The EF applied for Hg fits very well with aggregated figures from individual plants as available from the PRTR-reporting.

Table 1: Overview of emission factors applied for 2019 (or most recently available) up to the current cut-off point

	EF	Unit	Trend before
emissions from clinker burning			
NO_x	0.51	kg/t	falling
SO_2	0.27	kg/t	falling
NMVOC	0.046 (2013)	kg/t	constant
NH_3	0.044	kg/t	falling
Hg	0.026	g/t	falling
Pb	0.0092	g/t	falling
Cd	0.001	g/t	falling
PCB	28.0 (2004)	µg/t	constant
PCDD	0.0035	µg/t	falling
B(a)P[1]	1.0 (2004)	mg/t	constant
PAH-16[2]	240.0 (2004)	mg/t	constant
emissions from clinker grinding			
TSP	*0.022*	*kg/t*	*falling*
PM_{10}	*0.022*	*kg/t*	*falling*
$PM_{2.5}$	*0.018*	*kg/t*	*falling*

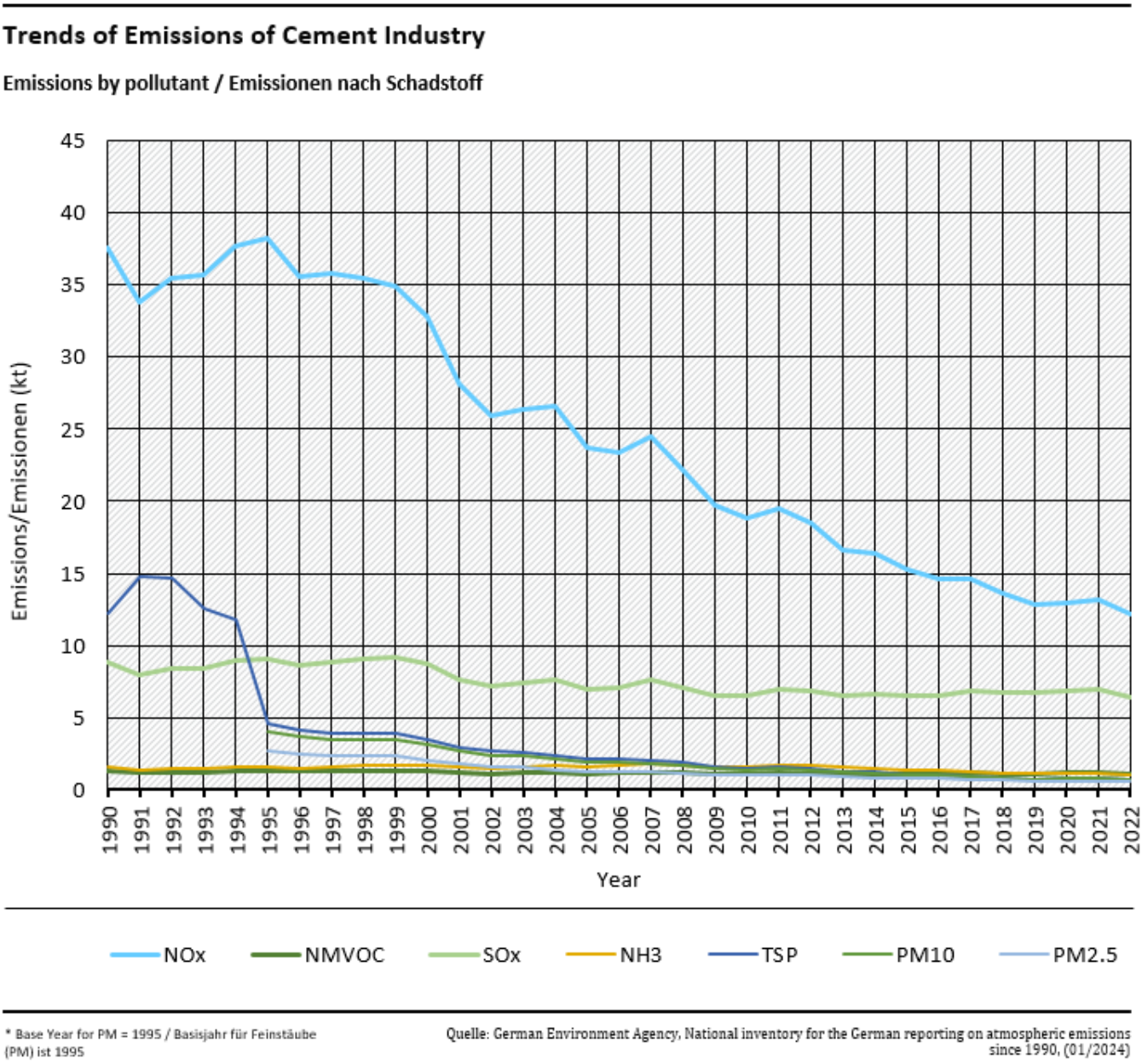
[1] The data for PAH 1-4 provided in the NFR tables only represents the sum the four PAHs, in this case even only for B[a]P. [2] Outside NFR tables, several more PAH specimen are known to be emitted here (research result for EPA-PAH, PAH16 standard).

According to research results, HCB emissions are not occuring from cement production and are, hence, reported as not applicable (NA).

The table of EF is related to two different AD sets. For the majority pollutants, annual amounts of *burnt* clinker are applied as activity data. In contrast, regarding PM emissions, the annual amount of *grinded* clinker is applied (included in further materials as domestic burnt clinker). Unfortunately, within the NFR tables only one AD (burnt clinker) can be provided.

Trends in emissions

All trends in emissions correspond to trends of emission factors in table above. No rising trends are to identify.



Emission trends in NFR 2.A.1

note: for 2023 further decreasing because of less production

Recalculations

With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

Planned improvements



At the moment, no category-specific improvements are planned.

[1)] Sum of two Statistical-IDs: GP19-235112100 and GP19-235112900

[2)] Ruppert et al. (2009): Ruppert, J., Scheuer, W., Schäfer, St.: „Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarungen für ausgewählte Industriebranchen: Teilvorhaben, UBA-FB 001334, available https://search.ebscohost.com/login.aspx?direct=true&db=cat04356a&AN=fuu.02331791&lang=de&site=eds-live, ReFoPlan Forschungskennzahl 370742301/03; Forschungsinstitut der Zementindustrie, Düsseldorf, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009

[3)] Schäfer et al. (2022): Schäfer, Dr. St., Ruppert, Dr. J., Furth, Dr. G., Schulte, S.; VDZ Technology gGmbH, Düsseldorf: “Überarbeitung der Emissionsfaktoren für Luftschadstoffe in den Branchen Zementklinkerproduktion und Glasherstellung; Teilbericht - Zementklinkerproduktion”; Forschungskennzahl 3719 52 1010; FB000678; ISSN 1862-4804; https://www.umweltbundesamt.de/publikationen/ueberarbeitung-der-emissionsfaktoren-fuer-0; on behalf of the Umweltbundesamt, Dessau-Roßlau, February 2022

2.A.2 - Lime Production

Short description

Category Code	Method	AD	EF
2.A.1	T1	AS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	Other HM	POPs
-/-	-/-	-/-	IE	-/-	-/-	-/-	NE	-/-	NE	NE	-/-	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

The statements made below regarding source category 2.A.2 refer solely to the amounts of burnt lime and dolomite lime produced in German lime works. Other lime-producing processes are included in NFRs 2.C.1 and 2.H.2.

Because of the wide range of applications covered by the sector's products, lime production is normally more isolated from economic fluctuations than is production of other mineral products such as cement. Production has fluctuated relatively little since the end of the 1990s. Dolomite-lime production, of which significantly smaller amounts are produced, basically exhibits similar fluctuations.

Methodology

The pertinent emissions level is obtained by multiplying the amount of product in question (quick lime or dolomite lime) and

the relevant emission factor.

Activity data

The Federal Association of the German Lime Industry (Bundesverband der Deutschen Kalkindustrie e. V. - BVK) [1)] collects and provides plant-specific production data for the entire time series.

Production amounts are determined via several different concurrent procedures resulting in adequately assured data quality (Tier 2).

Most companies are also required to report lime-production data within the framework of CO_2 emissions trading. The EU monitoring guidelines for emissions trading specify a maximum accuracy of 2.5%. It is additionally assumed that 2% of the burnt lime is separated as dust in all years as of 1990 via appropriate exhaust gas purification systems and is not returned to the production process. This is taken into account by a potential 2% increase in activity rates.

Emission factors

Due to a recommendation during NEC-Review 2021, the calculation of CO emissions from lime production is allocated to process emissions and based on default EF. All other EF are country-specific values derived from different research projects.

Table 1: Emission factors for quick-lime production

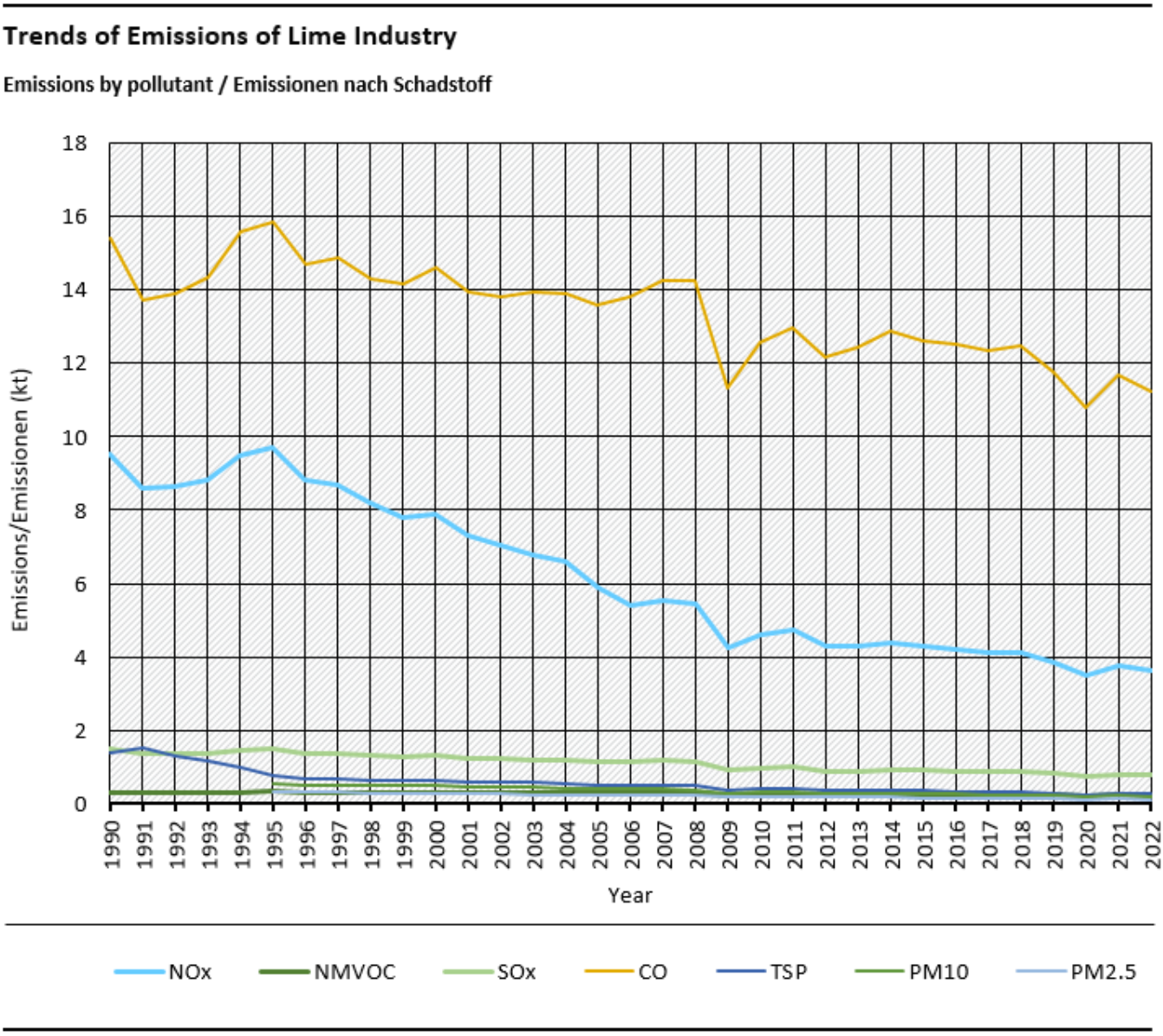
	EF	unit	Trend
NO_x	0.59	kg/t	falling
SO_2	0.12	kg/t	falling
NMVOC	0.041	kg/t	constant over time
CO	1.940	kg/t	default from EMEP/EEA (2019) [2)]
TSP	0.050	kg/t	falling
PM_{10}	0.038	kg/t	falling
$PM_{2.5}$	0.023	kg/t	falling
Hg	2.62	mg/t	falling

Table 2: Emission factors for dolomite production

	EF	unit	Trend
NO_x	1.73	kg/t	falling
SO_2	0.58	kg/t	falling
NMVOC	0.041	kg/t	constant over time
CO	1.940	kg/t	default from EMEP/EEA (2019) [3)]
TSP	0.034	kg/t	falling
PM_{10}	0.026	kg/t	falling
$PM_{2.5}$	0.015	kg/t	falling
Hg	2.63	mg/t	falling

Trends in emissions

All trends in emissions correspond to trends of emission factors in table above. No rising trends are identified.



Emission trends in NFR 2.A.2

note: small change for 2023

Recalculations

Recalculations were necessary due to small corrections of activity data from the years 2021 and 2022.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are

planned.

[1)] Federal Association of the German Lime Industry (Bundesverband der Deutschen Kalkindustrie e. V. - BVK): https://www.kalk.de/

[2), 3)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, chapter 2.A.2 Lime production 2019: Table 3-23 Tier 2 emission factors for source category 1.A.2.f.i, Lime production: https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/2-industrial-processes/2-a-mineral-products/2-a-2-lime-production/@@download/file; EEA, Copenhagen, 2019

2.A.3 - Glass Production

Short description

Category Code	Method	AD	EF
2.A.3	T2	AS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
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M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	Hg	**As**	**Cr**	**Cu**	**Ni**	**Se**	Zn	POPs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	NA	-/-	-/-	-/-	-/-	**L/T**	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Germany's glass industry produces a wide range of different glass types that differ in their chemical composition.

The national glass production sector includes of the following sub-sectors:

- container glass (bottles, jars, drinkware, and bowls),
- flat glass (used for windows, glass doors, transparent walls etc.),
- domestic glass,
- special glass

and

- mineral fibres (glass and stone wool).

The largest production quantities are found in the sectors of container glass and flat glass. Further processing and treatment

of glass and glass objects are not considered.

The glass industry, in particular container glass production, is the main factor in selenium emissions. It accounted for more than 60 % in 1990 and around 45 % in recent years, reaching a peak of almost 80 % in 1995. A complete analysis over all categories is not done (see above '*').

Methodology

The emissions are calculated via a higher Tier method resembling a Tier 2 method, as the activity rates are tied to specific emission factors for different glass types.

Activity data

The production figures are taken from the regularly appearing annual reports of the Federal Association of the German Glass Industry (Bundesverband Glasindustrie; BV Glas). “Production” refers to the amount of glass produced, which is considered to be equivalent to the amount of glass melted down.

Emission factors

The procedure used to determine emission factors for the various glass types involved and the pertinent emissions is described in detail in reports of two research projects (2008: Report-No. 001264[1)], 2021: Texte 45/2021[2)]). The emission factors were calculated for the various industry sectors. The factors vary over time in keeping with industry monitoring, not only as steady trends, but falling in most cases. The most recently EF are for different glass types the following:

Table 1: Overview of most recently applied emission factors

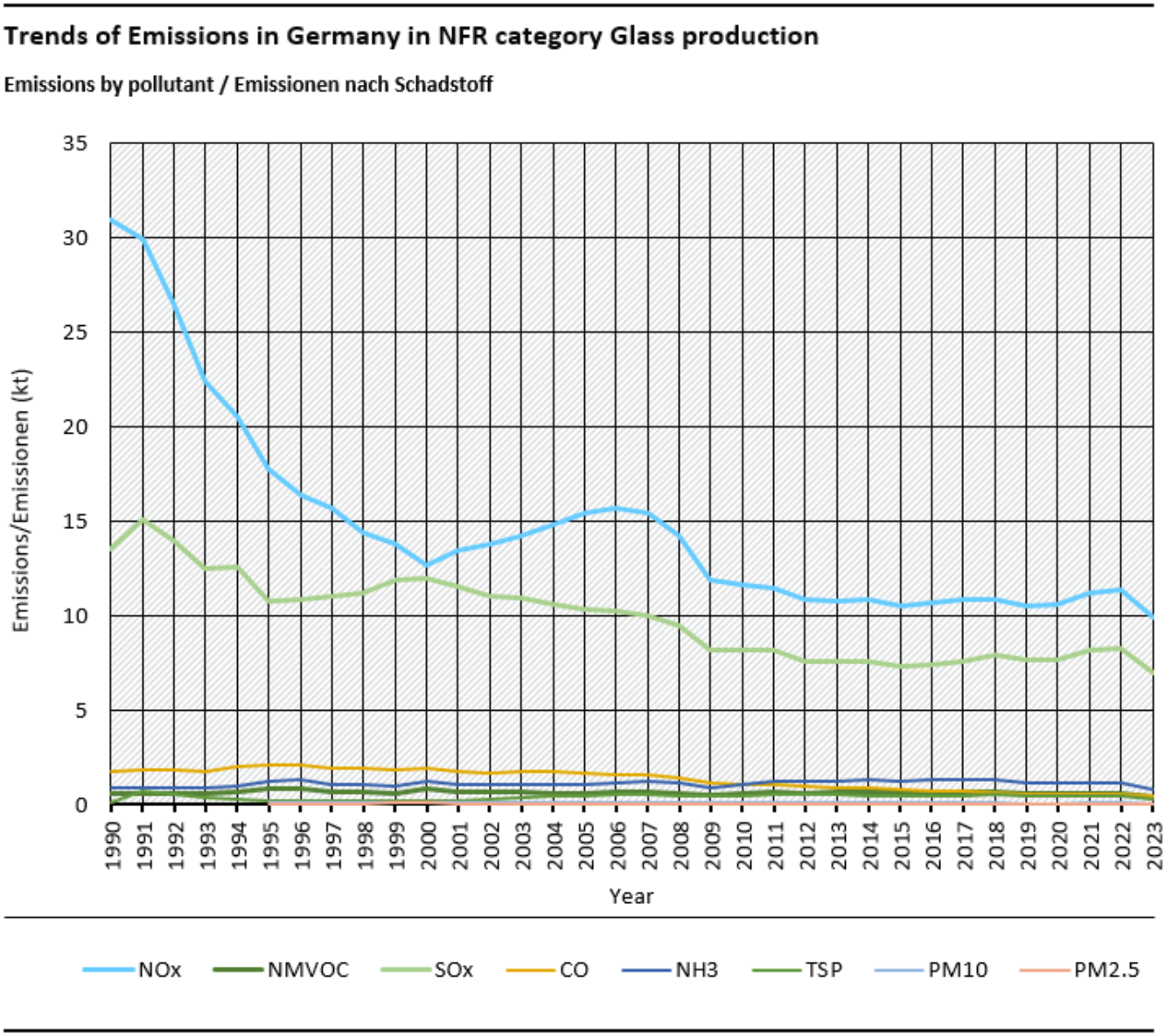
	Unit	Container glass	flat glass	domestic glass	special glass	fibre optics	stone wool
NO_x	kg/t	1.0766	1.7708	2.8602	3.5558	0.8	1.877
SO_2	kg/t	0.759	1.5677	0.0599	0.1157	0.1847	2.229
NMVOC	kg/t	NA	NA	NA	NA	0.6	0.657
CO	kg/t	0.0732	0.0241	0.0661	0.1195	0.06	0.185
NH_3	kg/t	0.0026	0.0191	NA	0.0295	1.10	1.163
TSP	kg/t	0.00863	0.01681	0.015	0.00765	0.01096	0.643
PM_{10}	kg/t	0.00742	0.01429	0.0129	0.0065	0.00932	0.0234
$PM_{2.5}$	kg/t	0.00483	0.00773	0.0069	0.00352	0.00504	0.0128
As	g/t	0.0279	0.0104	0.0023	0.1143	0.0354	NE
Pb	g/t	0.1237	0.0104	0.0076	0.1158	0.1571	NE
Cd	g/t	0.0032	0.0005	0.0000	0.0028	0.0041	NE
Cr	g/t	0.0186	0.0029	0.0007	0.0148	0.0236	NE
Cu	g/t	0.0035	0.02	0.0002	0.0085	0.0056	NE
Ni	g/t	0.0048	0.0061	0.0003	0.0142	0.0061	NE
Se	g/t	0.2794	0.0427	0.1273	0.0454	0.01	NE

For each glass type the estimated EF are explained in ‘Texte 45/2021’ with an expert votum and uncertainty estimation.

Emissions of BC are not estimated, but there is no evidence from the industry monitoring for this.

Trends in emissions

Trends in emissions correspond to trends of emission factors and of production development. The resulting trends are not constant, as a result of different EF for various glass types. So emissions of NO_x and SO_2 couldn't decrease last years due to increased production Level of relevant products.



Emission trends in NFR 2.A.3

Recalculations

Recalculations were necessary due to improvements of a cullet figures in former years (2007-2016) and due update of the production of stone wool in 2021 and 2022.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] UFoPlan FKZ 206 42 300/02: Teilvorhaben 02: „Providing up-to-date emission data for the glass and mineral fiber industry“ downloading via search “UBA-FB 001264” in (https://doku.uba.de ⇒ OPAC ⇒ use parameter ‘Signatur’

[2)] ReFoPlan FKZ – 3719 52 1010: „Revision of emission factors for air pollutants in the cement clinker production and glass manufacturing sectors“ downloading via https://www.umweltbundesamt.de/sites/default/files/medien/5750/publikationen/2021-03-18_texte_45-2021_luftschadstoff_glasindustrie.pdf

2.A.5.a - Quarrying & Mining - Other Than Coal

Category Code	Method	AD	EF
2.A.5.a	T1/T2	NS/IS/AS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	CO	Heavy Metals	POPs
NA	NA	NA	NA	**L/-**	**L/T**	**L/-**	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Quarrying & Mining is the main source for particulate matter emissions within the entire **Mineral industries sub-sector (2.A)**.

Short description

Generally, mining processes emit relevant amounts of particles.

NFR 2.A.5.a - Quarrying and mining of minerals (other than coal) includes the mining of limestone, hard rock, and building sands, as well as the increasing use of corresponding recyclates.

Due to the country-specific approach applied, the production of (potash and rock) salt is a sub-category of the mining processes considered in the German air pollutant emissions inventory.

Methodology

Withi the German air pollutant emissions inventory, different approaches are applied for (i) sands and rocks, and (ii) salts:

Sands and Rocks

By applying the 2023 GB method [1)], a tier2 method is available reflecting different national conditions, in particular specific input variables on humidity and wind speed, which are localized according to the German federal states. Here, as the three German city-states (Berlin, Hamburg, and Bremen) do not represent average weather conditions, they are considered part of the surrounding federal states (Brandenburg, Schleswig-Hollstein, and Niedersachsen). Parameters on weather as well as on areas can thus be improved in the model mentioned above. In a first approach, this was done by using weather data from the German Weather Service (DWD), which can be obtained as daily station data from (DWD, 2024) [2)]. No area information from the Corine land cover before 2010 is used (consistent data sets). In addition, information from CLC category 131 (Mineral extraction sites) had to be adjusted for areas of active open-pit lignite mines. (Copernicus, 2019) [3)]

Salts

Salt mining represents only a minor portion (less than 4%, depending on the PM fraction) of the particulate-matter emissions reported for NFR 2.A.5.a.

With respect to this limited scale of both activity and emissions, salt mining is considered too insignificant for the application of a higher tier (Please see trend discussion below). Therefore, in contrast to the mining/quarrying of sands and rocks described above, a tier1 approach based on information on production of salts and country-specific emission factors for TSP and PM is applied.

Activity Data

Sands and Rocks

As provided in the calculation model presented with the EMEP/EEA Guidebook, specific activity data for hard rock, sand, and recycled material are applied. Here, due to incomplete national statistics, these specific AD are taken from national and international association information available from Aggregates Europe – UEPG (2024) [4)].

Within the framework of technical consultations, historical data were confirmed by the National Association for Mineral Resources [5)].

However, additional information and figures on mineral raw materials are compiled by the Federal Institute for Geosciences and Natural Resources (BGR) [6)] but are not yet available.

Therefore, for time series consistency, data gaps are closed via interpolation or expert adjustments.

Salts

Production data for potash and rock salt are included in national statistics, with data gaps being filled as already described for sands and rocks above. Here, as potash salt is dominating, all reported emissions are modelled as resulting from potash salt.

Emission factors

Sands and Rocks

As described above, the calculation model provided by the EEA as part of the EMEP/EEA GB takes into account national circumstances and reduction measures. The calculations are available in from of more than ten MS Excel files (individual years since 1990, annually from 2010). Since the GB tool in principle calculates emissions for exactly one year [7)], files must be available for those years for which specific input data are available. In case of data gaps, intermediate years are interpolated .

With the help of the GB tools, annual implied EFs are estimated which are used for the inventory method (EM = AR x EF). As the calculation of this implied emission factors is influenced by national circumstances and weather conditions, the EF are

consideres as being country-specific.

Salts

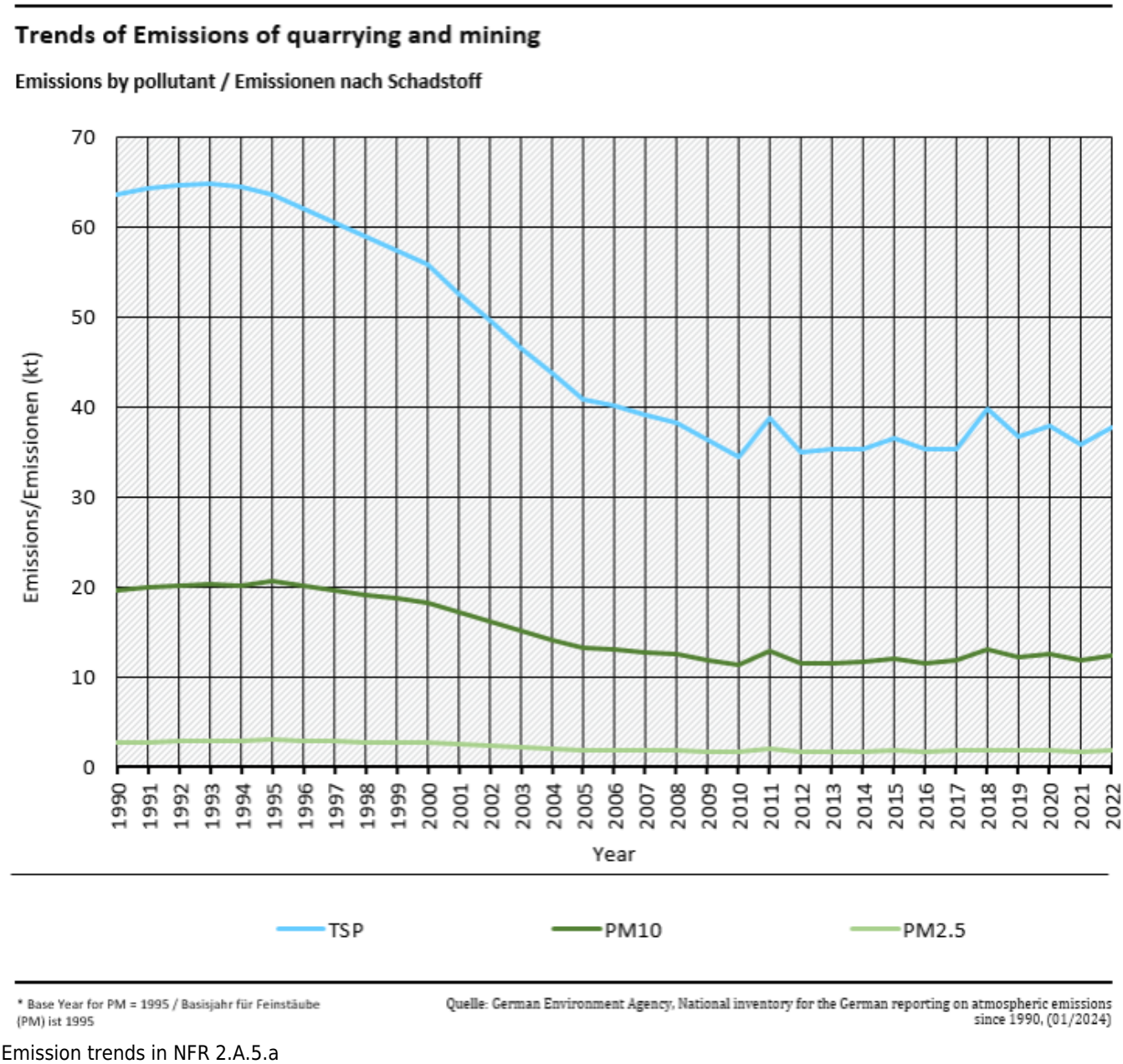
The emission factors for salt production are based on analogy to bulk product handling by an UBA expert judgement:

Table 2: Overview of emission factors applied for salt mining, in [kg/t salt]

	value	trend
TSP	0.031	constant over time
PM_{10}	0.016	constant over time
$PM_{2.5}$	0.003	constant over time

Trend discussion

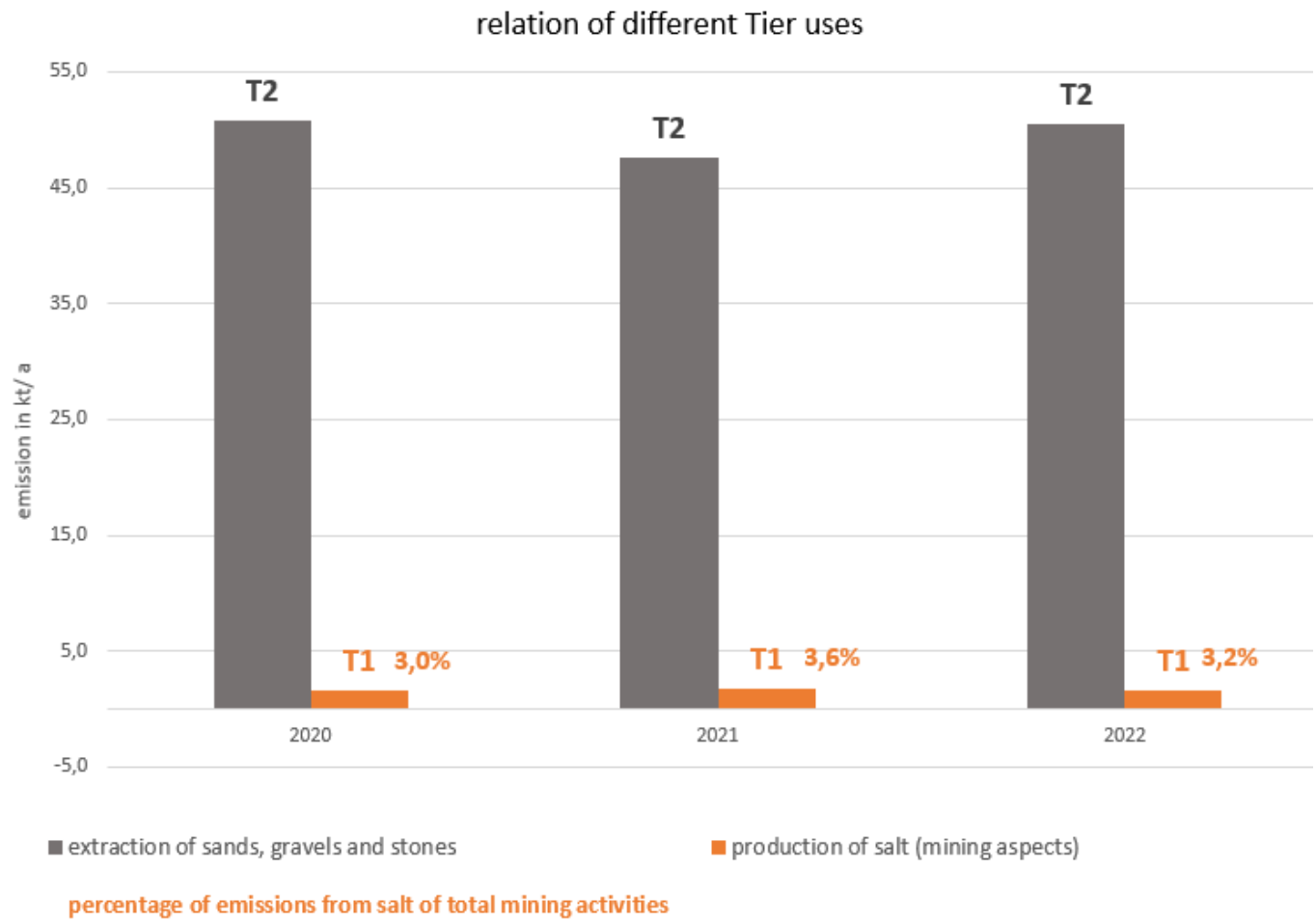
Trends in emissions follow the shrinking mining activities.



Emission trends in NFR 2.A.5.a

note: small change for 2023

As mentioned above, emissions from salt mining represent only a small portion (less than 4%) of the total emissions allocated to NFR sub-sector 2.A.5.a, depending on the specific pm fraction.



share-of-salt-in-mining

Recalculations

Recalculations were necessary due to updated production figures for the most recent year.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

It is planned to further evaluate country-specific conditions.

[1), 7)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-a-mineral-products/2-a-5-a-quarrying-1/view; Copenhagen, 2023
[2)] DWD (2024): ClimateDataCenter (CDC): https://opendata.dwd.de/climate_environment/CDC/observations_germany/climate/daily/kl/
[3)] Copernicus (2019): CLC-classes, https://land.copernicus.eu/user-corner/technical-library/corine-land-cover-nomenclature-guidelines/html/index-clc-131.html

[4)] Aggregates Europe – UEPG (2023): aggregates production data for European countries: https://www.aggregates-europe.eu/facts-figures/figures/; Brussels, Belgium, 2023
[5)] BV-Miro (2024): National Association for Mineral Resources: https://www.bv-miro.org/
[6)] BGR - Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources): https://www.bgr.bund.de/DE/Themen/Min_rohstoffe/Produkte/produkte_node.html;

2.A.5.b - Construction and Demolition

Short description

Category Code	Method	AD	EF
2.A.5.b	T1/T2	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	CO	Heavy Metals	POPs
NA	NA	NA	NA	-/-	**L/-**	**L/-**	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Regarding particle emissions, construction is the second-largest emissions source within NFR 2.A - Mineral industries.

Methodology

Since the last update of the EMEP/EEA air pollutant emission inventory guidebook, a tier1 method is applied to estimate particulate matter emissions. However, this tier1 method is applied with various adaptations to national conditions improving it to a rather higher tier, perhaps T1/T2.

The approach for uncontrolled fugitive emissions from 2.A.5.b was adapted for national circumstances within a research project by Kampffmeyer & Visschedijk (2016) [1)], partly considering existing emission-control technologies. As a result, statistical information is combined with modified default emission factors for TSP and PM.

Activity data

Activity data are determined taking into account figures for various construction activities and based on national production statistics.

AD is a result of multiplying the number of houses constructed and a conversion factor.

According to the method applied, figures of area of land affected by construction activities per building were concluded from statistical data and multiplied with emission factors, as explained below.

Emission factors

The emission factors used are results of the adaptation of EMEP/EEA Guidebook defaults (EMEP/EEA, 2023) [2)].

Table 1: Overview of apllied emission factors, in [kg/m^2 * y], for roads in [tons/km^2 * y]

type of building	pollutant	EF value	EF trend
single and two-family houses	TSP	0.0638	constant over time
	PM_{10}	0.0191	constant over time
	$PM_{2.5}$	0.0019	constant over time
apartment buildings	TSP	0.329	constant over time
	PM_{10}	0.099	constant over time
	$PM_{2.5}$	0.0099	constant over time
non-residential	TSP	0.631	constant over time
	PM_{10}	0.189	constant over time
	$PM_{2.5}$	0.0189	constant over time
roads	TSP	1,674	constant over time
	PM_{10}	502	constant over time
	$PM_{2.5}$	50.2	constant over time

However, further assumptions were necessary in order to calculate:

For example, the emission factors are adapted with correction factors of (i) 0.20 for the moisture level and (ii) 2.22 for the silt content.

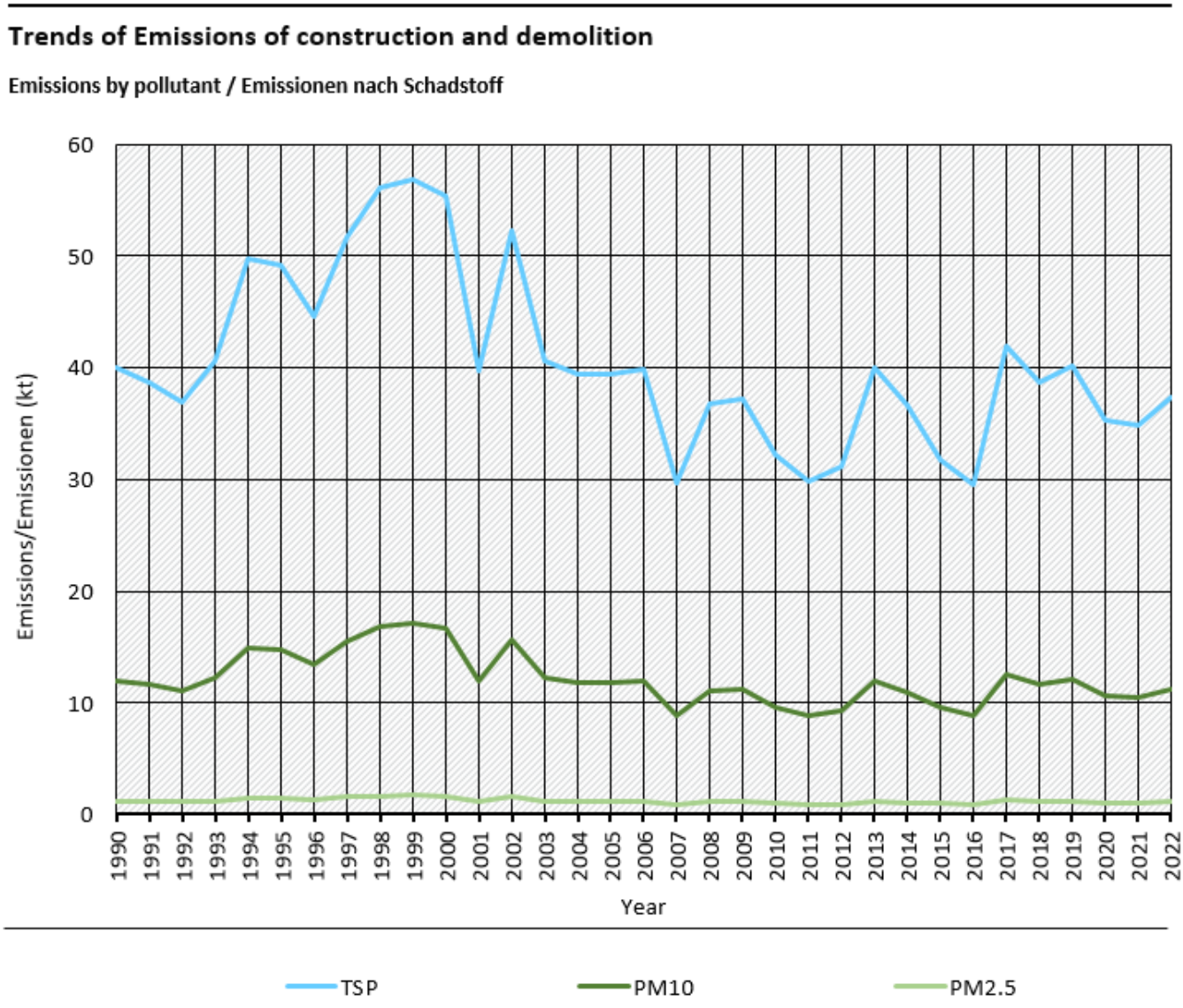
The assumption about the duration of the construction activity uses default values from (EMEP/EEA, 2023)[3)]:

Table 2: default duration of different construction activities, in years [y]

Type of building	estimated duration
Construction of houses (single and two family)	0.5 (6 months)
Construction of apartments (all types)	0.75 (9 months)
Non-residential construction	0.83 (10 months)
Road construction	1 (12 months)

Trends in emissions

All trends in emissions as product of EF and AD correspond to trends of construction activities.



Emission trends in NFR 2.A.5.b

Note for all: small change for 2023

Notes on PCB emissions from old buildings are provided in chapter 2.K - Consumption of POPs and Heavy Metals of this report.

Recalculations

Recalculations were necessary due to improvements for most recently years (2020-2022): a new data gapfilling method for construction of roads.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

FAQs

Where can I find emissions estimation of demolition activities? - Demolishing without any significant new construction is not covered and there are no other emission factors available for demolition activities only. Nevertheless you can find Information about emissions from 5.E.2 - Other Waste: Building Fires.

Why do German EFs differ from EEA defaults? - It has to do with the default 50% reduction for non-residential buildings and roads (as a result of wetting unpaved temporary roads) that is assumed in the calculations for Germany. This is also already accounted for in the EPA emission factors. It is a result of a control measure that is nearly always taken but in principle optional. In the Guidebook a 50% reduction is advised.

[1)] Kampffmeyer, T., Visschedijk, A.: Development of Methods for the Generation of Emission Data for Air Pollutants from Building Activity and Construction Zones, https://research.ebsco.com/linkprocessor/plink?id=46c9c9e5-c6f9-3229-b7af-6585eb409115; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2016

[2), 3)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-a-mineral-products/2-a-5-b-construction/@@download/file; Copenhagen, 2023

2.A.5.c - Storage, Handling and Transport of Mineral Products



All emissions from storage, handling and transport of chemical products are included elsewhere ('IE') in the values reported in NFR 2.L - Other production, consumption, storage, transportation or handling of bulk products.

2.A.6 - Other Mineral Products: Ceramics

Short description

Category Code	Method	AD	EF
2.A.6	T1	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	**CO**	**Pb**	**Cd**	**Hg**	Other Heavy Metals	POPs
-/-	-/-	-/-	-/-	-/-	**-/T**	**L/-**	NA	IE	NE	NE	NE	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

NFR category 2.A.6 (other) is not comparable with the CRF structure. Here you can find the same figures as CRF category 2.A.4.a Ceramics production.

The ceramics industry in Germany is very heterogeneous. It involves a large number of products that are characterized by different fields of application and corresponding chemical compositions. In addition to clay (as the main raw material), sand and other natural raw material amounts, synthetically produced materials such as aluminium oxide and silicon dioxide are also used. The mixture, which is homogenously mixed from primary raw materials and only in small quantities of secondary raw materials, is burned mainly in tunnel kilns and hearth furnaces at kiln temperatures between 1,100 - 1,300°C.

Method

In contrast to carbon dioxide, emissions of air pollutants are calculated using only the Tier 1 method, since no product-specific data are available and this source category is not a key source. In relation to the quantity produced, bricks and refractory products as well as wall and floor tiles are important.

Activity data

For submission in 2018, the production figures (activity rates) were evaluated as completely as possible by the Federal Statistical Office. In order to complete the data available, the annual production of each product category was determined in the context of an expert study in cooperation with the Federal Statistical Office (J. Gottwald et al., 2017)[1)]. Data from the Federal Statistical Office are available in different units (tonnes, square metres, pieces, value) depending on the product. In order to ensure consistent processing of the data, it is necessary to standardize the dimensions in tonnes by using conversion factors. The conversion factors for facing bricks, backing bricks and roof tiles are calculated differently. On information provided by the Bundesverband der Deutschen Ziegelindustrie e. V. this calculation in respect of technical discussions were fundamentally revised. Up to now, for the conversion of the volume data of the official statistics for the whole time series an average value for the gross density from 1994 is used. Now new average values for the bulk density of backing bricks for the year 2016 (BV Ziegel, 2019). The bulk density has increased over time since 1994 has fallen steadily, which is due to the increase in the proportion of well-insulating lightweight bricks. The Values for raw densities for the years between 1994 and 2016 were interpolated linearly. The brick product group has by far the largest share in the ceramic Total production. A review of the methodology for the other sectors of ceramic industry was not necessary.

Emission factors

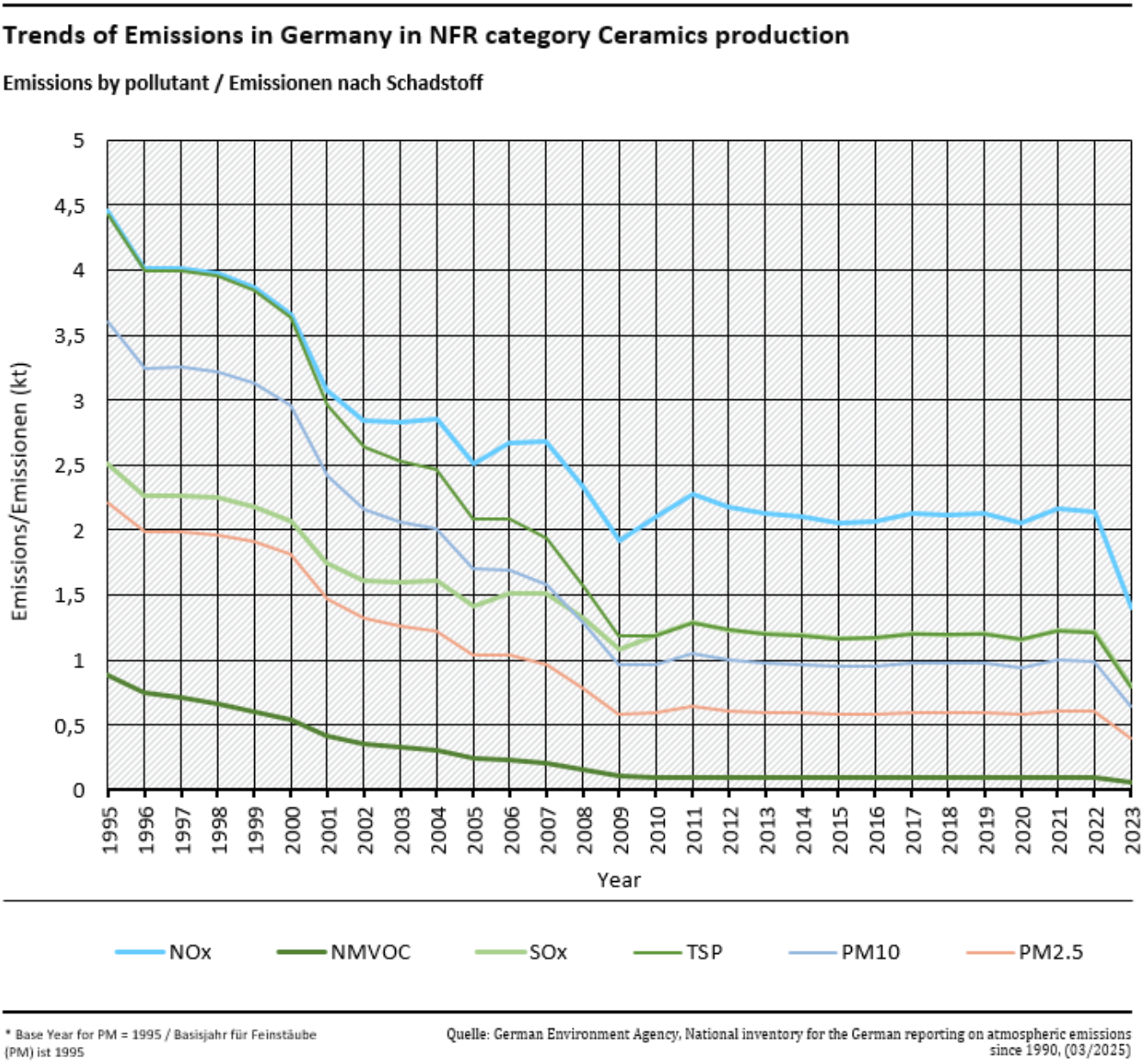
Process-related emissions originate in the raw materials for production (normally, locally available loams and clays with varying concentrations of organic impurities and specific raw material mixes). Some EF are documented in detail in a report of a research Project (Stein, Gronewäller, 2010) [2)] taking into account information of industry monitoring. Other EF are based on an expert judgements from UBA due to lack in EMEP/EEA air pollutant emission inventory guidebook.

Table 1: Overview of applied emission factors, in kg/t

	EF value	EF trend
NO_x	0.177	constant
SO_2	0.10	constant
NMVOC	0.008	falling
NH_3	0.004	constant
TSP	0.10	falling
PM_{10}	0.08	falling
$PM_{2.5}$	0.05	falling

Trends of emissions

> Advice for NFR-tables: The steep reduction for TSP and SO_2 from 1990 to 1991 is not result of ceramic Industry: The source for emissions data of year 1990 for eastern Germany is in cases of TSP and SO_2 the last statistic of the GDR for Mineral products and allocated at 2A6-level.



Emission trends in NFR 2.A.6

note: trends of emissions follow the deep production decrease of this industry

Recalculations

With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] J. Gottwald et al., 2017: Prüfung der Vollständigkeit der Berichterstattungskategorie 'Keramische Erzeugnisse'

insbesondere feinkeramische Erzeugnisse, Dessau-Roßlau, 2017;
https://www.umweltbundesamt.de/sites/default/files/medien/1968/publikationen/2017-01-19_dokumentationen_01-2017_emissionsrelevanz-feinkeramikbranche.pdf

[2)] Stein, Gronewäller, 2010: Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV aus dem Jahre 2004 für die Verwendung bei der UNFCCC- und UNECE-Berichterstattung
https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3923.pdf

2.B - Chemical Industry (OVERVIEW)

2.B Chemical Industry
2.B.1 Ammonia Production
2.B.2 Nitric Acid Production
2.B.3 Adipic Acid Production
2.B.5 Carbide Production
2.B.6 Titanium Dioxide Production
2.B.7 Soda Ash Production
2.B.10.a Other chemical industry
2.B.10.b Storage, Handling and Transport of Chemical Products

2.B.1 - Ammonia Production

Short description

Category Code	Method	AD	EF
2.B.1	T2	PS	D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
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As	Associations, business organisations
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M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	**NH_3**	$PM_{2.5}$	PM_{10}	TSP	BC	**CO**	Heavy Metals	POPs
-/-	NA	NA	**-/-**	NA	NA	NA	NA	**-/-**	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Ammonia is synthesised from hydrogen and nitrogen, using the Haber-Bosch process. Hydrogen is produced from synthetic gas – which in turn is produced from natural gas – via a highly integrated process, steam reforming. Nitrogen is produced via air dissociation. The various plant types involved in the production of ammonia cannot be divided into individual units nor be considered as independent process parts, due to the highly integrated character of the procedure. In **steam reforming**, the following process parts are distinguished:

- ACP - Advanced Conventional Process - with a fired primary reformer and secondary reforming with excess air (stoichiometric H/N ratio)
- RPR - Reduced Primary Reformer Process - under mild conditions in a fired primary reformer and secondary splitting with excess air (sub-stoichiometric H/N ratio)

and

- HPR - Heat Exchange Primary Reformer Process – autothermic splitting with heat exchange using a steam reformer heated with process gas (heat exchange reformer) and a separate secondary reformer or a combined autothermic reformer using excess air or enriched air (sub-stoichiometric or stoichiometric H/N ratio).

The following process is also used for ammonia synthesis: **partial oxidation**, which is the gasification of fractions of heavy mineral oil or vacuum residues in the production of synthetic gas. Most plants operate using steam-reforming, with naphtha or natural gas. Only 3% of European plants use partial oxidation.

The production decrease of more than 15% in the first year after German reunification was the result of a market shakeup, over 2/3 of which was borne by the new German Länder. The production level then remained nearly constant in the succeeding years until 1994. The reasons for the re-increase as of 1995 back to the 1990 level are not understood; the re-increase may however be due to a change in statistical survey methods. After 1990, production levels fluctuated only slightly. Since then, the rate of ammonia production has been stable.

Method

There were five plants in Germany which produced ammonia, using both steam reforming and partial oxidation. Since mid-2014 there are only four left, but both processes are still used.

Activity data

As ammonia production is a key category regarding the CO_2 emissions, activity data is collected plant-specifically.

The data is compiled based on a co-operation agreement between UBA and the German ammonia producers represented by the industry association Agrar (Industrieverband Agrar - IVA). Before delivery to UBA, the plant specific data is anonymized by the IVA.[1)]

Emission factor

For NO_x and NH_3 and CO, default emission factors from the EMEP/EEA Emission Inventory Guidebook 2019 are applied :

Table 1: Default emission factors, in [kg/t NH_3]

Pollutant	EF
NO_x	1
CO	0.1
NH_3	0.01
from (EEA, 2019) [2)]	

The CO emission factor has been included with submission 2022.

Recalculations

With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] IVA (2024): Industrieverband Agrar - IVA, https://www.iva.de/verband, Frankfurt am Main
[2)] EMEP/EEA (2019): EMEP/EEA Emission Inventory Guidebook 2019, Chapter 2.B Chemical industry 2019, Oct 2019: page 15, Table 3.2: Tier 1 emission factors for source category 2.B.1 Ammonia production: https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/2-industrial-processes/2-b-chemical-industry/2-b-chemical-industry/@@download/file: Copenhagen, 2019

2.B.2 - Nitric Acid Production

Short description

Category Code	Method	AD	EF
2.B.2	T2	PS	D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

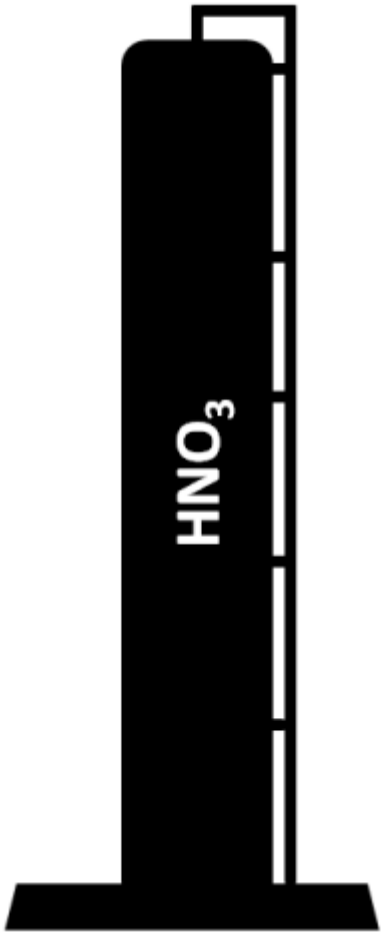
NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

During the production of nitric acid (HNO_3), nitrogen oxide is produced unintentionally in a secondary reaction during the catalytic oxidation of ammonia (NH_3). HNO_3 production occurs in two process stages:

- Oxidation of NH_3 to NO and
- Conversion of NO to NO_2 and absorption in H_2O.

Details of the process are outlined below:



Catalytic oxidation of ammonia

A mixture of ammonia and air at a ratio of 1:9 is oxidised, in the presence of a platinum catalyst alloyed with rhodium and/or palladium, at a temperature of between 800 and 950 °C. The reaction according to the Oswald process is as follows:

$4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$

Simultaneously, nitrogen, nitrous oxide and water are formed by the following undesired secondary reactions:

$4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$

$4\ NH_3 + 4\ O_2 \rightarrow 2\ N_2O + 6\ H_2O$

All three oxidation reactions are exothermic. Heat may be recovered to produce steam for the process and for export to other plants and/or to preheat the residual gas. The reaction water is condensed in a cooling condenser, during the cooling of the reaction gases, and is then conveyed into the absorption column.

Method

Activity data

In Germany, there are currently nine nitric acid plants.

As this source category is key category for N_2O emissions, plant specific activity data is collected here according to the IPCC guidelines.

This data is made available basically via a co-operation agreement with the nitric acid producers and the IVA (Industrieverband Agrar). As the data provided by the producers has to be treated as confidential, it is anonymised by the IVA before submitting it to the UBA, with one producer as exception who is delivering its data directly to the UBA. After checking this specific data, it is merged with that provided by the IVA.

According to the IVA, catalytic reduction is used as an abatement method in some of the plants.

Emission factors

Different tier2 default NO_x emission factors based on different technology types and abatement systems are used from the EEA Emission Inventory Guidebook 2019 (EF for medium and high pressure processes and for catalytic reduction of low, medium and high pressure process)[1)]. The applied emissions factors are listed in **Table 1**.

Table 1: Tier2 emission factors of NO_x for source category 2.B.2 Nitric acid production, in [kg/t]

EF	Process
7.5	medium pressure process
3	high pressure process
0.4	low, medium and high pressure process, catalytic reduction

Recalculations

With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, Part B: sectoral guidance chapters, 2.B Chemical industry: pp.21-23, Table 3.11, Table 3.12 and Table 3.14., Copenhagen, 2019

2.B.3 - Adipic Acid Production

Short description

In source category *NFR 2.B.3 - adipic acid production* NO_x and CO emissions from the production of adipic acid are reported. As there are only three producers of adipic acid, activity data provided by them has to be treated as confidential. Due to this reason, only emissions could be reported.

Category Code	Method	AD	EF
2.B.3	T3	PS	C

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	**CO**	Heavy Metals	POPs
-/-	NA	NA	NA	NA	NA	NA	NA	**-/-**	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

As this source category is a key category for N_2O emissions, plant specific activity data is collected according to the IPCC guidelines that is obtained basically via a co-operation agreement with the adipic acid producers.

A single data collection of plant specific NO_x and CO emissions and related emission factors for one year (2016) was sufficient as the emissions are below the threshold of significance. The derived emission factors are applied to the entire

time series and for every plant.

Activity Data

Due to confidentiality concerns, this data is not published (see short description).

Emission factors

Due to confidentiality concerns, this data is not published (see short description).

Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

Planned improvements



At the moment, no category-specific improvements are planned.

2.B.5 - Carbide Production

Short description

Category Code	Method	AD	EF
2.B.5	T3	PS	PS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	CO	Heavy Metals	POPs
NA	NA	NA	NA	**-/-**	**-/-**	**-/-**	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

During the German Reunification period, **calcium carbide** production took place mainly in the new German federal states (Neue Bundesländer), where production stopped shortly thereafter and there is only one producer left in the old German federal states. In the period under consideration, this producer cut its production by about 50 percent.

According to the responsible specialised association within the VCI, **no more silicon carbide** has been produced in Germany since 1993. Emissions from this process thus no longer occur.

Method

Activity data

Since Germany has only one producer, the relevant data must be kept confidential.

Only the data which consists of the amount of production in the former GDR was published, until 1989, by the country's central statistical authority. In combination with existing estimates for 1991 and 1992, those figures were used to interpolate production in the new German Länder in 1990.

Emission factors

In covered furnaces, producers collect all the carbon monoxide produced from the process and recycle it for further use. Following such use as energy recovery – i.e., following its combustion to produce carbon dioxide – it serves as an auxiliary substance for production of lime nitrogen and secondary products. Reactions in these processes yield carbon dioxide in a mineral form, as black chalk. In this form, it is used in agriculture. Upon request, the relevant producer provides the UBA with the data of amounts produced.

The emission factor for TSP is provided by the producer and is also confidential.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.



2.B.6 - Titanium Dioxide Production

Short description

In *NFR 2.B.6*, SO_2,CO, NO_x and TSP emissions from the production of titanium dioxide are reported.

Category Code	Method	AD	EF
2.B.6	T3	C	C

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	**SO_2**	NH_3	$PM_{2.5}$	PM_{10}	**TSP**	BC	**CO**	Heavy Metals	POPs
-/-	NA	**-/-**	NA	NA	NA	**-/-**	NA	**-/-**	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

Activity Data

There are two kinds of processes for the production of titanium dioxide: chloride process and sulfate process. The total production amount of these two processes is attained from the German Federal Statistical Office[1)].

For the calculation of individual production from each process, the fraction of chloride process is determined based on the estimated total production capacity in Germany (480 kt/y) and the production capacity via chloride process (165 kt/y) [2)3)].

Emission Factors

Emission factors for titanium dioxide production are the tier2 emission factors from EMEP/EEA Guidebook: NO_x, CO, and TSP are provided for the chloride process, while for the sulfate process only factors for NO_x and TSP are available.

The applied tier2 emission factors derived from the EMEP/EEA Guidebook 2019[4)] are listed in Table 1.

Table 1: tier2 emission factors for titanium dioxide production, in [kg/t]

Pollutant	Name of process	Emission factor
CO	Chloride	159
NO_x		0.1
TSP		0.2
NO_x	Sulfate	0.108
TSP		0.3

Emissions

The Titanium Dioxide Manufacturers Association (TDMA) reports the sum of SO_2 emissions from both processes directly to the UBA.

Since submission 2022, these emissions are no longer confidential and were therefore re-allocated from 2.B.10. Besides, CO, NO_x and TSP emissions are reported since submission 2022.

Except for SO_2, emissions of the mentioned pollutants are calculated through the multiplication of activity data and corresponding emission factors.

As all emission factors are constant over time, the emission trend is influenced only by the fluctuations of the production.

Recalculations

For SO_2 emissions from the production of **titanium dioxide** and **sulphuric acid**, estimates reported for the *second to last year* of the time series are routinely actualised by the producers. Furthermore, final emissions for the *last year of the time series* are not yet available at the time the inventory is compiled. Therefore, the values reported here represent a prediction and are updated with each new submission as well.

Otherwise, SO_2 emissions for 1990 und 1991 have been updated compared to last year's submission. As long as the values for 1990 and 1991 were considered confidential, assumptions were made to resolve the confidentiality. As the confidentiality has been lifted, these can be replaced with the correct values.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 9.1 - Recalculations.

Planned improvements



At the moment, no category-specific improvements are planned.

[1)] Destatis (2024): Federal Statistical Office (Statistisches Bundesamt, Destatis): Production statistics: Until 1994 GP89 - 4612 50, 1995 until 2008 GP241211500 and GP201211500 from 2009 onwards; Wiesbaden, 2024
[2)] https://forum-titandioxid.de/2020/03/12/sachlage-zu-titandioxid-und-titandioxidhaltigen-farben-und-lacken/
[3)] https://www.kronosww.com/products/about-tio2/

2.B.7 - Soda Ash Production

Short description

Category Code	Method	AD	EF
2.B.7	T1	NS/PS	C

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	CO	Heavy Metals	POPs
NA	NA	NA	**-/-**	NE	NE	**-/-**	NE	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

In Germany, soda ash is produced in three facilities, all of which use the Solvay process. The production data is thus confidential.

Method

Activity data

The total amounts of soda ash produced in Germany are determined with the help of two data suppliers. The Federal Statistical Office has long time series for this area. Due to the presence of a nearly inexplicable trend in the data of the Federal Statistical Office for the period since 2015, the relevant producers were contacted, and in 2021 cooperation

agreements were signed with both producers (for all three production sites). The German Environment Agency (UBA), which consolidates the relevant data, has decided that as of 2013 the pertinent time series is to be filled with the producers' data (this overlaps with a comparison carried out for the period 2013 through 2021).

Since Germany has only two producers, the production-quantity data from the two sources must be kept confidential.

Emission factor

Emission factors (for TSP and NH_3) are confidential due to restrictions on activity data.

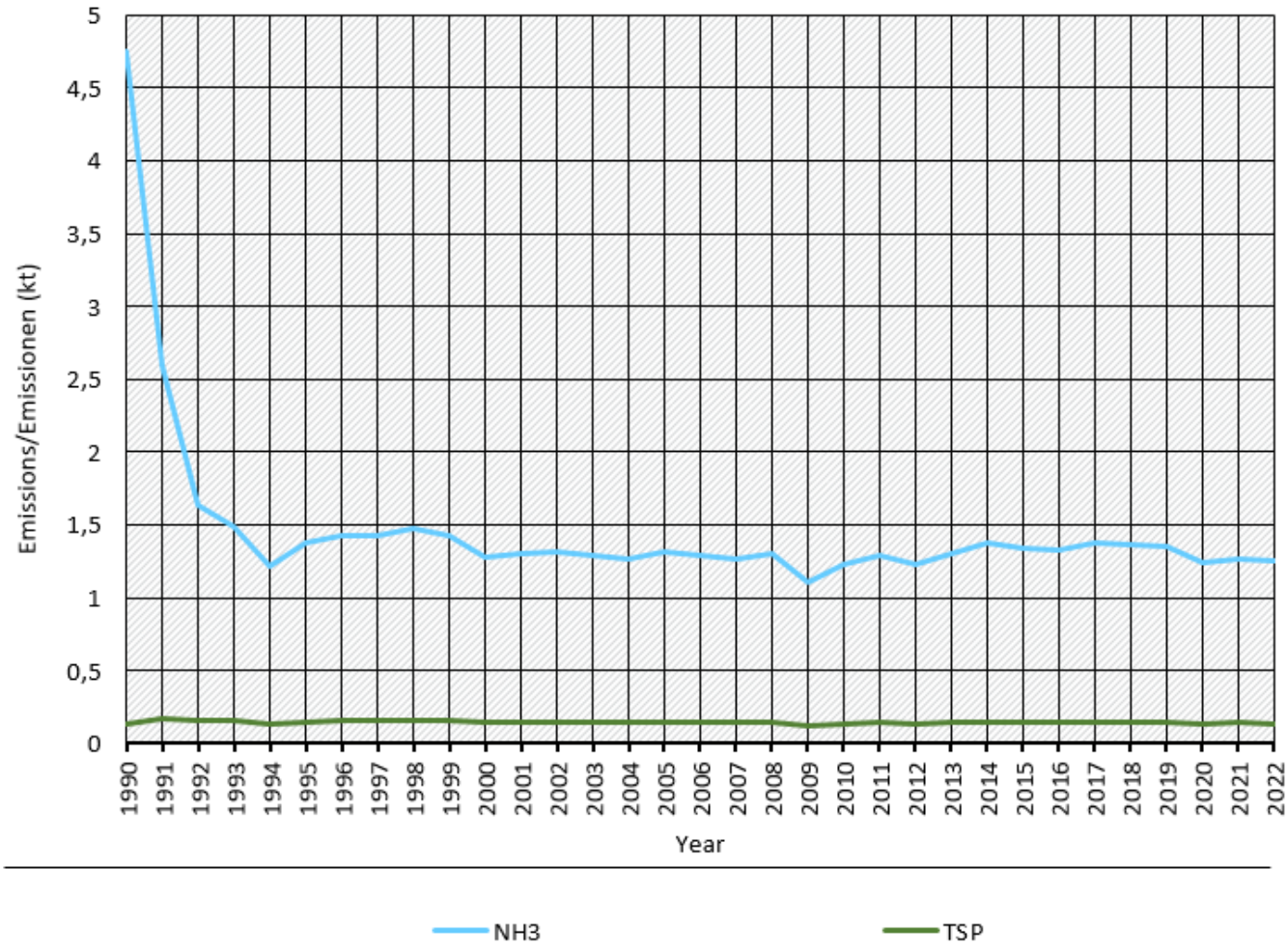
Discussion of emission trends

The steep reduction—especially for NH_3—at the beginning of the 1990s was due to closures in the eastern German industrial sector. For the year 1990 in the case of TSP for eastern Germany, a summary figure is reported for the Chemical Industry as a whole. However, after 1992, emissions of NH_3 occur at a lower level.

All trends in emissions correspond to trends of emission factors. No rising trends are to identify.

Trends of Emissions of Soda Ash Production

Emissions by pollutant / Emissionen nach Schadstoff



* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (01/2024)

Emission trends in NFR 2.B.7

note: small change for 2023

Recalculations

With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

2.B.10.a - Other Chemicals

Short description

In sub-category *2.B.10.a - Other Chemicals*, emissions from the production of organic chemicals,sulphuric acid, carbon black, fertilizers and from the chlor-alkali industry are reported. Relevant pollutants are NMVOC, CO, PCDD/F, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP and Hg.

Table 1: Overview of emission sources covered

Emission sources	Pollutants	Method	AD	EF	Key Category
Large Volume Organic chemicals	NMVOC (PCDD/F $_{\text{only for Ethylene Dichloride}}$)	T2	NS	CS	
Carbon Black	CO, SO_2, TSP, PM_{10}, $PM_{2.5}$, BC	T2	NS	D, CS	
Fertilizers	TSP, PM_{10}, $PM_{2.5}$, NH_3	T2	-	D, CS	
Sulphuric acid	SO_2	T2	NS	CS	L
Chlor-alkali industry	Hg	T3	PS	-	

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

Method

Large volume organic chemicals

The annual production volumes for all large volume organic chemicals are extracted from national production statistics by the Federal Statistical Office [1)].

These chemicals comprise:

- Acrylonitrile
- Ethylene
- Ethylbenzene
- Ethylene Dichloride

- Ethylene Oxide
- Formaldehyde (Methanal)
- Methanol
- Phthalic Anhydride
- Propene
- Styrene
- Vinyl Chloride
- Polyethylene (LD/HD)
- Polypropylene
- Polystyrene
- Polyvinyl Chloride
- Styrene Copolymeres

The emission factors for the production of organic chemicals as shown in Tables 2 and 3 are derived from best reference documents for polymers and LVOC mostly for the early years. For later years, plant-specific data on an aggregated level were used.

Table 2: National NMVOC emission factors for the production of organic chemicals, in kg/t

	Acrylonitrile	Ethylbenzene	Ethylene	Ethylene Dichloride	Ethylene Oxide	Formaldehyde (Methanal)	Methanol	Phthalic Anhydride	Propene	Styrene	Vinyl Chloride
1990-1994	5	0.6	5	C	5	5	0.04	5	2.5	0.02	0.2
1995	0.07	0.02	0.4	C	0.06	0.02	0.04	0.2	0.2	0.02	0.2
1996	0.05	0.015	0.3	C	0.045	0.015	0.04	0.15	0.15	0.02	0.15
1997	0.05	0.015	0.3	C	0.045	0.015	0.04	0.15	0.15	0.02	0.15
1998	0.04	0.012	0.25	C	0.04	0.012	0.04	0.12	0.12	0.02	0.12
1999	0.04	0.012	0.25	C	0.04	0.012	0.04	0.12	0.12	0.02	0.12
from 2000	0.035	0.01	0.2	C	0.03	0.01	0.04	0.1	0.1	0.02	0.1

Table 3: National NMVOC emission factors for the production of polymers, in kg/t

	Polyethylene (PE)		Polypropylen (PP)	Polystyrene (PS)	Polyvinyl Chloride (PVC)	Styrene Copolymeres
	Low density (LD)	High density (HD)				
1990-1994	8	6	8	1	0.25	5
1995	2.2	1	1	0.6	0.25	0.6
1996	1.6	0.75	0.75	0.4	0.25	0.5
1997	1.6	0.75	0.75	0.4	0.25	0.5
1998	1.3	0.6	0.6	0.32	0.25	0.4
1999	1.3	0.6	0.6	0.32	0.25	0.4
from 2000	1.1	0.5	0.5	0.27	0.14	0.3

Carbon Black

The figures for carbon black production in the new German Länder in 1990 were taken from the Statistical Yearbook (Statistisches Jahrbuch) for the Federal Republic of Germany; the production for 1991 and 1992 were estimated, due to confidentiality requirements. The other data for carbon-black production as of 1990 were obtained from national production statistics.

From 2005 onwards, Germany uses activity data calculated from the CO_2 emissions of the Emission Trading System (ETS), delivered by the German emission trading authority (DEHSt), and the default CO_2 emission factor from the IPCC Guidelines 2006 for carbon black production. A comparison of the statistical data and the emission trading data leads to the conclusion, that the statistical data is most probably overestimated.

Table 4: Emission factors of carbon black in Germany, in kg/t

	CO	SO_2	TSP	PM_{10}	$PM_{2.5}$
1990	4.80	19.16	0.28		
1991	4.60	19.01	0.28		
1992	4.40	18.50	0.27		
1993	4.20	18.00	0.26		

	CO	SO_2	TSP	PM_{10}	$PM_{2.5}$
1994	4.00	17.50	0.25		
1995	3.75	17.00	0.25	0.23	0.12
1996	3.50	16.00	0.25	0.23	0.12
1997	3.25	15.00	0.25	0.23	0.12
1998	3.00	14.00	0.25	0.23	0.12
1999	2.90	13.40	0.25	0.23	0.12
2000	2.80	12.80	0.25	0.23	0.12
2001	2.70	12.54	0.25	0.23	0.12
2002	2.65	12.28	0.25	0.23	0.12
2003	2.60	12.00	0.25	0.23	0.12
2004	2.55	11.70	0.25	0.23	0.12
2005	2.50	11.50	0.25	0.23	0.12
2006	2.50	11.20	0.24	0.22	0.12
2007	2.50	10.90	0.23	0.21	0.11
2008	2.50	10.60	0.22	0.20	0.11
2009	2.50	10.30	0.21	0.19	0.10
from 2010	2.50	10.00	0.20	0.18	0.10

Fertilizer production

The activity data is also extracted from national production statistics by the Federal Statistical Office[2)] and consists of mono and multicomponent fertilizers.

The emission factors are country specific values derived from Jörß et al. (2006)[3)] and are presented in the following table.

Table 5: Emission factors of fertilizers in Germany

	PM_{10}	$PM_{2.5}$	TSP
1990	NA	NA	1.420376946
1991-1994	NA	NA	2
from 1995	0.115938	0.0781395	0.1695

Urea production

The activity data is from the federal statistical office of Germany (GP 2015 31 300). The amount of urea is reported there in t-N. As the emission factor is in kg/t urea, the reported amount of urea in t-N is multiplied with the molar mass of urea and divided with the molar mass of nitric (60.06/14).

AR of urea (in t) = AR of urea (in t-N) * (molar mass of urea)/ (molar mass of N)

The emission factor of 2.5 kg/t urea is a tier2 default value derived from the EMEP/EEA Guidebook 2019[4)].

Sulphuric acid

The activity data for sulphuric acid production is from the Federal Statistical Office of Germany.

For the SO_x EF for sulphuric acid production a survey was made in 2019. The producers were directly asked by the association. Based on the producers data obtained, new EFs for the years 2017 and 2018 were developed.

All emissions were measured by the producers respectively or limit values are specified in the permit decision for the installation. The derived (implied) EF is weighted by the amount of H_2SO_4 produced. Therefore, big producers have stronger influence on the (implied) EF.

However, due to significant process optimizations and technology improvements implemented since 1990, the country-specific EF applied is well below the default.

Chlor-alkali industry

For the mercury (Hg) losses from the Chlor-alkali industry, Germany used to apply the data annualy published by OSPAR [5)] on plant specific production capacity for the AD and plant specific emissions from the chlor-alkali industry.

Because of the BAT (best available technique) conclusion for the Chlor-alkali industry, the production based upon the amalgam process has stopped in 2017. Most production sites switched to membrane technology.

However, Hg emissions are still ocurring because two production sites still continue to use the amalgam process for the production of certain alcoholates not regulated by the BAT conclusions for Chlor-alkali production. Before 2018, these Hg-emissions were reported together with the Hg from Chlor-alkali production. But the OSPAR convention does not request the Hg emissions from alcoholate production to be reported, so CEFIC does no longer report these emissions to OSPAR. Therfore, as of 2018, PRTR data is used to determine mercury emissions belonging to the alcoholate production.

Recalculations

For SO_2 emissions from sulphuric acid production, and for Hg emissions from chlor-alkali industry, the emissions of the two last years are always actualized. This is because the emissions of the last year are always a prediction, as the final emissions are still not published by the time of reporting.

From Submission 2022 onwards, the SO_2 emissions from titanium dioxide production are no longer confidential and are therefore reallocated back to category 2.B.6. Since then, the SO_2 emissions reported here are only from the sulphuric acid production. Besides, Germany reports the NH_3 and TSP emissions from urea production instead of from nitric fertilizer production based on the Emep/EEA Guidebook method by using statistical data from the federal statistical office.

Otherwise no recalculations of SO_2 from the sulphuric acid production, NH_3 und TSP from urea production are necessary compared to last year's submission.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 9.1 - Recalculations.

Planned improvements



At the moment, no category-specific improvements are planned.

[1)] DESTATIS, Fachserie 4, Reihe 3.1, Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe (“manufacturing industry; production in the manufacturing industry”)
[2)] Federal Statistical Office (Statistisches Bundesamt - Destatis): Fachserie 4, Reihe 3.1, Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe (“manufacturing industry; production in the manufacturing industry”), Wiesbaden, 2024
[3)] Jörß et al. (2007): Jörß, W.; Handke, V. (Institut für Zukunftsstudien und Technologiebewertung (IZT), Berlin) mit Beiträgen von Lambrecht, U., Dünnebeil, Fr. (Institut für Energie und Umweltforschung Heidelberg (ifeu)): Emissionen und Maßnahmenanalyse Feinstaub 2000–2020. Annex A, chapter A.2.4.8, UBA-TEXTE Nr. 38/200; https://www.umweltbundesamt.de/publikationen/emissionen-massnahmenanalyse-feinstaub-2000-2020; on behalf of the Umweltbundesamt; Dessau-Roßlau, 2007.
[4)] EMEP/EEA (2019): European Environment Agency: EMEP/EEA air pollutant emission inventory guidebook 2019, Part B: sectoral guidance chapters, 2.B Chemical industry (Oct 2019): chapter 3.2.2, pp.32, table 3.2.9, Copenhagen, 2019
[5)] ODIMS (OSPAR Data & Information Management System); https://odims.ospar.org/en/search/?dataset=chlor_alkali_data

2.B.10.b - Storage, Handling and Transport of Chemical Products

Category Code	Method					AD					EF				
2.B.10.b	T2					NS					CS				
	NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	Diox	PAH	HCB
Key Category:	-	-/-	-	-	-	-	-	-	-	-	-	-	-	-	-

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

Short description

Emissions from storage cover all refinery products. According to the EMEP guidebook, fuel-related emissions are reported under 1.B.2. (see Chapter 3., 1.B.2a Oil). Emissions from other mineral oil products that are not used as fuel (like naphtha, methanol etc.) are reported separately here.

Method

A distinction of mineral oil products is only made between fuels and naphtha. Based on the individual annual amount for these two subcategories, a split factor is calculated.

Activity data

The annual production of naphtha through the time series is listed in **Table 1** below.

Table 1: Annual naphtha production, in [kt]

1990	11546.09
1991	12566.84

1992	12705.24
1993	12986.79
1994	13393.21
1995	13369.77
1996	13430.44
1997	15070.53
1998	15959.62
1999	15810.00
2000	16091.47
2001	16736.24
2002	16660.01
2003	16981.74
2004	17895.30
2005	18024.31
2006	17016.65
2007	16708.99
2008	15744.92
2009	15236.77
2010	16610.69
2011	15708.84
2012	15770.00
2013	16213.82
2014	17065.99
2015	16331.02
2016	15797.92
2017	15605.03
2018	11439.19
2019	11263.72
2020	11804.49
2021	13686.27
2022	12669.02
2023	10580.86

Emission factors

The emission factor used for NMVOC was determined by evaluating emission declarations from refineries for the period 2004 to 2016, in the framework of a research project (Bender & von Müller, 2019)[1)]. Since no data is available for earlier years, the emission factor obtained this way is applied for all years as of 1990.

Table 2: Emission factor of NMVOC from storage of petroleum products, in [g/m^3]

	EF
Storage of liquid petroleum products in tank-storage facilities outside of refineries	100
Storage of gaseous petroleum products in tank-storage facilities outside of refineries	500

Recalculations

No recalculations have been carried out compared to last year's submission.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2020**, please see the pollutant specific recalculation tables following chapter 8.1 - Recalculations.

Planned improvements

An ongoing research project estimates emissions from storage and cleaning of tanks for oil and oil products - results are planned to be implemented into the inventory in 2025/26.

[1)] Bender, M., & von Müller, G. (2020). Emissionsfaktoren zu Raffinerien für die nationale Emissionsberichterstattung (FKZ 3716 41 107 0).

2.C - Metal Industry (OVERVIEW)

The Metal industry comprises the following categories and sub-categories:

2.C Metal Industry
2.C.1 Iron and Steel Production
2.C.2 Ferroalloys Production
2.C.3 Aluminium Production
2.C.4 Magnesium Production
2.C.5 Lead Production
2.C.6 Zinc Production
2.C.7.a Copper Production
2.C.7.b Nickel Production
2.C.7.c Other Metal Production
2.C.7.d Storage, Handling and Transport of Metal Products

Within NFR sub-category **2.C.1 - Iron and Steel production**, Germany coveres emisisons from the production of sinter, pig-iron production, oxygen and electric steel, hot and cold rolling and iron and steel castings.

The sub-categories **NFR 2.C.2 - Production of Ferroalloys**, **2.C.5 - Lead production**, **2.C.6 - Zinc production** and **2.C.7.a - Copper production** are listed directly as such in the CSE.

NFR 2.C.3 - Aluminium production covers both primary and remelted (=secondary) aluminium.

Sub-category **NFR 2.C.7.c - Other metal production** also includes thermal galvanisation.

2.C.1 - Iron & Steel Production

Short description

The source subcategory *NFR 2.C.1 - Iron & Steel Production* comprises process-related emissions from oxygen steel and electric steel production.

Category Code	Method	AD	EF
2.C.1	T2	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	**CO**	**Pb**	**Cd**	**Hg**	As	**Cr**	Cu	**Ni**	Se	Zn	**PCDD/F**	B[a]P	B[b]F	B[k]F	I[x]P	**PAH1-4**	**HCB**	**PCBs**
-/-	-/-	**L/-**	-/-	**L/T**	**L/T**	**-/-**	NE	**L/-**	**L/T**	**L/T**	**L/T**	NE	**L/T**	NE	-/-	NE	NE	**L/T**	NE	NE	NE	NE	**L/T**	**L/-**	**L/T**

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

In 2023, a total of 25.6 million tonnes of raw steel were produced in six integrated steelworks. Electrical steel production amounted to another 9,8 million tonnes.

Other structural elements are sinter production, hot iron production, hot rolling, iron and steel foundries (including malleable casting). The last Siemens-Martin steelworks (Stahlwerk Brandenburg) was shut down shortly after 1990. The last Thomas steelworks (Maxhütte Sulzbach-Rosenberg) discontinued its production in 2002. Due to their minor relevance and their phase-out, the emissions from Siemens-Martin and Thomas steel production are jointly calculated with the emissions from oxygen steel production.

Energy-related emissions from steel production for the years 1990 to 1994 (for individual pollutants until 1999) are reported under 1.A Fuel combustions in the respective subcategory 1.A.2.a. A detailed explanation for the individual pollutants is also found there.



Method

Activity data

Activity data is collected from plant operators by national institutions. Since the discontinuation of the special public statistics for iron and steel production (FS. 4, R. 8.1), the information is collected by the German steel trade association Wirtschaftsvereinigung Stahl (WV Stahl) based on a formal agreement.

In the iron and steel industry, only minor amounts of secondary fuels are used for pig iron production in individual blast furnaces. They are used as substitute reducing agents of coke and coal. To date, these materials have not yet been included in the national statistics nor in the Energy Balance. For this reason, the data used is also provided by WV Stahl.

Emission factors

The emission factors used to calculate emissions are based on emission data from individual plants. The emission factors for 1995 to 2001 were determined by the German Environment Agency (UBA for its initials in German) itself and those for 2008 and later through a research project. (Hensman et al., 2011)[1)]

As the EF for the years 1995 to 2001 as well as for 2008 are based on real stack emission data. Since both combustion and process-related emissions are released through the same stacks, emission factors could not be calculated individually for combustion or process-related emissions. Hence, wherever plant-based EF were availaible, as it the case for most pollutants for the years 1995 and later, all emissions are reported under 2.C.1.

Please note that the reported emissions also cover diffuse emissions from sources that are not covered in the EMEP/EEA Guidebook. For many pollutants and sources, individual EFs for channelled as well as diffuse emissions have been determined. While there is sufficient knowledge and measurement data of channelled emissions, the emission data concerning diffuse sources is usually based on estimations using parameters adapted to the local conditions of the individual emission source. Therefore, emission data for one source of diffuse emissions is not significant for the diffuse emissions from other plants. The emission factors given below were calculated as the weighted average of the pollution loads reported by the plant operators for individual diffuse sources, in relation to their corresponding production amounts.

Table 1: Overview of the emission factors applied for sinter production

	Type of source	EF 1990	EF 1995	EF 2000	EF 2005	EF 2010	Unit
Cd		0.098			0.052	0.017	g/t
CO		19.152		17.325	15.497	14.4	kg/t
Cr		0.077			0.044	0.02	g/t
HCB		0.03					mg/t
Hg		0.059			0.028	0.005	g/t
Ni		0.139			0.068	0.015	g/t
NMVOC		0.12					kg/t
NO_x		IE[13)]		0.558	0.46	0.401	kg/t
PAH	channelled	320.00	248.571	177.143	120		mg/t
Pb		5.299			3.242	1.7	g/t
PCB		3.0	2.285714	1.571429	1		mg/t
PCDD/F		6.0	4.575	3.149	1.724	0.796	µg/t
SO_2		IE[14)]		1.08	0.837	0.691	kg/t
TSP	channelled		0.65	0.465	0.234	0.096	kg/t
TSP	diffuse					0.046	kg/t
PM_{10}	channelled		0.445	0.336	0.177	0.07	kg/t
PM_{10}	diffuse					0.016	kg/t
$PM_{2.5}$	channelled		0.214	0.206	0.13	0.056	kg/t

Table 2: Overview of the emission factors applied for pig iron production

	Type of source	EF 1995	EF 2000	EF 2005	EF 2010	Unit
PAH	channelled	0.5[15)]				mg/t
Cd	channelled	4.0				mg/t
Cd	diffuse	0.203				mg/t
CO	channelled	1.18	0.915	0.65	0.491	kg/t
CO	diffuse	0.398				kg/t
Cr	channelled	0.019	0.006	0.002	0.001	g/t
Cr	diffuse	0.008				g/t
Hg	channelled	2.436	0.192	0.015	0.003	mg/t
Hg	diffuse	0.005				mg/t
Ni	channelled	21.0	6.0	2.0	1.0	mg/t
Ni	diffuse	8.0				mg/t
NMVOC		18.525				g/t
NO_x	channelled	0.051938	0.051938	0.051938	0.0517	kg/t
NO_x	diffuse	0.001				g/t
Pb	channelled	0.022				g/t
Pb	diffuse	0.011				g/t
PCDD/F		0.026	0.009	0.004	0.004	µg/t
SO_2	channelled	0.242				kg/t
SO_2	diffuse	0.04				kg/t
TSP	channelled	0.022	0.015	0.01	0.008	kg/t

	Type of source	EF 1995	EF 2000	EF 2005	EF 2010	Unit
TSP	diffuse	0.016				kg/t
PM_{10}	channelled	0.013	0.009	0.006	0.006	kg/t
PM_{10}	diffuse	0.007				kg/t
$PM_{2.5}$	channelled	0.009	0.007	0.005	0.004	kg/t

Table 3: Overview of the emission factors applied for oxygen steel production

	Type of source	EF 1995	EF 2000	EF 2005	EF 2010	Unit
Cd		0.053	0.038	0.024	0.016	g/t
CO		11.500	11.077	10.654	10.400	kg/t
Cr	channelled	0.715	0.306	0.125	0.028	g/t
Cr	diffuse	0.069				g/t
Ni	channelled	0.090	0.060	0.030	0.006	g/t
Ni	diffuse	0.004				g/t
NO_x	channelled	0.006	0.005	0.005	0.004	kg/t
NO_x	diffuse	0.0037				kg/t
PAH	channelled	0.100				mg/t
Pb	channelled	2.941	1.883	0.824	0.189	g/t
Pb	diffuse	0.278				g/t
PCB		2.670	1.740	1	1	mg/t
PCDD/F		0.070	0.070	0.070	0.069	µg/t
SO_2	diffuse	0.001				kg/t
TSP	channelled	0.155	0.145	0.145	0.024	kg/t
TSP	diffuse	0.049				kg/t
PM_{10}	channelled	0.099	0.093	0.093	0.020	kg/t
PM_{10}	diffuse	0.019				kg/t
$PM_{2.5}$	channelled	0.025	0.023	0.023	0.017	kg/t

Table 4: Overview of the emission factors applied for electric steel production

	Type of source	EF 1995	EF 2000	EF 2005	EF 2010	Unit
Cd		0.240	0.157	0.065	0.016	g/t
CO	channelled	1.700	1.187	0.674	0.366	kg/t
CO	diffuse	0.001				kg/t
Cr	channelled	0.481	0.206	0.258	0.323	g/t
Cr	diffuse	0.851				g/t
Hg	channelled	0.306	0.288	0.154	0.070	g/t
Ni	channelled	0.483	0.207	0.145	0.124	g/t
Ni	diffuse	0.284				g/t
NMVOC		0.035	0.024	0.012	0.006	kg/t
NO_x	channelled	0.122	0.12	0.106	0.098	kg/t
NO_x	diffuse	0.014				kg/t
PAH		45	22.1	3.798	3.793	mg/t
Pb	channelled	4.075	1.747	0.720	0.170	g/t
Pb	diffuse	0.056				g/t
PCB		5.68	3.360	1.500	1.500	mg/t
PCDD/F		0.466	0.295	0.158	0.158	µg/t
SO_2	channelled	0.113				kg/t
SO_2	diffuse	0.004				kg/t
TSP	channelled	0.28	0.12	0.074	0.018	kg/t
TSP	diffuse				0.043	kg/t
PM_{10}	channelled	0.179	0.08	0.051	0.013	kg/t
PM_{10}	diffuse				0.007	kg/t
$PM_{2.5}$	channelled	0.045	0.04	0.038	0.011	kg/t

Table 5: Overview of the emission factors applied for hot and cold rolling

	Type of source	EF 1995	EF 2000	EF 2005	EF 2010	unit	Trend
CO					5.0	g/t	constant
NH_3			0.700			g/t	constant
NMVOC			3.0			g/t	constant
NO_x			0.410	0.276	0.196	kg/t	falling
SO_2			0.059	0.050	0.044	kg/t	falling
TSP	channelled				0.020	kg/t	constant
TSP	diffuse				0.010	kg/t	constant
PM_{10}	channelled				0.304	g/t	constant
PM_{10}	diffuse				0.645	g/t	constant
$PM_{2.5}$	channelled				0.266	g/t	constant

Table 6: Overview of the emission factors applied for iron and steel casting

	EF 2010	Unit	Trend
NH_3	0.027	kg/t	falling
NMVOC	0.150	kg/t	constant
NO_x	0.242	kg/t	falling
PAH	0.100	g/t	constant
PCDD/F	0.190	µg/t	constant
SO_2	0.256	kg/t	falling
TSP	0.200	kg/t	constant
PM_{10}	0.137	kg/t	constant
$PM_{2.5}$	0.0836	kg/t	constant

HCB

For the calculation of HCB emissions in **sinter production**, the standard emission factor is used. By implementing the EMEP/EEA Guidebook standard emission factor, Germany is following recommendations provided by the Expert Review Team for the NECD-Review in 2020.

PAH

In the 2021 review the application of a consistent methodology in reporting of PAH emissions in 2C1-iron and steel production was claimed. As there was not enough data available to report individual PAHs Germany decided to only report total-PAHs for the whole time. Therefore a national total-PAH emission factor for **pig iron production** was needed as the national inventory solely included BaP emissions for that source.
Emissions of PAH depend on the coating material used. As tar-free materials are used for coating and the blast furnace gas is conducted and used PAH emissions should not play any role. But as PAH emissions could not be surely ruled out and in order to avoid an underestimation of PAH emissions in pig iron production the emission factor for total-PAH is set to the 10-fold of the BaP emission factor following a conservative ansatz and not changing the overall PAH emission trend.

Discussion of emission trends

The trends in emissions correspond to the trends of emission factors given in the tables above, which are often driven by regulatory measures.
However, since 2010, the main driver of the emission trends in most cases is the activity data.

Recalculations

Recalculations were necessary for 2022 due to the implementation of the now finalised National Energy Balance.



For more **information on recalculated emission estimates for the Base Year and 2022**, please see the pollutant specific recalculation tables in the following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] Hensmann et al. (2011): Hensmann, M., Haardt, S., Ebert, D.: Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichterstattung (FKZ 3707 42 301); https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/4362.pdf, on behalf of the Umweltbundesamt, Dessau-Roßlau, October 2012

[13)], [14)]

emissions reported under NRF 1.A.2.a

[15)]

see section on PAH below

2.C.2 - Ferroalloys Production

Short description

Category Code	Method	AD	EF
2.C.2	T1	IS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	As	**Cr**	Cu	Ni	Se	Zn	POPs
NE	NE	NE	NA	-/-	-/-	-/-	NE	NE	NE	NE	NE	NA	NE	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Source category *Ferroalloys Production* is of minor significance and not a key source. Ferroalloys are non-ferrous metal aggregates used in steel production.
Germany has five producers of ferrochrome, silicon metal and ferrosilicon. These materials are used as alloying agents in stainless-steel production. The only process applied in Germany since 1995 is the electric arc process generating only a small amount of process-related emissions (specifically due to electrode consumption). The blast-furnace process, which produces much higher emissions, was used, to some extent, until 1995. In 2023, ferroalloys production amounted to 51.3 kt.

Method

Activity data

The activity data from the years 1990 to 1994 has been taken from official production statistics of the Federal Statistical Öffice. Since 1995, the data from the official production statistics is no longer suitable to use in this context. Since then, data from the British Geological Survey [1)] has been used instead.

The most recent activity data is available for 2021. This data has been carried forward into 2022. As soon as updated statistical data is available - in general, every two years -, a recalculation will be carried out.

Emission factors

The emission factor for TSP (0.1 kg/t for the current year and back to 1998) and the splitting factors for PM_{10} and $PM_{2.5}$ were determined in a research project (Jörß et al., 2007) [2)]. There were higher but decreasing EF for the period 1990-1997 due to the technology changes.

Uncertainties

The uncertainties for the production amounts are 50% and for the emission factors not more than 300%.

Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

Planned improvements

Actualized production figures of the latest world mineral production report for the years 2019-2022 are not implemented because the reasons for the changes are not explained. These revision only belong to estimated values of the category “other ferro-alloys”. For submission 2026, the implementation of the new vaules will be justified.

[1)] Idoine, N.E.; Raycraft, E.R.; Hobbs, S.F.; Everett, P.; Evans, E.J.; Mills, A.J.; Currie, D.; Horn, S.; Shaw, R.A.: World mineral production 2018-22. British Geological Survey, 98pp. Keyworth, Nottingham; URL: https://nora.nerc.ac.uk/id/eprint/537241/; Nottingham, UK, 2024.

[2)] Jörß et al. (2007): Jörß, W., Handke, V. (Institut für Zukunftsstudien und Technologiebewertung (IZT), Berlin) with Lambrecht, U., Dünnebeil, Fr. (Institut für Energie und Umweltforschung Heidelberg (ifeu)): Emissionen und Maßnahmenanalyse Feinstaub 2000–2020. UBA-TEXTE Nr. 38/200; https://www.umweltbundesamt.de/publikationen/emissionen-massnahmenanalyse-feinstaub-2000-2020.; on behalf of the Umweltbundesamt; Dessau-Roßlau, 2007.

2.C.3 - Aluminium Production

Short description

Within category *2.C.3 - Aluminium production*, emissions from primary aluminium and secondary aluminium production are reported.

Category Code	Method	AD	EF
2.C.3	T2, T3	AS	D, CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	**SO_2**	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	**CO**	**Pb**	**Cd**	**Hg**	**PCDD/F**	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAHs**	HCB
-/-	NE	-/-	NA	-/-	-/-	-/-	NE	**-/-**	-/-	-/-	-/-	-/-	**-/T**	-	-	-	-/-	L/T

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

In Germany, primary aluminium is produced in electrolytic furnaces with pre-baked anodes. The pre-baked anodes are produced in separate anode production plants, where petroleum coke and tar pitch are mixed together and subsequently baked. This process produces PAH emissions.

Secondary aluminium is produced in several different furnace types. Emissions can vary according to different scrap qualities. The use of hexachloroethane for degassing during refining operations of secondary aluminium production has been prohibited by law in Germany since 2002, resulting in an omission of the source for HCB.

In 2023, the primary and secondary aluminium production amounted to 667.6 kt.

Method

Activity data

Annual production figures are derived from the annual statistical report of the German association for non-ferrous metals [1)].

The total quantity of waste gas incurred per tonne of aluminium during the production of primary aluminium was multiplied by an average concentration value formed from several individual figures coming from different plants. The values are weighted appropiately and then used to derive the average concentration value.

Emission factors

The emission factors are either default values according to the 2023 EMEP/EEA air pollutant emission inventory guidebook [2)] or determined in research projects [3)]. The emission factors also make allowance for fugitive emission sources, such as emissions via hall roofs.

The emission factors for SO_2 are calculated from the specific anode consumption. The anodes consist of petrol coke. This material has a specific sulphur concentration of about 1.2 %, from which an SO_2 emission factor of 10.4 kg/t Al can be calculated. The average anode consumption is 430 kg of petrol coke per tonne of aluminium.

The following tables show some process-related emission factors.

Table 1: Emission factors applied for anode production

	EF	Unit	Trend
BaP	4.096	mg/t	falling

Benzo(a)pyrene is the lead substance for measurements.

Table 2: Emission factors applied for primary aluminium production

	EF	Unit	Trend
CO	120	kg/t	constant
SO_2	7.341	kg/t	constant
TSP	0.83	kg/t	falling
PM_{10}	0.7055	kg/t	falling
$PM_{2.5}$	0.581	kg/t	falling
Cd	0.15	g/t	constant
Ni	0.162	g/t	falling
Zn	10	g/t	constant
NO_x	1	kg/t	constant

Nitrogen oxide emissions essentially arise from the nitrogen content of the fuels in combustion processes. At temperatures above 1,000 ° C, Nitrogen oxide can also form from nitrogen in the air. Another source of NO_x is the electrolysis in primary aluminium production due to the presence of nitrogen in the anode, which can be oxidized to NO_x. All these emission sources resulting from energy-related processes are included in 1.A.2.b. It is not known whether other sources of NO_x have quantitative effects. In order not to miss process-related NO_x emissions, the standard emission factor is also used. Germany is following recommendations provided by the Expert Review Team for the NECD Review 2017.

Table 3: Emission factors applied for secondary aluminium (resmelted aluminium) production

	EF	Unit	Trend
TSP	0.055	kg/t	constant
PM_{10}	0.047	kg/t	constant
$PM_{2.5}$	0.03843	kg/t	constant
Cd	7	mg/t	constant
Cu	8.411	mg/t	constant

	EF	Unit	Trend
Hg	1.7	mg/t	constant
Pb	4.452	mg/t	constant
Zn	4	g/t	constant
HCB (years 1990-2001)	5	g/t	constant

For the period between 1990 and 2001, however, no data on national emissions of HCB in secondary aluminium industries is available. In order to be able to calculate these HCB emissions, the default emission factor for HCB was used.

Uncertainties

The uncertainties for the production amounts are 5% and for the emission factors not more than 200%.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

According to the BREF for Non-ferrous metals Industries the measurement and detection of PAH emission is done using BaP as a marker. That’s why Germany only gathered measurment data for BaP. A NEC-review recommendation is to assess the use of default emission factors for the 3 other PAHs to complete PAH emission reporting. Germany will realize that in the next submission 2026.

[1)] WVMetalle, 2021: German association for non-ferrous metals (WirtschaftsVereinigung Metalle): Annual statistical report: https://www.wvmetalle.de

[2)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.C.3 - Aluminium production 2023; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-c-metal-production/2-c-3-aluminium-production-2023/@@download/file; Copenhagen, 2023.

[3)] Ökopol, IER Universität Stuttgart, IZT Berlin, Institut für Gießereitechnik (IfG) 2010: Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarung für ausgewählte Industriebranchen TV02: NE-Metallindustrie, Gießereien, Kalkindustrie, FKZ 3707 42 301/02, Aufttraggeber: Umweltbundesamt, 2010

2.C.4 - Magnesium Production

There is no primary magnesium production in Germany (not occurring - NO).
Emissions of NOx, NMVOC, SO_2, NH_3 and CO from the production of secondary magnesium are reported in sub-category 1.A.2.b.

Planned improvements

There are no planned improvements.

2.C.5 - Lead Production

Short description

Within this NFR subcategory, SO_2, $PM_{2.5}$, PM_{10}, TSP, As, Cd, Cu, Hg, Pb, Zn, PCB and PCDD/F emissions from the production of lead are reported.

Category Code	Method	AD	EF
2.C.5	T2	AS	D, CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	**SO_2**	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	CO	**Pb**	**Cd**	**Hg**	**As**	Cr	**Cu**	Ni	**Se**	**Zn**	**PCDD/F**	PAHs	HCB	PCB
NA	NA	-/-	NA	-/-	-/-	-/-	NE	NA	-/-	-/-	-/-	-/-	NA	-/-	NA	NE	-/-	-/-	NA	NA	**L/T**

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

Activity data

Annual production figures are derived from the annual statistical report of the German association for non-ferrous metals [1)]. In **2023**, the primary and secondary lead production amounted to **305 kt**:

Emission factors

The emission factor for SO_x is a tier1 default value according to the EMEP/EEA air pollutant emission inventory guidebook 2023 [2)] and is supposed to be constant over time. All other emission factors are tier2 values with a decreasing trend and determined in research projects. For heavy metals (HM), the applied emission factors are derived from a research project [3)].

Table 2: emission factors applied for primary and secondary lead production

	EF (primary)	EF (secondary)	Unit
SO_2	2.05		kg/t
$PM_{2.5}$	17.5		g/t
PM_{10}	21.3		g/t
TSP	25		g/t
As	49.213	41.179	mg/t
Cd	62.448	19.767	mg/t
Cu	162.663		mg/t
Hg	0.3	0.325	g/t
Pb	6.028	4.506	g/t
Zn	664	50	mg/t
PCB	2.1		mg/t
PCDD/F	0.34		µg/t

Uncertainties

The uncertainties for the production amounts are 5% and for the emission factors not more than 300%. Only for dioxines the upper bond uncertainty is about 900%.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

The emission factor applied for PCB is still based on values from older versions of the EMEP/EEA Guidebook and seems to be to high due to legal terms. As the emission factor could not be updated with the current submission, this revision will be scheduled for submission 2026.

[1)] WVMetalle (2021): German association for non-ferrous metals (WirtschaftsVereinigung Metalle): Annual statistical report: https:https://www.wvmetalle.de

[2)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.C.5 Lead production 2023 FINAL; Copenhagen, 2023. https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-c-metal-production/2-c-5-lead-production-2023/@@download/file

[3)] Ökopol, IER Universität Stuttgart, IZT Berlin, Institut für Gießereitechnik (IfG) 2010: Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarung für ausgewählte Industriebranchen TV02: NE-Metallindustrie, Gießereien, Kalkindustrie, FKZ 3707 42 301/02, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2010

2.C.6 - Zinc Production

Short description

Within this NFR subcategory, SO_2, $PM_{2.5}$, PM_{10}, TSP, As, Cd, Hg, Pb, Zn, PCDD/F, and PCB emissions from the production of zinc are reported.

Category Code	Method	AD	EF
2.C.6	T2	AS	D,CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	**SO_2**	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	CO	**Pb**	**Cd**	**Hg**	**As**	Cu	Cr	Ni	**Se**	**Zn**	**PCDD/F**	PAHs	HCB	**PCBs**
NA	NA	-/-	NA	-/-	-/-	-/-	NE	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NE	**L/-**	-/-	NA	NA	**L/T**

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

Activity data

The yearly production figures were taken from the annual statistical report of the German association for non-ferrous metals [1)]. In **2023**, primary and secondary zinc production fell to a total of **0.76 kt** due to reduced production outputs or even production stops:

Emission factors

The emission factor for SO_x is a tier1 default value according to the EMEP/EEA air pollutant emission inventory guidebook 2023 [2)] and is supposed to be constant. All other emission factors are tier2 values with a decreasing trend and determined in research projects. The EF for the heavy metals (HM) are taken from a research project [3)].

Table 2: emission factors applied for primary and secondary zinc production

	EF (primary)	EF (secondary)	Unit
SO_2	1.35		kg/t
$PM_{2.5}$	38.5		g/t
PM_{10}	61.3		g/t
TSP	100		g/t
As	123.882	30	mg/t
Cd	1085	230	mg/t
Hg	500	1.5	mg/t
Pb	19.605	0.95	g/t
Zn	51.968	9	g/t
PCB	1		mg/t
PCDD/F	0.15		µg/t

Uncertainties

The uncertainties for the production amounts are 5% and for the emission factors not more than 300%. Only for dioxines the upper bond uncertainty is about 900%.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] WVMetalle (20219: German association for non-ferrous metals (WirtschaftsVereinigung Metalle): Annual statistical report: https:https://www.wvmetalle.de

[2)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.C.6 - Zinc production 2023; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-c-metal-production/2-c-6-zinc-production-2023/@@download/file; Copenhagen, 2023.

[3)] Ökopol, IER Universität Stuttgart, IZT Berlin, Institut für Gießereitechnik (IfG) 2010: Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarung für ausgewählte Industriebranchen TV02: NE-Metallindustrie, Gießereien, Kalkindustrie, FKZ 3707 42 301/02, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2010

2.C.7.a - Copper Production

Short description

Within this NFR subcategory, SO_2, $PM_{2.5}$, PM_{10}, TSP, PCDD/F, HCB, As, Cd, Cu, Hg, and Pb emissions from the production of copper are reported.

Category Code	Method	AD	EF
2.C.7.a	T2	AS	D, CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	**SO_2**	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	CO	**Pb**	**Cd**	**Hg**	**As**	Cr	**Cu**	Ni	Se	**Zn**	**PCDD/F**	PAHs	**HCB**
NA	NA	-/-	NA	-/-	-/-	-/-	NE	NA	-/-	**L/T**	-/-	**L/-**	NA	-/-	NE	NE	-/-	-/-	NA	**L/-**

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

Activity data

The annual production figures were taken from the annual statistical report of the German association for non-ferrous metals (WirtschaftsVereinigung Metalle) [1)] until 2020. Since 2021 the production figures for primary copper have been directly taken from the producer whereas for secondary copper no updating was possible. In 2023 the primary and secondary copper

production amounted to 559.7 kt.

Emission factors

The emission factors are either default values according to the EMEP/EEA air pollutant emission inventory guidebook 2023 [2)] or determined in research projects [3)], [4)], [5)] or from companies environmental reports[6)]. Nickel emissions in secondary copper production are not reported.

Table 1: Tier 1 emission factors applied for entire time series (primary and secondary copper production)

	EF	Unit	Source
HCB	1	mg/t	German association for non-ferrous metals (WirtschaftsVereinigung Metalle) [7)]
PCDD/F	2.9	µg/t	Rentz et al. 2008 [8)]

Table 2: Emission factors applied for primary copper production

	EF	Unit	Source
TSP	0.09	kg/t	Aurubis, 2023 [9)]
PM_{10}	0.0765	kg/t	calculated from Aurubis, 2023
$PM_{2.5}$	0.063	kg/t	calculated from Aurubis, 2023
SO_2	3.6	kg/t	Aurubis, 2023
As	0.8	g/t	Aurubis, 2023
Cd	15	g/t	EMEP/EEA GB 2023 [10)]
Cu	13.8	g/t	Aurubis, 2023
Hg	0.031	g/t	EMEP/EEA GB 2023
Pb	3.1	g/t	Aurubis, 2023

Table 3: Emission factors applied for secondary copper production

	EF	Unit	Source
TSP	0.100	kg/t	PAREST 2013 [11)]
PM_{10}	0.085	kg/t	PAREST 2013
$PM_{2.5}$	0.07	kg/t	PAREST 2013
SO_2	3.0	kg/t	EMEP/EEA GB 2023
As	2	g/t	EMEP/EEA GB 2023
Cd	486.428	mg/t	NE-G-K 2010 [12)]
Cu	46,088.62	mg/t	NE-G-K 2010
Hg	2.644	mg/t	NE-G-K 2010
Pb	21,977.15	mg/t	NE-G-K 2010

Uncertainties

The uncertainties for the production amounts are 7% and for the emission factors not more than 50% for primary and 200% for secondary copper production.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the prvious submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1), 7)] WVMetalle (2021): German association for non-ferrous metals (WirtschaftsVereinigung Metalle): Annual statistical report: https:https://www.wvmetalle.de
[2), 10)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.C.7.a Copper production 2023; https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-c-metal-production/2-c-7-a-copper/view|https://www.eea.europa.eu, Copenhagen, 2023
[3), 8)] Rentz et al. (2008): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, https://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008
[4), 12)] Ökopol, IER Universität Stuttgart, IZT Berlin, Institut für Gießereitechnik (IfG) 2010: Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarung für ausgewählte Industriebranchen TV02: NE-Metallindustrie, Gießereien, Kalkindustrie, FKZ 3707 42 301/02, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2010
[5)] Theloke et al. (2013): Theloke, J., Kugler, U., Kampffmeyer, T., Uzbasich, M., Kuhn, A., Dämmgen, U.: Beschreibung der Minderungsmaßnahmen im Projekt PAREST Maßnahmenblätter; Teilbericht zum F&E-Vorhaben „Strategien zur Verminderung der Feinsatubbelastung - PAREST - UBA Texte 48/2013, https://www.umweltbundesamt.de/publikationen/beschreibung-minderungsmassnahmen-im-projekt-parest, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2013
[6), 9)] Aurubis, 20243: Aurubis, Umwelterklärungen 2023, Aurubis AG, https://www.aurubis.com/

2.C.7.b - Nickel Production

In subcategory *NFR 2.C.7.b - Nickel production* the TSP, SO_2 and Ni emissions from nickel mining are reported.

Reporting only covers the year 1990 because in 1991 nickel mining stopped in Germany.

Category Code	Method	AD	EF
2.C.7.b	T1	AS	D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

	NO_x	NMVOC	**SO_2**	NH_3	$PM_{2.5}$	PM_{10}	**TSP**	BC	CO	Pb	Cd	Hg	As	Cu	Cr	**Ni**	Se	Zn	PCDD/F	PAHs	HCB
1990-1991:	NE	NE	-/-	NE	NR	NR	-/-	NR	NE	NE	NE	NE	NE	NE	NE	-/-	NE	NE	NE	NE	NE
as of 1992:	NO																				

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

Activity data

Annual production data were derived from the World Mineral Statistics report of the British Geological Survey 1990-94 [1)].

Here, Nickel was produced only in the former GDR, in the New German Länder and only until 1990:

Table 1: Nickel production, in [t]

1990	as of 1991
872[2)]	NO

Emission factors

The emission factors are the default values according to the EMEP/EEA air pollutant emission inventory guidebook 2023 [3)].

Table 2: applied Tier1 emission factors, in [kg/t]

	EF
SO_2	18
TSP	0.3
Ni	0.025

Uncertainties

Recalculations

There is no primary nickel production in Germany. Therefore it is **not necessary to update** the activity data and emission factors.

Planned improvements

At the moment, no category-specific improvements are planned.

[1), 2)] Taylor et. al (1995): Taylor, L.E., Lofty, G.J., Hillier, J.A., Fellows, M.E., Bate, D.G., Linley, K.A., Mills, A.J., White, R.: BRITISH GEOLOGICAL SURVEY: World Mineral Statistics 1990-94: https://nora.nerc.ac.uk/id/eprint/535237/1/WMS_1990_1994.pdf; here: page 192: Mine Production of Nickel; Keyworth, Nottingham, UK, 1995

[3)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; Chapter 2.C.7.b - Nickel production FINAL; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-c-metal-production/2-c-7-b-nickel/@@download/file, Copenhagen, 2023

2.C.7.c - Other Metal Production

Short description

In source category *NFR C.7.c - Other Metal Production* thermal galvanisation is reported and the main pollutants are PM.

Category Code	Method	AD	EF
2.C.7.c	T1	AS	PS, CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	**SO_2**	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	CO	Heavy Metals	POPs
NA	NA	NE	NA	-/-	-/-	**L/T**	NE	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

Activity data

Annual production figures were provided by the German association “Industrieverband Feuerverzinken e.V” (IFV) back to 2010 [1)] with figures based on annual queries of its member companies.

As the market share covered by the members of IFV used to be about 45%, the IFV extrapolated the total values for Germany on this basis.

Emission factors

The emission factor for TSP was determined on the basis of data supplied for the FMP (Ferrous Metals Processing) BREF review.
The split factors originate from (Jörß et al., 2007) [2)].

As produced amounts are considered confidential, no emission factors can be published here.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] IFV (2011): Industrieverband Feuerverzinken e.V. (IFV), https://www.feuerverzinken.com/
[2)] Jörß et al. (2007): Jörß, W.; Handke, V. (Institut für Zukunftsstudien und Technologiebewertung (IZT), Berlin) with Lambrecht, U., Dünnebeil, Fr. (Institut für Energie und Umweltforschung Heidelberg (ifeu)): Emissionen und Maßnahmenanalyse Feinstaub 2000–2020. UBA-TEXTE Nr. 38/200; https://www.umweltbundesamt.de/publikationen/emissionen-massnahmenanalyse-feinstaub-2000-2020., on behalf of the Umweltbundesamt; Dessau-Roßlau, 2007.

2.C.7.d - Storage, Handling and Transport of Metal Products



All emissions from storage, handling and transport of metal products are included elsewhere ('IE') in the values reported in NFR 2.L - Other production, consumption, storage, transportation or handling of bulk products.

2.D - Solvent Use And Product Use (OVERVIEW)

The *solvent and product use* subsector comprises very different products not only in use but also in production. All products are assigned to one of the following nine source categories covering alltogether 37 SNAP codes.

2.D Solvent Use and Product Use	relevant SNAP Codes
2.D.3.a Domestic Solvent Use including fungicides	60408, 60411
2.D.3.b Road Paving with Asphalt	040611, not use of solvents
2.D.3.c Asphalt Roofing	040610, not use of solvents
2.D.3.d Coating Applications	60101 - 60108
2.D.3.e Degreasing	60201, 60203, 60204
2.D.3.f Dry Cleaning	60202
2.D.3.g Chemical Products	60301 - 60314
2.D.3.h Printing	60403
2.D.3.i Other Solvent Use	60401, 60402, 60404 - 60407, 60409, 60412



This site provides general information relevant for all product groups covered by NFR 2.D. For more specific information and data please refer to the category-specific sites linked above.

Please note: Emissions from **2.D.3.b & c** are not calculated via the solvent containing model and therefore **excluded from this description and trend diskussion**.

General description for 2.D.3.a, d, e, f, g, h and i

Category Code	Method	AD	EF
2.D.3.a,d,e,f,g,h,i	T2	NS	CS

Category Code	Method	AD	EF
Method(s) applied			
D	Default		
T1	Tier 1 / Simple Methodology *		
T2	Tier 2*		
T3	Tier 3 / Detailed Methodology *		
C	CORINAIR		
CS	Country Specific		
M	Model		
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.			
(source for) Activity Data			
NS	National Statistics		
RS	Regional Statistics		
IS	International Statistics		
PS	Plant Specific		
As	Associations, business organisations		
Q	specific Questionnaires (or surveys)		
M	Model / Modelled		
C	Confidential		
(source for) Emission Factors			
D	Default (EMEP Guidebook)		
CS	Country Specific		
PS	Plant Specific		
M	Model / Modelled		
C	Confidential		

NO_x	**NMVOC**	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NA	**2.D.3.a L/-**	NA	NA	NA	NA	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

'NMVOC' is defined in accordance with the VOC definition found in the EC solvents directive. For purposes of the definition of solvents, the term 'solvent use' is also defined in accordance with the EC solvents directive.

Method

NMVOC emissions are calculated in accordance with a product-consumption-oriented approach.

In this approach, solvent-based products or solvents are allocated to the source category, and then the relevant NMVOC emissions are calculated from those solvent quantities via specific emission factors. Thus, the use of this method is possible with the following valid input figures for each product group:

- Quantities of VOC-containing (pre-) products and agents used in the report year,
- The VOC concentrations in these products (substances and preparations),
- The relevant application and emission conditions (or the resulting specific emission factor).

The quantity of the solvent-based (pre-)product corresponds to the consumption which is the sum of production plus import minus export.

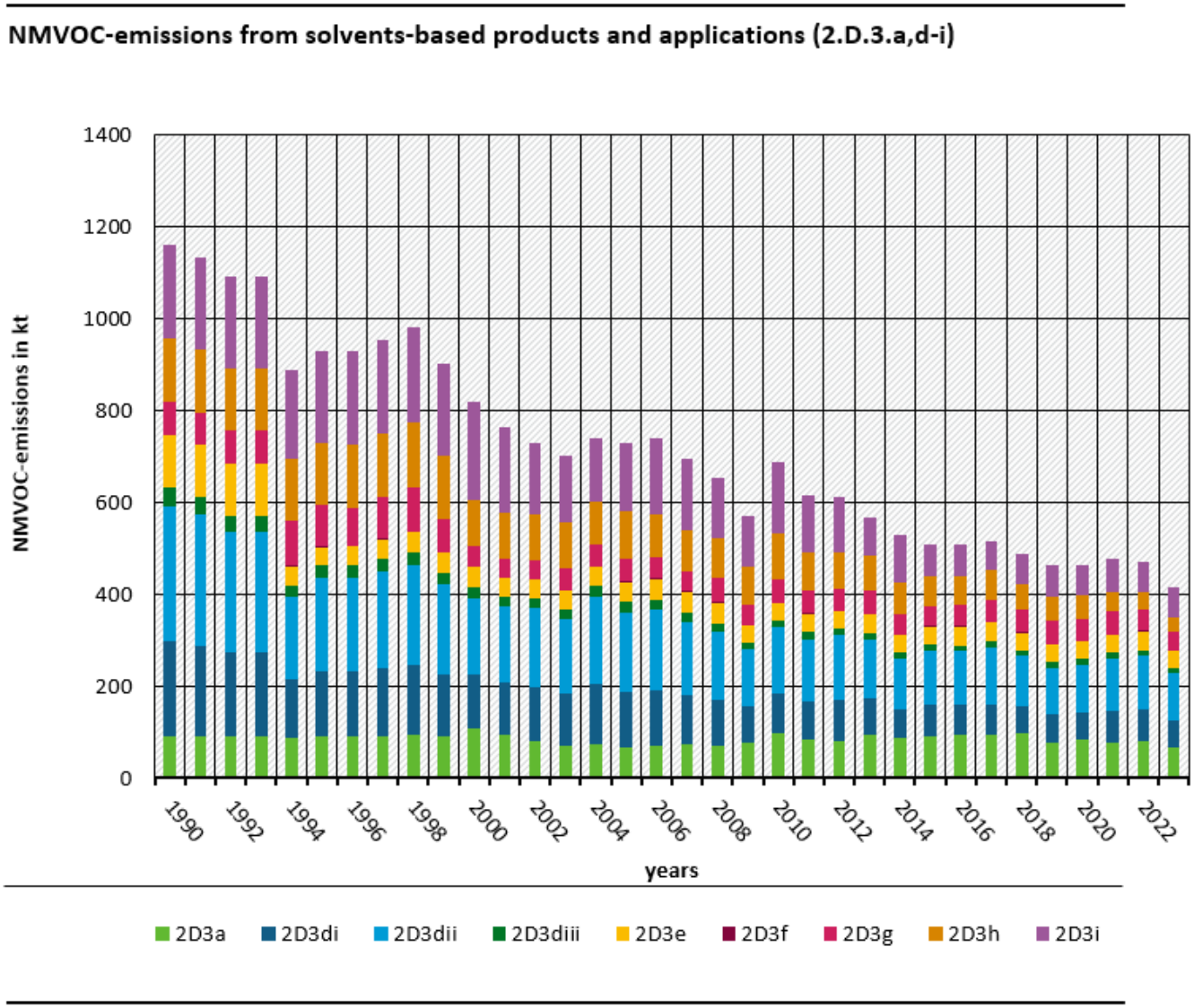
NMVOC Emission = consumption of a certain product * solvent content * specific emission factor

The calculated NMVOC emissions of different product groups for a source category are then aggregated.

The product / substance quantities used are determined at the product-group level with the help of production and foreign-trade statistics. Where possible, the so-determined consumption quantities are then further verified via cross-checking with industry statistics.

Discussion of emission trends

Since 1990, so the data, NMVOC emissions from use of solvents and solvent-containing products in general have decreased by nearly 60%. The main emissions reductions have been achieved in the years since 1999. This successful reduction has occurred especially as a result of regulatory provisions such as the 31st Ordinance on the execution of the Federal Immissions Control Act (Ordinance on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain facilities – 31. BImSchV) [1)], the 2nd such ordinance (Ordinance on the limitation of emissions of highly volatile halogenated organic compounds – 2. BImSchV) [2)] and the TA Luft.



Uncertainties

Uncertainties for emissions for each product were obtained by error propagation and refer to the 95% confidence interval. For the majority of activity data (domestic consumption) based on official statistics, a relative uncertainty of ±10% has been applied.
Regarding the solvent content, for each product a relative error at ±15% was applied, but not exceeding 100% or falling below 0%.
As for emission factors, for each product a relative error at ±15% was applied, but not exceeding 100% or falling below 0%.
Hence the overall uncertainty of emissions caused by application of products of this source group is 40% with exception of 'antifreeze agents for cars' at 60%.

Recalculations

Routinely the NMVOC emissions of the last reported year must be updated in the next reporting cycle in accordance with the then final data of the foreign trade statistics.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

The following review recommendations will be proofed for implementation in submission 2026
* Reporting of activty data in the NFR-tables and/or IIR * As At the moment, no general improvements for all product groups are planned. However, improvements specific for the several sub-categories are provided on the category-specific sites linked above.

[1)] 31. BImSchV: Ordinance on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain facilities; https://www.gesetze-im-internet.de/bimschv_31_2024/BJNR0070A0024.html
[2)] 2. BImSchV: Ordinance on the limitation of emissions of highly volatile halogenated organic compounds; https://www.gesetze-im-internet.de/bimschv_2_1990/index.html

2.D.3.a - Domestic Solvent Use, including Fungicides

Short description



For a general product and method description refer to 2.D.3. This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level.

The following product groups are taken into consideration:

i) Domestic solvent use (SNAP code 60408)

- **Soaps**
- **Laundry detergents, dishwashing detergents and cleaning products** (fabric softeners; universal detergents; washing agents; auxiliary washing preparations; dishwashing liquids; detergents for dishwashers; floor detergents; carpet shampooers; car cleaning shampoos; glass cleaners; WC cleaners)
- **Care products for footwear, leather articles, furniture, floors and cars**
- **Polishing agents** (for metal)
- **Deodorizers** (for rooms and others)
- **Perfumes** (including after shaves; eau de toilette, perfumes)
- **Cosmetic and make-up preparations** (make-up; hand care products; nail care products; pedicure products; face cleanser; suntan lotions; face and body care products and others)
- **Shampoos and hair care products** (shampoos; preparations for permanent waving or straightening; hair sprays; lotions and brilliantines; toning shampoos; hair colouring products; hair bleaching and other)
- **Other personal care products** (shaving creams; personal deodorants and antiperspirants; bath essences; depilatories, deodorants, preparations for intimate hygiene and other)
- **Antifreeze agents for cars**

ii) Domestic use of pharmaceutical products (SNAP code 60411)

Specific information

Calculation of domestic consumption was based on:

- the German production statistics and external trade statistics for the subgroup “Domestic solvent use”.
- turnover values of pharmaceuticals produced in Germany for the subgroup “Domestic use of pharmaceutical products”,

Solvent contents for this product group corresponds to personal information from industrial associations and German literature [1)].

For alcohol-based cleaning detergents an emission factor of 3% was assumed for calculations [2)]. For all other products of this source category (e.g. hair spray, after shave, perfumes), an emission factor of 95% was applied.

Discussion of emission trends

Specific information

Until 1999, data of the present source categories 2.D.3.a, 2.D.3.h and 2.D.3.i were treated as one source group. Since 2000, a more detailed data collection enables to follow the development of source group 2.D.3.a, which accounts for about 8 to 20 per cent of total NMVOC emissions from solvent-based products. For more than 30 years there have not been observed a

decreasing trend.

The following four product groups account for 44 to 69 per cent of 2.D.3.a emissions:

- hair sprays,
- antifreeze agents for cars,
- eau de toilette
- pharmaceutical products.

As emission factors and solvent contents largely remained robust since 2000, domestic consumption of products caused visible changes in NMVOC emissions. For instance, the annual amount of used ‘antifreeze agents for cars’ primarily depends on the weather situation of the specific year. As antifreeze agents have one of the highest domestic consumption values of the category ‘domestic solvent use’, they significantly effect the final value of emitted NMVOC of this category. The increase in emissions in 2010 can be explained by a long-lasting cold season. For few product groups, such as personal deodorants, antiperspirants and car surface protectants, domestic consumption and hence NMVOC emissions show a declining trend compared to 2005. However, for many product groups, such as soaps, hair sprays, eau de toilette and pharmaceutical products domestic consumption and emissions increased for in the same period.

Uncertainties



For the majority uncertainties of activity data (domestic consumption) and emission factors see 2.D.3.

For the product group of ‘antifreeze agents for cars’ a relative uncertainty of ±20% is applied for the activity data and of ±25% for the emission factors based on expert estimation.

[1)] Berner (1996): Berner, P.: Maßnahmen zur Minderung der Emissionen flüchtiger organischer Verbindungen aus der Lackanwendung - Vergleich zwischen Abluftreinigung und primären Maßnahmen am Beispiel Baden-Württembergs, Stuttgart: Institut für Energiewirtschaft und Rationelle Energieanwendung, Universität Stuttgart, Forschungsbericht Band 42, 1996 - Dissertation, Stuttgart, 1996

[2)] Wooley et al. (1990): Wooley, J., Nazaroff, W.N., Hodgon, A.T.: Release of ethanol to the atmosphere during use of consumer cleaning products, J. Air Waste Manage. Assoc. 40, 1114-1120, Berkeley, California, 1990.

2.D.3.b - Road Paving

Short description

Category Code	Method	AD	EF
2.D.3.b	T1	AS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	Heavy Metals	PCDD/F	**PAHs**	HCB	PCBs
-/-	-/-	-/-	NA	-/-	-/-	-/-	NE	IE	NA	NA	NE	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Currently, the report tables list produced quantities of mixed asphalt products (from stationary installations only) and NMVOC, NO_x and SO_2 emissions caused of this. Only emissions from asphalt production are reported. Figures relative to emissions released during laying of asphalt have not been examined.

Method

Activity data

The applicable quantity of mixed asphalt products produced (activity rate) has been taken from communications of the Deutscher Asphaltverband (DAV; German asphalt association). In total about 660 asphalt-mixing plants produce most

recently 38 Million tonnes of hot-mix for road paving [1)].

Emission factors

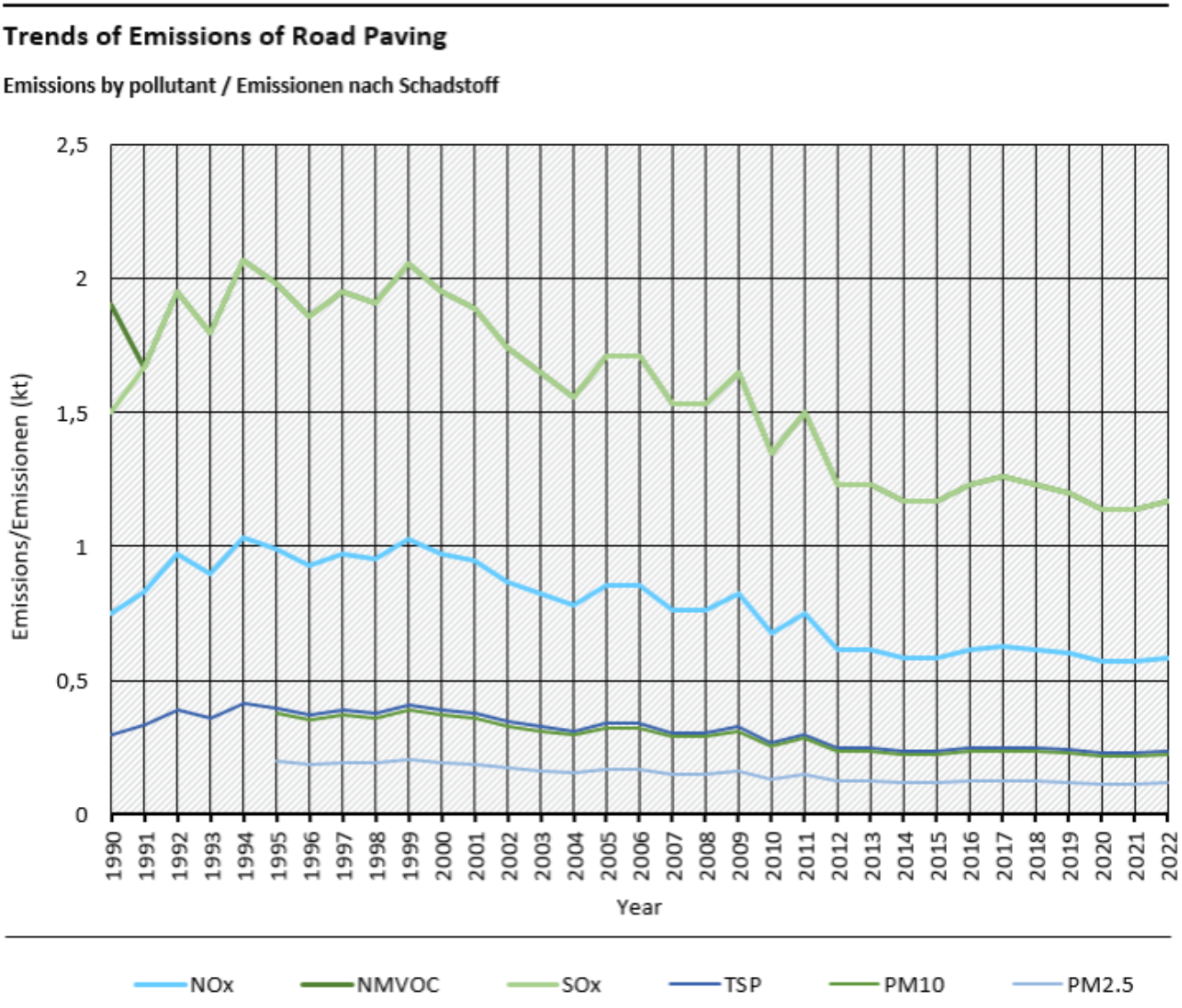
Emission factors have been determined country-specifically, pursuant to Tier 2. For determination of emission factors for emissions measurements from over 400 asphalt-mixing plants, made during the period 1989 through 2000, were used. The majority of the emissions occur during drying of pertinent mineral substances. Almost all of the NMVOC emissions originate in the organic raw materials used, and they are released primarily in parallel-drum operation, as well as from mixers and loading areas. On average, about 50% of the NOx and SO_x involved come from the mineral substances (proportional process emissions). CO emissions are calculated solely in connection with fuel inputs.

Table 1: Overview of applied emission factors for production of mixed asphalt, in [kg/t]

	EF value	EF trend
NMVOC	0.030	constant
NO_x	0.015	constant
SO_x	0.030	constant
TSP	0.006	constant
PM_{10}	0.0057	constant
$PM_{2.5}$	0.003	constant

Trends in emissions

All trends in emissions correspond to trends of production amount. No rising trends are to identify.



Emission trends of road paving

note: small change for 2023

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] https://www.asphalt.de/themen/aktuelles/

2.D.3.c - Asphalt Roofing

Short description

Category Code	Method	AD	EF
2.D.3.c	T1	AS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	SO_2	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	CO	Heavy Metals	PCDD/F	**PAHs**	HCB	PCBs
NA	-/-	NA	NA	NE	NE	NE	NA	NA	NA	NA	NE	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Bitumen is used in production and laying of roof and sealing sheeting. Roof and sealing sheeting is laid by means of both hot and cold processes.

The hot process, involving welding of sheeting, produces significant emissions of organic substances.

The relevant emissions trends depend primarily on trends in quantities of polymer bitumen sheeting produced. Use of solvent-containing primers is not considered here; it is covered via the solvents model – cf. 2.D.3.a Domestic Solvent Use.

Because of importance from other sources as solvents use, NMVOC emissions are considered and taken into account in this part of the emissions inventory.

Method

Activity data

Since a cooperation agreement was concluded, annual quantities of roof and sealing sheeting produced (activity data) are provided by the Verband der Dachbahnenindustrie (VDD) [1)], the roof-sheeting manufacturers association (VDD, actual table exchanged with UBA).

Emission factors

In the process, a distinction is made between emissions from (i) the production and (ii) the laying of roof and sealing sheeting.

The emission factor for **production of roof and sealing sheeting** was obtained via a calculation in accordance with current technological standards of German manufacturers (VDD, see activitiy data).

The emission factor for laying of **polymer-bitumen sheeting** has been derived from an ecological balance sheet [2)].

The implied emission factor applied for the entire source category has been increasing slightly, as a result of the increasing impact of polymer-bitumen sheeting. However, since no pertinent detailed data are available, NMVOC emissions are calculated in keeping with a Tier 1 method.

Table 1: Overview of applied NMVOC emission factors, in [kg/m^2]

source of emissions	EF value	EF trend
production of roofing materials	0.00035795	constant over time
roofing of sheeting and shingle	0.000027 to 0.000040	rising

Please note that emissions from the use of solvents are reported within the specific categories of solvents-use as based on the underlying model. Therefore, the emission factors applied here are comparably low. The trend of emission is not influenced importantly by the changing use of material types.

The TERT reiterates the recommendation that Germany should include an emission estimate for the PM components and, until this is possible, change the notation key and provide a justification. Therefore, the notation key in the NFR is set to “NE” now and can be explained as follows: Roofing includes the production of shingles and layers using bitumen (no hot mix cases are estimated for Germany) with only fugitive emissions relevant.

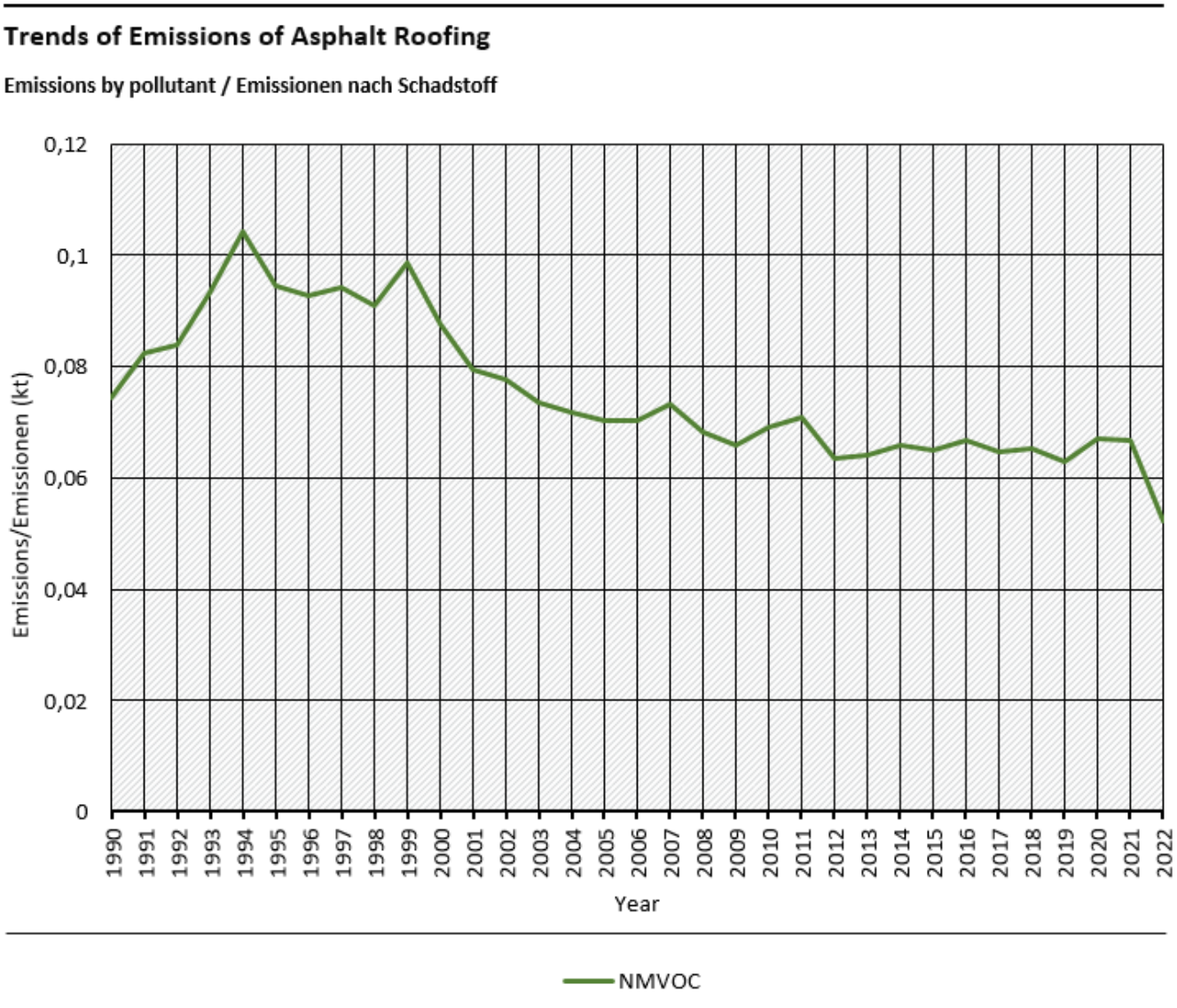
A Tier 1 method is available in the EMEP/EEA Guidebook, but the reference used is tonnage [t], not the area produced in m^2 as required for national calculations. Therefore, the default emission factor for PM provided in [g PM per Mg shingle] cannot be applied with the national activity data.

Due to the wide range of products, only an informative conversion is possible. Using this calculated tonnage with the Tier1 EF would result in excessively large emissions. The calculation of the bitumen consumption for the roofing materials is used for checking the national bitumen quantities.

As a result of such hypothetical calculations, neither the approach of the activity data seems suitable nor the quantity relevance seems sufficient. Therefore, particulate-matter emissions are reported as ´not estimated` (NE).

Trends in emissions

The trend of NMVOC emissions corresponds to the trend of produced amounts. No rising trends are to identify.



Emission trends of road paving

note: small change for 2023, but 2022 production decrease occurs

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] vdd Industrieverband Dach- und Dichtungsbahnen e. V. (VDD);
https://www.derdichtebau.de/vdd-industrieverband-dach-und-dichtungsbahnen-e-v/
[2)] Kreißig, J. (1996): Ganzheitliche Bilanzierung von Dachbahnen aus Bitumen : Kurzbericht. Frankfurt am Main, 1996

2.D.3.d - Coating Application

Short Description



For a general product and method description refer to 2.D.3. This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level and trend.
This source category comprises NMVOC emissions from the use of solvent-based products of three major sub-categories: Decorative coating applications, industrial coating applications and other non-industrial paint application.
The following product groups are taken into consideration:

i) Decorative coating applications:

- **Application of paints and lacquers in Car repairing (SNAP code 60102)**
- ***Professional application of paints and lacquers for Construction and Building (SNAP code 60103)** (emulsion paints for indoor application; silicate exterior paints; synthetic resin plasters / silicate; varnishes; primers and protection coatings; other coatings)
- **Do-it-yourself application of paints and lacquers for Building (SNAP code 60104)** (emulsion paints for indoor application; silicate exterior paints; synthetic resin plasters / silicate; varnishes; primers and protection coatings; other coatings)
- **Application of paints and lacquers for Wood surfaces (SNAP code 60107)** (wooden interiors, carpentry)

ii) Industrial coating applications

- **Application of paints and lacquers for Manufacture of cars (SNAP code 60101)** (primers, fillers, top coat / clear lacquers)
- **Application of paints and lacquers for Car Repairing of commercial vehicles (SNAP code 60102)**
- **Application of paints and lacquers for Coil Coating (SNAP code 60105)**
- **Application of paints and lacquers for Boat Building (SNAP code 60106)**
- **Application of paints and lacquers for Wood surfaces (SNAP code 60107)** (furniture)
- **Other industrial paint application (SNAP code 60108)** (such as paint spray, electrical appliances, mechanical engineering, automotive accessories, metal goods, wire enamel, synthetic materials, paper/foil)

iii) Other non-industrial paint application (SNAP code 60109)

- **marking paints**
- **corrosion protection**
- **other**

Method

Specific information

An emission factor of 95% was allocated to all open applications (e. g. all decorative coating applications). For installation-related industrial applications specific emission factors were assessed and applied.

Discussion of emission trends

Specific information

After the reunification of East and West Germany, the paints and coating application industries had economically good years. The emissions from 1990 to 1993 stayed on a high level. After 1993, this economic hype ended. In consequence, also the emissions declined. The significant dip in the time series in 1994 may relate to an over-estimation for the years until 1994. But the difference between 1993 and 1994 has to be mainly linked to the enhancement of the emission calculation method as from 1996. Since then national production and foreign trade statistics has been used for the calculation of product and solvent consumption instead of expert judgements. However, a recalculation could only be done backwards to the year 1994 due to the unavailability of production and foreign trade statistics in the necessary differentiation before (German reunification). Since 2000, a more detailed data collection procedure enables to follow the development of different applications, which altogether account for 35-47 % of total NMVOC emissions from solvent-based products.

The clear decrease in the NMVOC emissions in 2.D.3.d has ended in 2015.
The following seven applications caused major emissions and developments in category 2.D.3.d: Wooden furniture, Mechanical engineering, Varnishes DIY, Varnishes professional, Wooden interiors, Manufacture of cars and Corrosion protection

A major reason for the decrease of overall emissions in this source category is the fulfillment of the Decopaint-Directive according to maximum solvent contents. The German “Blauer Engel” (“Blue Angel”) environmental quality seal supported this development by certifying a range of products, including low-solvent paints and lacquers.



For general uncertainties, recalculations and improvements of activity data and emission factors see 2.D.3.

2.D.3.e - Degreasing

Short Description

For a general product and method description refer to 2.D.3. This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level and trend.
This source category comprises NMVOC emissions from the use of solvents in following processes:

- **Metal degreasing (SNAP code 60201)**
- **Electronic component manufacturing (SNAP code 60203)**
- **Other industrial cleaning (SNAP code 60204)** (e.g. precision mechanics, optics, manufacture of watches and clocks)

Discussion of emission trends

Specific information

Until 1999, data of the present source categories 2.D.3.e and f were treated as one source group. From 1990 to 1993 only a rough expert estimation was carried out, which since 1994 in a first step and since 2000 in a second step could be improved by a more detailed data collection that enables to follow the development of source group 2.D.3.e. Since 2000, the share of this source group accounts for about 5-9 % of total NMVOC emissions from solvent-based products on a very stable niveau.

Uncertainties

The relative overall uncertainty of emissions caused by applications of this source group is estimated at 50%.

For general uncertainties, recalculations and improvements of activity data and emission factors see 2.D.3.

2.D.3.f - Dry Cleaning

Short Description



For a general product and method description refer to 2.D.3. This site only contains product group specific information.

This source category comprises NMVOC emissions from **Solvent application for professional textile cleaning (SNAP code 60202)**. The German inventory summarizes hydrocarbon solvents and perchloroethylene as solvent.

Discussion of emission trends

Specific information

Until 1999, data of the present source categories 2.D.3.e and f were treated as one source group. Source group 2.D.3.f accounts for about not more than 0.3 % of total NMVOC emissions from solvent-based products and remained stable.

Uncertainties

The overall uncertainty of emissions caused by applications of this source group is estimated as 50%.



For general uncertainties, recalculations and improvements of activity data and emission factors see 2.D.3.

{{ :sector:ippu:other_solvent_and_product_use:chemical_products:nmvoc_tsp-em_2d3g-blasbitumen_1990-2023.xlsx |
}}

2.D.3.g - Chemical Products

Short description



For a general product and method description refer to 2.D.3. This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level.
Source category *NFR 2.D.3.g - Chemical products* comprises NMVOC emissions from the use of solvents in the following manufacture processes:

- Polyester processing (SNAP code 60301)
- Polyvinylchloride processing (SNAP code 60302)
- Polyurethane processing (SNAP code 60303)
- Polystyrene foam processing (SNAP code 60304)
- Rubber processing (SNAP code 60305)
- Pharmaceutical products manufacturing (SNAP code 60306)
- Manufacture of paints and lacquers (SNAP code 60307)
- Manufacture of inks (SNAP code 60308)
- Glues manufacturing (SNAP code 60309)
- Bitumen blowing (SNAP code 60310)
- Adhesive manufacturing, magnetic tapes manufacturing, photographs manufacturing (SNAP code 60311)
- Textile finishing (SNAP code 60312)
- Solvents manufacturing(SNAP code 60314):
    - Manufacture of wood preservatives
    - Manufacture of building material additives
    - Manufacture of solvent-based consumer goods
    - Manufacture of surface cleaning agents
    - Manufacture of antifreeze agents and de-icers
    - Manufacture of waxing and dewaxing agents
    - Manufacture of paint strippers

Discussion of emission trends

Specific information

The data recording of source category 2.D.3.g started in 1990. Since 2000, a more detailed data collection procedure enables to follow the development of different applications, which altogether accounts for about 6-11 % of total NMVOC emissions from solvent-based products. Since that time total emissions of NMVOC emissions of 2.D.3.g remain relatively stable. In some major activities amounts of NMVOC emissions raised, such as from solvents used in polystyrene foam processing and the manufacture of solvent-based consumer products.

Bitumen blowing

Method

Bitumen used for road paving, roof coating and other application like pipe sealing needs some enhanced properties that can be achieved by air blowing.

This is done in so-called *bitumen blowing units* (BBU) that can operate either in continuous or in batch mode. The BBU usually are located in refineries or can be part of road paving or roof coating plants.

Thermal post-combustion in combination with closed capture systems to control emissions are best available technology and demanded by relevant legislation in Germany.

In the EMEP/EEA air pollutant emission inventory guidebook 2023 [1)], tier2 emission factors for bitumen blowing are presented for NMVOC, TSP, Cd, As, Cr, Ni, Se and PAH. As most of them are unreferenced and based on US plants before 1980 they seem to be unsuitable to represent national conditions. Therefore, country-specific emission factors are applied instead.

Activity data

The applicable quantities of treated bitumen are calculated from the total-bitumen-production figures published annually by the Federal Office of Economics and Export Control (BAFA), in its official mineral-oil data (Amtliche Mineralöldaten) (BAFA, 2024) [2)].

The applicable percental share of blown bitumen was obtained from a one-time data survey of the association Arbeitsgemeinschaft der Bitumenindustrie e.V (bitumen industry working group) [3)] that was carried out for the year 1994 and in the framework of the research project (Theloke et al., 2000) [4)] commissioned by the Federal Environment Agency (UBA). The percentage share remains constant for all years in question, and it amounts to 10%.

Emission factors

NMVOC and PAH emissions from bitumen blowing are calculated with emission factors derived from the uncontrolled standard emission factor of the EMEP/EEA air pollutant emission inventory guidebook 2023 [5)] taking account of the maximum permitted levels and reduction-measures requirements specified in the Technical Instructions on Air Quality Control (TA Luft).

The emission factors for Cd, Cr and Ni were derived from original measurements with an increased safety factor (maximum or ten-fold).

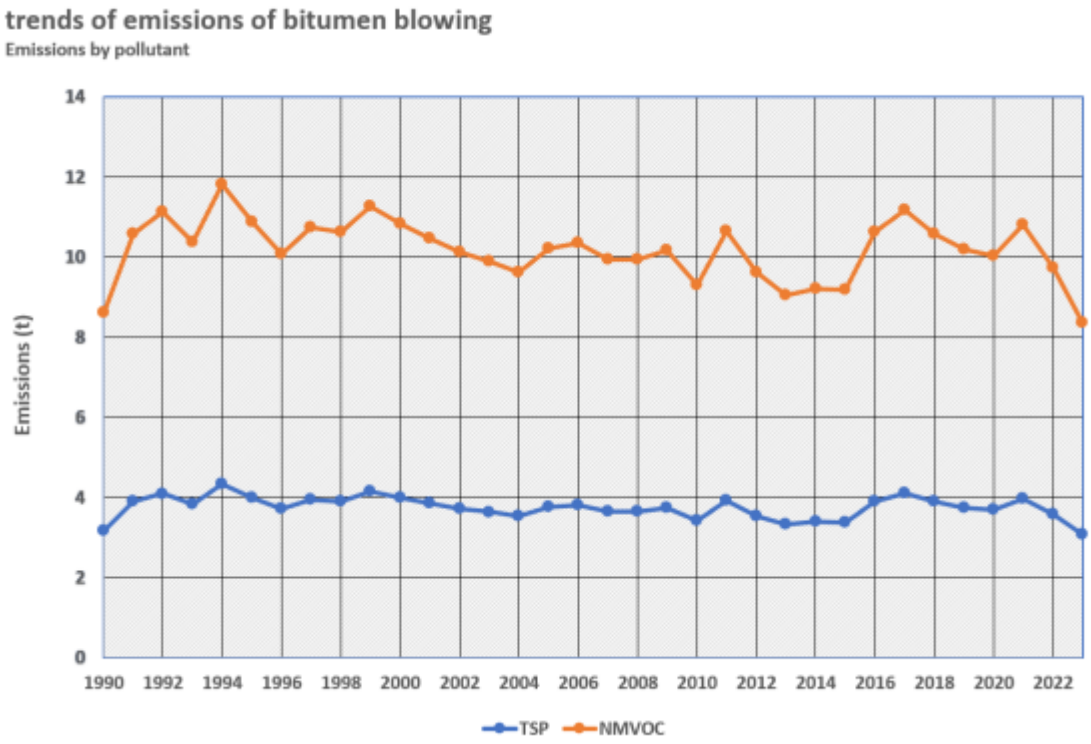
All emission factors remain constant for all years in question.

Table 1: Overview of tier-2 emission factors applied for bitumen blowing with post-combustion

	EF 2010	Unit	Reference
NMVOC	27.20	g/t	based on EMEP/EEA (2023) [6)]
TSP	10.00	g/t	from measurements (Trumbore et al., 1998) [7)]
Cd	0.03	mg/t	from measurements (Trumbore et al., 1998)
As	0.50	mg/t	default from EMEP/EEA (2023) [8)]
Cr	4.00	mg/t	from measurements (Trumbore et al., 1998)
Ni	21.00	mg/t	from measurements (Trumbore et al., 1998)
Se	0.50	mg/t	default from EMEP/EEA (2023)
PAH	2.55	mg/t	based on EMEP/EEA (2023)

Discussion of emission trends

All trends in emissions correspond to trends of the production development. No rising trends are to identify.



Trend of annual NMVOC and TSP emissions from bitumen blowing

Uncertainties

Emission factors: Relative error rates at ±15% and ±25% (Adhesive manufacturing, magnetic tapes manufacturing, photographs manufacturing) were applied, but not exceeding 100% or falling below 0%.
For **bitumen blowing** emission factor uncertainties are on a higher level just to 100%. For Cd and TSP the uncertainty are even greater than a factor of two.

For general uncertainties, recalculations and improvements of activity data and emission factors see 2.D.3.

[1), 5), 6), 8)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-d-2-l-other/2-d-3-g-chemical/view, table 3-8., Copenhagen, 2023
[2)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.
[3)] Eisele, F.: oral information of the Arbeitsgemeinschaft der Bitumenindustrie e.V, Persönliche Information, Institut für Energiewirtschaft und Rationelle Energieanwendung (IER), Universität Stuttgart, Stuttgart
[4)] Theloke et al. (2000): Theloke J., Obermeier A., Friedrich R.: Ermittlung der Lösemittelemissionen 1994 in Deutschland und Methoden zur Fortschreibung; https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/2484.pdf; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2000
[7)] Trumbore, D. C. (Owens Corning, Asphalt Technology Laboratory, Summit, IL 60501; Spring 1998): The Magnitude and Source of Air Emissions from Asphalt blowing operations. *Environmental Progress*, Vol. 17, No. 1; https://onlinelibrary.wiley.com/doi/epdf/10.1002/ep.670170120

2.D.3.h - Printing

For a general product and method description refer to 2.D.3. This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level and trend.
This source category comprises NMVOC emissions from the **use of solvent-based products during printing and in arts (SNAP code 60403)**. The following technologies / applications / products are taken into consideration:

- **Offset printing** (coldset web presses)
- **Sheetfed offset** (conventional; UV colours)
- **Offset printing** (heatset)
- **Endless offset printing**
- **Printing of books**
- **Flexography** (solvent-based inks; water-based inks)
- **Rotogravure package printing** (solvent-based inks; water-based inks)
- **Publication gravure printing**
- **Screen printing**
- **Other printing applications**
- **Inks / paints for artists**
- **Ink for writing and drawing**

Method

Specific information

Solvent contents and emission factors for the different printing technologies are based on a study carried out in 1999 by Jepsen et al.[1)].

Discussion of emission trends

Specific information

Until 1999, data of the present source categories 2.D.3.a, 2.D.3.h and 2.D.3.i were treated as one source group. Since 2000, a more detailed data collection enables to follow the development of source group 2.D.3.h, which accounts for about 8 - 15 % of total NMVOC emissions from solvent-based products. Emissions of this source group decreased in the whole time-series more than 70 % among others due to minor application of isopropanol and more environmentally friendly technologies.

Furthermore, the importance of single technologies changed (e.g. printing of books got less important, digital printing raises gained in importance), which influences total emissions of 2.D.3.h.

For general uncertainties, recalculations and improvements of activity data and emission factors see 2.D.3.

[1)] Jepsen et al. (19990): Jepsen, D., Grauer, A., Tebert, C.: Ermittlung des Standes der Technik und der Emissionsminderungspotenziale zur Senkung der VOC-Emissionen aus Druckereien, Ökopol GmbH on behalf of the Umweltbundesamt, FKZ 297 44 906/01, https://oekopol.de/oekopol_archiv/de/Archiv/betrieblicher%20und%20komunaler%20US/voc_druckereien/vocdekurz.pdf,

Berlin / Dessau-Roßlau, 1999.

2.D.3.i - Other Solvent Use

Short description



For a general product and method description refer to 2.D.3. This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level and trend.
In source category *2.D.3.i - Other Solvent Use*, emissions from various product groups and processes are reported. Relevant pollutants are NMVOC and some heavy metals.

Emissions from lubricants use in stationary and mobile applications were reported here just to the submission 2023. For the actual submission emissions of all lubricants use are reallocated to 2.G.4 due to a NECD review recommendation.

NO_x	**NMVOC**	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

2.D.3.i - Other solvent use

Method

In sub-category *2.D.3.i - Other product use: Other solvent use* the following product groups and processes are taken into consideration:

- **Glass and mineral wool enduction (SNAP code 60401/02)**
- **Fat, edible and non-edible oil extraction (SNAP code 60404)**
- **Application of glues and adhesives (SNAP code 60405)** (paper and packaging; wood; footwear; transport; Do-it-yourself-applications; others)
- **Preservation of wood (SNAP code 60406)**
- **Underseal treatment and conservation of vehicles (SNAP code 60407)**
- **Vehicles dewaxing (SNAP code 60409)**
- **Other: (SNAP code 60412)**
    - Plant protectives
    - Dichloromethane in strippers
    - Removal of paints from incorrectly coated aluminium parts
    - Removal of paint from steel parts
    - Concrete additives
    - De-icing (Aircraft de-icing; De-icing of operated areas; Other de-icing applications)
    - Applications in scientific laboratories (R&D; analyses; universities)

Discussion of emission trends

Specific information

Until 1999, data of the present source categories 2.D.3.a, 2.D.3.h and 2.D.3.i were treated as one source group.

Since 2000, a more detailed data collection enables to follow the development of source category 2.D.3.i, which accounts for about 12 to 26 % of total NMVOC emissions from solvent-based products.

The following product groups cause major emissions in category 2.D.3.i:

- Concrete additives,
- Underseal treatment and conservation of vehicles,
- Application of glues and additives,
- Deicing and
- Fat, edible and non-edible oil extraction

In total, these six activities account for between 88 and 93 per cent of total NMVOC emissions from 2.D.3.i.

A decrease in these NMVOC emissions can be observed since 2005 mainly due to a clearly reduced consumption of concrete additives.

Uncertainties

Uncertainties for emissions for each technology / application were obtained by error propagation and refer to the 95% confidence interval.

Exceptions were de-icing applications, applications in scientific laboratories with a relative error at 25%.



For general uncertainties, recalculations and improvements of activity data and emission factors see 2.D.3.

2.G - Other Product Use (OVERVIEW)

NFR 2.G includes emissions from fireworks, tobacco, charcoal used for barbecues and the stionary and mobile apllication of lubricants.

For detailed information on applied methods, activity data, emission factors, emissions and recalculations, please refer to the sub-chapters linked below.

Category Code	Method	AD	EF
Use of Fireworks	CS	NS, AS	D, CS
Use of Tobacco	T2	NS	CS, D
Use of Charcoal for barbecues	T1	NS	D
Use of Lubricants	T1, T2	NS, M	CS, D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	Hg	As	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/F**	**PAHs**	HCB
-/-	**L/-**	-/-	-/-	**L/-**	**L/-**	-/-	-/-	-/-	-/-	**L/-**	NA	NA	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

2.G(a) - Fireworks

Short description

NFR Code	Name of Category	Method	AD	EF
2.G(a)	Other Product use: Fireworks	CS	NS, AS	D, CS

In this sub-category of *2.G - Other product use*, Germany reports the following emissions resulting from fireworks:

NO_x	SO_2	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Cu	Pb	Zn
-/-	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

The sold amounts of fireworks have increased strongly from 1990 to 1995. From 1995 to 1997 the emissions were relatively high but decreased from 1997 to 2000. Since then, the emissions have remained on rather constant level showing only small fluctuations. As the public sale of fireworks were temporarily forbidden in 2020 and 2021 due to corona restrictions, emission estimates for these two years are well below previous years.

In 2022, the restricitions were suspended and the consumed fireworks reached a normal level again. The sales based on the returned fireworks of the previous year. It was not until next year that the import quota normalized. In 2023, **32,916 t** of fireworks were consumed in Germany.

Methodology

In 2019, measurements were made by a Finnish laboratory for the VPI – Verband der pyrotechnischen Industrie (Association of the pyrotechnical industry) of dust emissions during the burning of fire works. The experiments were made in a container in which the whole fireworks were burned.
In 2020, VPI and UBA had an intensive information exchange, in which the VPI presented the results of these measurements. The different emission factors were discussed and finally, based on the expert judgement, it was decided which EFs shall be used for the reporting. In a next step, activity data were updated to allow for more differentiation. More detailed information about the revised methodology for the calculation of fine particulate emissions from firework is published in the professional journal “Gefahrstoffe” by Dauert et al. (2002) [1)]. Furthermore, the other EFs have been discussed resulting in some changes to these values. The results are presented below. In February 2021, the VPI published an article in the paper “Propellants, Explosives, Pyrotechnics” provoiding a description of the experiment together with the measurement results (Keller & Schragen, 2021) [2)].

Activity data

For the calculation of the activity data the following formula is used:

$$AD = production + import - export - disposal + return_{previous\ year} - return_{recent\ year}$$

The **production, disposal, return from the year before and return of the year** data are yearly updated by the VPI.
Import and export: For import and export, statistical data from the Federal Statistical Office are applied (DESTATIS, 2024)

[3]. **Return**: Amount of unsold fireworks returned to producer **Disposal**: Amount of disposed unsold fireworks damaged during transport from producer to seller

Emission factors

The emission factors of SO_2, CO, NO_x, Cu, Pb and Zn are the Default-EFs derived from the EMEP/EEA Guidebook 2023 [4].

Table 1: Default Tier 2 emission factors applied, in g/t product

pollutants	Default-EF
SO_2	3.020
CO	7.150
NO_x	260
Cu	444
Pb (until 2003)	784
Zn	260

The emission factors for PM_{10}, $PM_{2.5}$ and TSP are measured values from the VPI.

Table 2: Country-specific PM emission factors applied, in g/t product

	PM_{10}		**$PM_{2.5}$**		**TSP**	
	New Years Eve	**Rest of Year**	**New Years Eve**	**Rest of Year**	**New Years Eve**	**Rest of Year**
1990-2004	52,002.56	62,799.96	41,463.05	49,644.24	52,002.56	62,799.96
2005	47,509.31	72,317.11	38,129.60	57,167.68	47,509.31	72,317.11
2006	45,793.40	71,986.67	36,930.61	56,906.46	45,793.40	71,986.67
2007	45,174.65	72,071.88	36,615.74	56,973.82	45,174.65	72,071.88
2008	45,955.36	71,471.31	37,390.41	56,499.06	45,955.36	71,471.31
2009	45,701.68	70,204.58	37,132.12	55,497.69	45,701.68	70,204.58
2010	44,826.79	69,253.15	36,536.80	54,745.57	44,826.79	69,253.15
2011	44,068.30	68,877.53	36,121.87	54,448.64	44,068.30	68,877.53
2012	45,566.16	69,993.91	37,527.36	55,331.16	45,566.16	69,993.91
2013	46,098.42	67,212.39	38,026.91	53,132.33	46,098.42	67,212.39
2014	46,621.17	67,680.72	38,595.22	53,502.55	46,621.17	67,680.72
2015	47,474.24	67,313.58	39,383.93	53,212.31	47,474.24	67,313.58
2016	47,523.35	66,094.38	39,539.55	52,248.52	47,523.35	66,094.38
2017	47,853.44	65,938.58	39,907.83	52,125.36	47,853.44	65,938.58
2018	48,270.00	63,519.57	39,713.09	50,213.10	48,270.00	63,519.57
2019	48,085.00	63,217.87	40,033.58	49,974.60	48,085.00	63,217.87
2020	42,979.14	70,081	34,730.076	55,400	42,979.14	70,081
2021	51,421.30	53,130	42,704.70	42,000	51,421.30	53,130
2022	48,123.27	60,846.50	40,336.06	48,100	48,123.27	60,846.50
2023	47,654	62,010.30	40,080.40	49,020	47,654	62,010.30

The EMEP/EEA GB 2023 offers default-EFs for the pollutants As, Hg, Ni and Cr [5]. However, the VPI has proofed that these emissions do not occur in Germany, further proofing that no Pb is emitted from firewoks after 2003.

See the following explanations:

As and **Hg:** As confirmed by the members of the VPI, these two heavy metals went out of use in 1980. Since about 1980 the explosives administrative regulation (Sprengverwaltungsvorschrift) is regulating which substances are allowed to be used and As and Hg are forbidden to be used. In 2003 the DIN EN 14035:2003 came into force, which did forbid these substances. The actual follow-up norm DIN EN 15947-5 was published in February 2016 and describes the German implementation of the harmonized and in the official journal of the European Union 2017, C 149/2 published norm EN 15947:2015.

Pb: As the DIN EN 14035:2003 entered into force as from 2003, which did forbid this substance, there are no such emissions from 2003 onwards. The actual follow-up norm DIN EN 15947-5 was published in February 2016 and describes the German

implementation of the harmonized and in the official journal of the European Union 2017, C 149/2 published norm EN 15947:2015.

Cd: The members of the VPI were asked and did explain, that Cd was never used, because it has no pyrotechnical effect. Since 2013 Cd is on the candidates list of the substances of Very High Concern (SVHC), published according article 59, para. 10 of the REACH-ordinance.

Ni: The members of the VPI informed that Ni was never used, because it has no pyrotechnical effect. It is part of the harmonized assessment according the ordinance (EG) Nr. 1272/2008 (CLP). Belonging to this, it is assessed as cancerogen category 2.

Cr: According the information from the members of the VPI Cr is not anymore used since the beginning of the 1980. Since 2012 (REACH Annex XIV (Ordinance (EU) Nr. 125/2012) Cr was implemented in the REACH Annex XIV. So from that year a permission duty is necessary. So far, none of the fireworks producers has requested for a permission.

Uncertainties

The uncertainty for the AD is given as 10% and for the EF as 20%.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] Dauert et al. (2002): Dauert, U., Keller, F., Kessinger, S., Kuntze, D., Schragen, C.: “Feinstaubemissionen aus Feuerwerk zu Silvester und deren Einfluss auf die Luftqualität” (Particulate Matter Emissions from New Year’s Eve Fireworks and their Influence on Air Quality – Novel Method for Quantification of Emissions). journal “Gefahrstoffe”, Jahrgang 82 (2002) No.1&2, p. 5-22; doi.org/10.37544/0949-8036-2022-01-02; Dessau-Roßlau, 2002.
[2)] Keller, F. and Schragen, Chr. (2021): Determination of Particulate Matter Emission Factors of Common Pyrotechnic Articles; https://onlinelibrary.wiley.com/doi/epdf/10.1002/prep.202000292, DOI: 10.1002/prep.202000292, 2021.
[3)] DESTATIS (2024): Statistisches Bundesamt (Federal Statistical Office, DESTATIS): (foreign statistics of federal office of statistics)[(Statistisches Bundesamt (51000-0013): Aus- und Einfuhr (Außenhandel), https://www-genesis.destatis.de/genesis//online?operation=table&code=51000-0013&bypass=true&levelindex=1&levelid=1664263187988, Statistisches Bundesamt, Wiesbaden, 2024.
[4)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.D.3.i, 2.G Other solvent and product use, Table: 3-14: Tier 2 emission factor for source category 2.D.3.i, 2.G Other solvent and product use, Other, Use of Fireworks., https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-d-2-l-other/2-d-3-i-2/@@download/file, Copenhagen, 2023

2.G(b) - Other Product use: Tobacco

Short description

Category Code	Name of Category	Method	AD	EF
2.G(b)	Other Product use: Tobacco	T2	NS	CS/D

In this sub-category, Germany reports the emissions from the smoking of cigarettes and cigars.

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Cu	Ni	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4
-/-	-/-	NE	-/-	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

Activity data

Statistical data from the tax registration of sold tobacco, cigarettes and cigars provide by the Federal Statistical Office (DESTATIS) [1) 2)] are used as **activity data**.

For the calculation of the **overall consumption quantity of tobacco** the default quantity of tobacco for cigarettes and cigars of the emission guidebook 2023 (note to table 3-15 p. 23) [3)] is applied: a cigarette contains 1 g of tobacco and a cigar contains 5 g of tobacco.

The **quantity of consumed tobacco** has decreased in 2023 for the second consecutive year to a historical low value of **99,434 t**.

Emission factors

The emission factors applied in the German inventory were derived from a study by (Toenges-Schuller et al.)[4)] for the Umweltbundesamt Germany. Based on this study, most of the applied emission factors represent average values from different studies.

Table 1: tier2 emission factors applied

	Value	Unit	Data source
NO_x	1.8	kg/t tobacco	EMEP/EEA 2023[5)]
NMVOC	9.56	kg/t tobacco	average value
NH_3	5.33	kg/t tobacco	average value
CO	112.51	kg/t tobacco	average value
TSP/PM_{10}/$PM_{2.5}$	18.85	kg/t tobacco	average value
BC	0.074	kg/t tobacco	average value
Cd	5.4	g/t tobacco	EMEP/EEA 2023
Cu	5.4	g/t tobacco	EMEP/EEA 2023
Ni	2.7	g/t tobacco	EMEP/EEA 2023
Zn	2.16	g/t tobacco	average value

PCDD/F	0.1	µg/t tobacco	EMEP/EEA 2023
B[a]P	0.21	g/t tobacco	average value
B[b]F	0.26	g/t tobacco	average value
B[k]F	0.26	g/t tobacco	average value
I[1,2,3-c,d]P	0.42	g/t tobacco	average value

Uncertainties

As tax registration statistics has a high level of accuracy, its uncertainty is expected to be below 5% whereas the uncertainty for the amount of tobacco in cigarettes is set to 20%. In contrast, as the tobacco quantity for cigars varies much stronger, the uncertainty is set to 100% here.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] Destatis (2022): Statistisches Bundesamt (Federal Statistical Office, DESTATIS): GENESIS data warehouse: Versteuerung von Tabakwaren 73411, SBA FS 14 R 9.1.1 Absatz von Tabakwaren, https://www.destatis.de/DE/Themen/Staat/Steuern/Verbrauchsteuern/Publikationen/Downloads-Verbrauchsteuern/absatz-tabak-jahr-2140911227004.pdf?__blob=publicationFile; Statistisches Bundesamt, Wiesbaden, 2022.
[2)] Destatis (2023): Statistisches Bundesamt (DESTATIS): Code 73411 - Tabaksteuerstatistik; https://www-genesis.destatis.de/datenbank/online/statistic/73411/details/search/s/NzM0MTE=, Statistisches Bundesamt, Wiesbaden, 2024.
[3), 5)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.D.3.i, 2.G Other solvent and product use, Table: 3-15 Tier 2 emission factors for source category 2.D.3.i, 2.G Other solvent and product use, Tobacco combustion https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-d-2-l-other/2-d-3-i-2/@@download/file Copenhagen, 2023.
[4)] Toenges et al. (2016): Toenges-Schuller, N., Joppe, S., Tremöhlen, M.: “Entwicklung von Methoden zur Berechnung von Emissionen von Luftschadstoffen aus der Verwendung von Holzkohle, Tabak, Feuerwerk und Kerzen sowie aus dem Entfachen von Brauchtumsfeuern”, EF000814, Aviso GmbH Aachen; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2016.

2.G(c) - Use of Charcoal for barbecues

Category Code	Name of Category	Method	AD	EF
2.G©	Other Product use: Fireworks	T1	NS	C

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

In this sub-category of *2.G - Other product use*, Germany reports the following emissions resulting from the burning of charcoal for barbecues:

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NE	NE	NE	NE	**-/-**	**-/-**	**-/-**	NE	NE	NE	NE

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

The amount of charcoal used for barbecue has been ever-expanding from 1990 to 2012 and is predominantly imported.

After several years with stable demand, consumption is declining the fourth consecutive year.

However, as there is only one big producer, used amounts and emission factors are considered confidential and cannto be provided here.

Activity data

The annual charcoal consumption for barbecue is calculated as

annual imports + annual domestic production - annual exports

,

with the relevant amounts of charcoal derived from national statistics provided by the Federal Statistical Office (DESTATIS).

Other applications for charcoal are not included.

The model is based on the two assumptions that (i) there is no storage of charcoal and that (ii) all charcoal is burned during usage.

Emission factors

The emission factors are comparable as those from the CEPMEIP Database (SNAP: 060508) (CEPMEIP, 2018) [1)].

Uncertainties

The uncertainties of consumption are 20% and the uncertainties of emission are not more than 54% for the lower and upper bounds.

Recalculations

The import and export data for 2022 were changed as revised activity data for the foreign sale was available from the Federal Statistical Office. The emissions of $PM_{2.5}$, PM_{10} and TSP reported for 2022 increased by 4.9 %.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] CEPMEIP (2018): Co-ordinated European Programme on Particulate Matter Emission Inventories, Projections and Guidance (CEPMEIP), CEPMEIP Database, SNAP code : 060508;
http://www.air.sk/tno/cepmeip/em_factors.php?PHPSESSID=cc235582eb4e09bf725d6f859deb382d

2.G.4 - Use of Lubricants

Short description

In source category *2.G.4 - Other Product Use: Lubricants*, emissions from both stationary and mobile application of lubricants are reported.

Category Code	Method	AD	EF
2.G.4	T1, T2	NS, M	CS, D
covering emissions from:			
use of lubricants in stationary applications	T2	NS	CS
use of lubricants in mobile applications	T1	NS, M	D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	**Heavy Metals**	POPs
NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	-/-	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Use of lubricants in stationary applications

Method

This sub-category comprises the entire use phase including the process stages of input and output. The products or lubricants covered here, are:

- Compressor oils
- Turbine oils
- Gear oils (automotive oils including automatic transmission fluids, industrial-gear oils)
- Hydraulic oils
- Insulating oils
- Machine oils
- Process oils
- Other industrial oils not for lubricating purposes
- Metal working fluids fluids (hardening oils, water-miscible and not water-miscible metal working fluids, anticorrosive oils)
- Greases
- Base oils
- Extracts from lubricant refining



2-stroke engine oils are excluded here as they are considered to be part of the 2-stroke fuel and are therefore burned *intentionally* in 2-stroke engines as applied in road vehicles (mopeds) and other mobile machinery (chainsaws, lawn mowers etc.). In contrast, emissions from the *unintended* co-incineration of lubricants in mobile machinery and vehicles are reported in Use of lubricants in mobile applications.



'NMVOC' is defined in keeping with the VOC definition found in the EC solvents directive. For purposes of the definition of solvents, the term 'solvent use' is also defined in keeping with the EC solvents directive.

The consumption of lubricants in stationary applicants in Germany has remained at a relatively constant level since 1990, apart from a sharp decrease in the crisis years 2009 and 2020. After a slight rebound in 2021, the **consumption of lubricants in 2023** falls to an historical low level of **533,351 t** .

Activity data

The emissions calculation method follows a Tier-2 approach. It uses national statistical data from BAFA [1)] for the quantities placed on the market specific per lubricant types as activity rate and specific emission factors for each lubricant type. It is assumed that the amount of lubricants placed on the market per year equals the lubricant use (consumption) in the same year.

Emission factors

Along the life cycle of the different lubricant types, different kinds of losses occur. Only some types of losses are of relevance with regard to air emissions and the different lubricants types differ significantly from each other. Relevant emitted pollutants identified for lubricants are NMVOC and CO_2. But only for engine oils used in machinery and in vehicles emission of both could be accounted for due to combustion of a small fraction of lubricating oils directly resulting in CO_2 emissions.

For insulating oils [2) 3)], process oils [4) 5) 6)], greases [7) 8)] and extracts from lubricant production [9) 10) 11)] no emissions are expected to arise.

All emission factors are are constant in the entire time series. They were determined in a research project (Zimmermann, 2018) [12)].

Table 1: Tier2 emission factors for specific lubricant-type groups in percent

		NMVOC	

Lubricant-type group	Proportion range of total sales since 1990	Default	Range	Reference
Compressor oils	≤ 1 %	1.5 %	1-2 %	13) 14) 15) 16) 17) 18)
Turbine oils	< 1 %	0.5 %	0-1 %	19) 20) 21)
Automotive gear oils	5-10 %	1 %	0-2 %	
Industrial gear oils	2-3 %	1.5 %	1-2 %	
Hydraulic oils	6-15 %	1.5 %	1-2 %	
Machine oils	1-7 %	2.5 %	0-5 %	22) 23) 24)
Other oils not for lubricating purposes	2-7 %	25 %	0-50 %	25) 26) 27) 28)
Metalworking fluids	5-9 %	5 %	0-10 %	29) 30) 31)
Base oils	4-16 %	10 %	5-15 %	32)

In 1995 four categories fell away/ceased to exist (Table 2) and three type groups were newly introduced due to modifications/changes in the Mineral Oil Statistics concerning lubricants. A slight adjustment of the procedure for the years 1990-1994 was needed. Table 2 shows the affected categories as well as the ways in which they were handled in the calculation procedure.

Table 2: Handling of categories in the Mineral Oil Statistics, 1990-1994

Category	Remarks concerning the procedure	EF_{NMVOC}
Other lubricating oils, specialty and other lubricating oils, non-specialty	These are handled like the “machine oils” group, which is lacking in the 1990-1994 period. This group includes various specialty and non-specialty libricationg oils.	2.5 %
Other mineral oils for special applications	This category contains no lubricating oils. It is handled like the category “Other industrial oils not used for lubrication” which is lacking in the 1990-1994 period.	25 %
Light-coloured plasticisers and extender oils	Extender oils and plasticisers are classified with the process oils. They are handled accordingly.	0 %

Uncertainties

For activity data, an uncertainty of 5 percent is assumed considering the well developed national statistics.

The emission factors are based on a broad review of literature and results from relevant research projects and have been discussed with senior lubricant experts. The experts suggested using ranges which are provided in the emission factor table 1.

The modifications of the Mineral Oil Statistics in 1995 show no impact of overall amount of lubricants. Only a reclassification of lubricants from unspecified application categories to specified application categories was made. The emissions for the years 1990-1994 could therefore be just up to 25% to high.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

No category-specific improvements are planned.

Use of lubricants in mobile applications

In sub-category *2.D.3.i - Other product use: Use of lubricants in mobile applications*, the German air pollutant emisisons inventory includes emissions from the unintentional co-incineration of lubricants in mobile sources.

As emissions from the use of lubricants in stationary machinery result mostly from the evaporation whereas emissions from mobile machinery result mostly from the unintentional co-incineration within the engine, the methods for emission calculation differ widely.

Therefore, the approaches for estimating emissions from these two areas of lubricant application are looked at in separate sub-chapters linked below.

Methodology

Activity data

Basically, the amounts of lubricants unintentionally co-incinerated in engines other than 2-strokes is estimated from the annual amounts of fuels used in these engines, excluding the amounts of fuels used for international aviation and navigation.

Here, the majority of lubricant co-incineration takes place in road vehicles. These related amounts of co-incinerated lubricants are calculated directly within TREMOD [33)].

Table 1: Annual amounts of lubricants co-incinerated in mobile vehicles and machinery - excluding 2-stroke engines, in terajoules

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
1,400	1,601	1,713	1,757	1,804	1,922	1,951	1,977	1,985	1,999	1,770	1,801	1,803	1,811

source: own estimations and TREMOD [34)]

The **emission factors** are derived from chapter *1.A.3.b.i-iv Road transport 2023*, Table 3-87 of the EMEP/EEA air pollutant emission inventory guidebook 2023 [35)].

Table 3-87: Heavy metal emission factors for all vehicle categories in ppm/wt lubricant

Category	Pb	Cd	Cu	Cr	Ni	Se	Zn	Hg	As
Passenger cars, petrol	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
Passenger cars, diesel	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
LCVs, petrol	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
LCVs, diesel	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
HDVs, petrol	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
HDVs, diesel	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
L-category	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0

These default values were transferred via a NCV of 0.03985 GJ/kg into the following energy-related values:

Table 2: tier1 emission factors for heavy-metal emissions from co-incinerated lubricants, in g/TJ

As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
0.00	114	482	19,523	0.00	800	0.81	114	11,297

Discussion of emission trends

With default emission factors applied, emissions' trends depend solely on the amounts of unintentionally co-incinerated lubricants (see Table 1).

Table 3: Annual heavy-metal emissions from co-incinerated lubricants, in metric tonnes

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
As	NA													
Cd	0.16	0.18	0.20	0.20	0.21	0.22	0.22	0.23	0.23	0.23	0.20	0.20	0.21	0.21
Cr	0.67	0.77	0.83	0.85	0.87	0.93	0.94	0.95	0.96	0.96	0.85	0.86	0.87	0.87
Cu	27.3	31.3	33.4	34.3	35.2	37.5	38.1	38.6	38.8	39.0	34.6	34.7	35.4	35.4
Hg	NA													
Ni	1.12	1.28	1.37	1.41	1.44	1.54	1.56	1.58	1.59	1.60	1.42	1.42	1.45	1.45
Pb	0.0011	0.0013	0.0014	0.0014	0.0015	0.0016	0.0016	0.0016	0.0016	0.0016	0.0014	0.0014	0.0015	0.0015
Se	0.16	0.18	0.20	0.20	0.21	0.22	0.22	0.23	0.23	0.23	0.20	0.20	0.21	0.21
Zn	15.8	18.1	19.3	19.9	20.4	21.7	22.0	22.3	22.4	22.6	20.0	20.1	20.5	20.5

Recalculations

Activity data (annual amounts of unintentionally co-incinerated lubricants) have been revised slightly for the entire time series.

Table 4: Revised annual amounts of unintentionally co-incinerated lubricants, in terajoules

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
current submission	1,400	1,601	1,713	1,757	1,804	1,922	1,951	1,977	1,985	1,999	1,770	1,801	1,803
previous submission	1,400	1,601	1,713	1,746	1,792	1,916	1,946	1,971	1,977	1,990	1,765	1,778	1,812
absolute change	0.14	0.04	0.08	11.1	11.3	6.23	5.27	5.47	8.33	8.54	4.86	23.0	-9.31
relative change	0.01%	0.00%	0.00%	0.64%	0.63%	0.33%	0.27%	0.28%	0.42%	0.43%	0.28%	1.30%	-0.51%

On the other hand, the tier1 **emission factors** applied so far, remain unaltered compared to last year's submission.

Therefore, the canges in the **emission estimates** reported for this sub-category result solely from the named revisions in activity data.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

Although there are no improvements planned for this specific sub-category, several routine model revisions are scheduled for mobile sources with impact on fuel consumption data and, hence, the amounts of unintentionally co-incinerated lubricants.

[1)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2, Eschborn, 2024.

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[4), 15), 30)] Zimmermann, T., Jepsen, D., Sander, K. (2017): Survey of the structure of the waste oil collection market and optimization potentials for higher waste oil qualities with regard to the waste hierarchy - Erhebung der Struktur des Altölsammelmarktes und Optimierungspotenziale für bessere Altölqualitäten im Kontext der Abfallhierarchie.; FKZ 3714 31 3270; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2016.
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[6), 11), 27)] Bartz, W. J.; Springer, G.; Blanke, H.-J.: Expert Praxislexikon Tribologie Plus: 2010 Begriffe für Studium und Beruf, 2., völlig neubearb. Aufl. des Lexikons der Schmierungstechnik von G. Vögtle; Expert Verlag: Renningen, 2000.
[8), 28)] VSI: Grundöle; https://www.vsi-schmierstoffe.de/index.php.)
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[12), 32)] Zimmermann, T., Jepsen, D. (2018): Entwicklung von Methoden zur Berechnung von Treibhausgas- und Luftschadstoffemissionen aus der Verwendung von Schmierstoffen und Wachsen.; Ökopol; https://oekopol.de/archiv-de/DE_718/; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2018
[17)] Kline & Company: Lubricant Consumption and Used Oil Generation in California: A Segmented Market Analysis: Part II: Collectable Used Oil Availability in California, 2000-2011. https://www2.calrecycle.ca.gov/Publications/Details/1512; published 03/03/2015: Sacramento, CA, USA, 2012.
[18)] UNEP: Compendium of Recycling and Destruction Technologies for Waste Oils; https://www.unep.org/resources/report/compendium-recycling-and-destruction-technologies-waste-oils; Osaka, Japan, 2012.
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[35)] EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/@@download/file; Copenhagen, 2023.

2.H - Other: Pulp & Paper, Food (OVERVIEW)

Within NFR category 2.H - Other, emissions from the production of pulp & paper as well as food & beverages are reported.

2.H.1 Pulp and Paper Industry
2.H.2 Food and Beverages Industry
2.H.3 Other Industrial Processes

2.H.1 - Pulp and Paper Industry

Short description

Category Code	Method	AD	EF
2.H.1	T1	AS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
-/-	-/-	-/-	NE	-/-	-/-	-/-	NE	-/-	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

The fibre pulp for paper production is produced, via chemical or mechanical processes, either from fresh fibre or from processed recycled paper. A distinction is made between integrated and non-integrated pulp and paper mills. Non-integrated pulp mills solely produce pulp for sale on the open market.

On the other hand, integrated mills produce both pulp and paper, at integrated sites. A paper mill can either produce paper from fibre material produced at other locations or be integrated within complete pulping processes set up at one site.

Sulphate pulp mills normally operate in both integrated and non-integrated modes, whereas sulphite pulp mills are normally only integrated – i.e. part of paper-production chains. Mechanical pulping and recycled fibre processing is usually an integrated part of the papermaking but has become a stand alone activity in a few single cases.

Fibre production processes

In the chemical pulping process the fibres are liberated from the wood matrix as the lignin is removed by dissolving in the cooking chemical solution at high temperature.

Sulphate process

The sulphate or kraft process is the world's most common pulping process, since it yields higher pulp strengths and can be used with all types of wood. In the kraft pulp process the active cooking chemicals (white liquor) are sodium hydroxide (NaOH) and sodium sulphate (Na_2S). The term “sulphate” is derived from the make up chemical sodium sulphate which is added in the recovery cycle to compensate for chemical losses. As a result of the large amount of sodium hydroxide used, the pH value at the start of cooking is between 13 and 14 (alkaline pulping process). In the two German plants, carbonate is extracted from the circulation of liquor via bonding with calcium (causticising) and then, in a separate lime oven; the burnt lime is then reused for causticising.

This process produces atmospheric emissions in chemical recovery (boilers), in bark combustion, from lime kiln - from the combustion of strong and weak non-condensable gases (NCG) in dedicated burner, in wood-handling, in pulp cooking, in pulp washing, in bleaching, in bleaching-chemical processing, in evaporation, in processing of circulating water and in operation of various types of tanks. Such emissions include fugitive emissions that occur at various processing points – primarily in (liquor)-recovery boilers, lime kilns and auxiliary boilers. The main components of emissions include nitrogen oxides, sulphur-containing compounds, such as sulphur dioxide, and NCG which consists mainly out of total reduced sulphur (TRS), namely, methyl mercaptan (MM), dimethyl sulphide (DMS), dimethyl disulphide (DMDS), and hydrogen sulphide (H_2S).

The two German sulphate-pulping plants are fitted with a system for post-incineration of NCG equipped with wet scrubbers for SO_x removal and with systems for NO_x-reduced combustion in recovery boilers (>20 % NO_x reduction; figures of the German Pulp and Paper Association (VDP, September 2004). Because of the odours of reduced sulphur compounds, the two relevant plants are practically leak-proof and fitted with an advanced collection and odour abatement technique - otherwise they would not be permitted in Germany. All residues end up in (liquor)-recovery boilers and do not emit in reduced form.

Sulphite process

Sulphite pulp is produced in 4 of 6 installations in Germany. In such plants, pulping is based on the use of aqueous sulphur dioxide (SO_2) and a base - calcium, sodium, magnesium or ammonium. The four German mills use the acid bisulphite method. Acid processes are those in which the pH is 1 to 2.5. Sulphite pulping for papermaking derives its name from the use of a bisulphite solution as the delignifying medium. The cation used for papermaking pulp is magnesium (all four mills in Germany). The sulphate process and the sulphite process have numerous similarities, including similarities with regard to possibilities for using various internal and external measures to reduce emissions. From the standpoint of environmental protection, the main differences between the two pulp-production processes have to do with chemical aspects of the cooking process and the temperature in the recovery boiler, with aspects of preparation and post-processing of chemicals and with bleaching intensity – bleaching in sulphite plants is less intensive, since sulphite pulp is whiter than sulphate pulp.

Atmospheric emissions occur especially in recovery (boilers) and in bark combustion. Waste-gas emissions with less concentrated SO_2 are released in washing and sorting processes, and they are released by ventilation shafts of evaporators and by various tanks. Such emission escape – in part, as fugitive emissions – at various points of the process. They consist primarily of sulphur dioxide, nitrogen oxides and dust.

All four sulphite pulping plants in Germany are operated with a collection system for concentrated and less concentrated sulphur dioxide-containing and odorous gases (organic acids) and they include multistage SO_2 scrubbers fitted downstream from recovery boilers (>98 % SO_2 reduction) and recirculation of the recovered chemicals (SO_2 cycle). One plant is fitted with equipment for NO_x-reduced combustion in recovery and auxiliary boilers (total of >40 % NO_x reduction, loc. cit.).

A number of measures are available for reducing consumption of fresh steam and electrical energy and for increasing plant-internal generation of steam and electricity. Sulphite pulp mills can generate their own heat and electricity by using the thermal energy in concentrated liquor, bark and waste wood. The recovery boiler acts as a power station where the concentrated spent sulphite liquor is burnt. Generated heat is utilised for the generation of high-pressure, superheated steam. Part of the energy content in the high-pressure steam is utilised for generating power in a back-pressure turbine.

Medium-pressure steam extracted from the turbine and low-pressure exit steam are utilised for covering the heat energy demand in the pulp process. Integrated plants that operate a recovery boiler are nearly electricity self-sufficient and only need limited supply of fossil-fuel-based power. However; these additional amounts can be generated in either in on-site

facilities or at off-site locations. Integrated sulphite pulp and paper mills consume 18 to 24 GJ of process heat, and 1.2 to 1.5 MWh of electrical energy, per tonne of pulp.

Explanation of the management of process related sulphur and ammonia emissions for pulping processes occurring in Germany Sulphur emission levels from sulphite mills and the potential for further reductions are highly dependent on the type of mill. Due to differences between different sulphite processes, the emission levels might show higher variations than in kraft (sulphate)pulp mills.: Many sulphite pulp mills (e.g. all mills in Austria and Germany) have installed a system for the collection of the vent gases from nearly all processes that may release diffuse SO_2. The vast majority of these diffuse gases are captured by the weak gas collection system and used as combustion air in the recovery boiler. Well designed, maintained and operated gas collection systems allow the recovery of almost all fugitive SO2 emissions of the mill so that no significant diffuse SO_2 emissions are released to the environment. All SO_2-containing gases are collected and treated and SO_2 is recovered.

Emissions of odorous gases in sulphite pulping are normally limited compared to kraft (sulphate) pulping. However, emissions of furfural mercaptan and H_2S might cause odour and emissions of gaseous sulphur may also cause annoyances. At many mills, emissions of odorous gases are collected and burnt in the recovery boiler (all German and Austrian mills). Another option is treatment in wet scrubbers.

Exceptions with ammonia emissions are prohibited and actually excluded. Both circumstances are therefore not relevant for Germany.

Mechanical pulp

Mechanical pulp is produced in 8 plants in Germany. In mechanical pulping, wood fibres are separated from each other via mechanical energy applied to the wood matrix. This process is designed to conserve most of the lignin in the wood, in order to maximise yields while ensuring that the pulp has adequate strength and whiteness. In German mills two main processes are differentiated:

- the groundwood process (GW), in which pieces of wood are wettened and pressed against a rotating grinder

and

- the thermomechanical pulping process (TMP), in which wood chips are broken down into fibres in disk refiners.

Mechanical-pulp properties can be influenced by increasing the process temperature and, in the case of the refiner process, by chemical pre-treatment of the wood chips. The pulping process in which wood is chemically pre-softened and then broken down into fibres, under pressure, is known as chemical-thermal-mechanical pulping (CTMP).

In most cases, the waste-gas emissions consist of emissions from heat and energy generation in auxiliary boilers and of emissions of volatile organic carbon (VOC). VOC emissions occur in storage of wood chips, in removal of air from containers for washing wood chips, as well as from other containers. They also occur in connection with condensates that are produced in recovery of steam from refiners and contaminated with volatile wood components. Some of these emissions are released as fugitive emissions, from various parts of mills.

Paper and carton production

Paper is made from fibre materials, water and chemical additives. The entire paper-making process consumes large amounts of energy. Electricity is required primarily for operation of various motors and for grinding of fibres. Process heat is used primarily for heating water, other liquids and air, as steam in the drying process of paper machines and for converting steam into electrical energy (with heat/power cogeneration). Large amounts of water are required as process water and for cooling. Various additives are used in the paper production process as process supplies and to enhance product properties (paper additives).

Most of the waste-gas emissions produced by non-integrated paper mills are produced by steam-production and electricity-generation systems. The boilers used in such systems are standard boilers that do not differ from those of other combustion systems. It is assumed that such systems are operated in the same manner as other auxiliary boilers of the same capacity.

Overall, most product-specific waste-gas emissions are site-dependent (for example, they depend on the type of fuel used, the size and type of the relevant facility, whether the plant is integrated or non-integrated, whether it generates electricity). The auxiliary boilers used in Germany cover a wide spectrum of different sizes (from 10 to more than 200 MW). With smaller boilers, the only useful approach is to use low-sulphur fuels and the pertinent combustion technologies, while secondary

reduction measures can also be effective with larger boilers.

Methodology

Activity data

The figures are available from the base year 1990 onwards and are collected annually by the Association of German Paper Mills compiled in a so-called Performance Report [1)]. The separate AD of sulphate pulp and sulphite pulp may not be published, but only in sum.

Emissions factors

Since 2005 real emission factors from German plants for pulp production are available (German contribution to revision of the Best Available Technique Reference Document (BREF) for the pulp and paper industry, 2007). For this reason, in many cases interpolations were carried out between default and country specific values for 1990 and the real, plant-based values (valid from 1995 up to now). In 2022 the national expert evaluated the used EFs with new figures of the producers [2)]. Some changes have been necessary with the following results:

Table 1: Overview of most recently applied emission factors, in [kg/t]

	EF sulphate pulp	EF sulphite pulp
CO	0.47	0.1
NO_x	1.07	1.7
NMVOC	C	NA
SO_2	0.02	1.5
TSP	0.09	0.14
PM_{10}	0.07	0.11
$PM_{2.5}$	0.05	0.07

A range of measures in sulphite pulp production, carried out on a continual basis, led to reductions of SO_2 emissions. EF of NMVOC is confidential since the AD of sulphate pulp is confidential.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] and other short statistics: https://www.papierindustrie.de/papierindustrie/statistik
[2)] Figures of facilities: „Data of periodic monitoring“ made available by industry association, but not public available because of confidentiality issues

2.H.2 - Food & Beverages Industry

Category Code	Method	AD	EF
2.H.2	T1	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NA	-/-	NA	NA	-/-	-/-	-/-	NE	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Emissions occurring in this sector in Germany derive from the following production processes which are analogous to the IPCC category (Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual (Volume 3)):

Alcoholic beverages

- Wine
- Beer
- Spirits

Bread and other foods

- Meat, fish and poultry
- Sugar
- Margarine, hard/hardened fats
- Cake, cookies and breakfast cereals
- Bread
- Animal feedstuffs

- Coffee roasting

Following pollutants are reported:

- volatile organic compounds (NMVOC),
- particulate matter ($PM_{2.5}$, PM_{10} and TSP).

Pursuant to the 1993 Classification of Economic Activities (WZ 93), the food and beverage industry is divided into nine groups and a total of 33 classes. Governmental statistical evaluations are oriented to this classification. The German food industry includes an especially large number of small and medium-sized enterprises (SMEs); nearly 80 percent of its companies have fewer than 100 employees, and only 3 per cent have more than 500 employees (BpB, 2002, p.51).

Energy related emissions from the sugar industry are reported under category 1.A.2.e.

Methodology

The Inventory Database (CSE) lists activity rates (produced amounts) and emission factors for the relevant sectors. The activity rates for the various products / product groups, with the exception of that for feedstuffs, were obtained from the Federal Statistical Office [1)2)].

Activity data

Annual activity data for feedstuffs are obtained from the Federal Ministry of Food, Agriculture and Consumer Protection [3)].

The produced amounts serve as activity data for the following products: Animal fat [t], Animal food [t], Beer [hl], Bread production (craft) [t], Bread production (industrial) [t], Cake & cookies [t], Coffee [t], Dried fodder [t], Meat [t], Other wine and sparkling [hl], Red Wine [hl], Smoked Products [t], Spirituous beverages [hl] Sugar [t], White wine [hl].

For the purpose of international comparability, the inventory team aggregates all products to the common unit of kilotons. These totals can be find in CRF tables and NFR tables as activity data, but this approximately converted figure is not statistically published. The procedure for the uniform reporting of the activity rate shows a high degree of uncertainty due to the very different products of official statistics.

Emission factors

For emissions calculations, country-specific emission factors were used where available. These emission factors were evaluated and updated by a research study carried out by Theloke et al. (2008) [4)]. Otherwise, the emission factors recommended by IPCC and CORINAIR were used.

All NMVOC emission factors except for beer were perpetuated during the complete time series. The emission factor for beer changed in 2000.

Table 1: Overview of NMVOC emission factors applied

	Unit	EF	Source
Animal Fat	kg/t	1	Expert judgement
Animal Feed	kg/t	0.1	Expert judgement
Beer	kg/hl	0.002	Expert judgement
Bread (artisanry)	kg/t	3	Guidebook 2019 (Bouscaren, 1992)
Bread (industry)	kg/t	0.3	Expert judgement
Cakes & Cookies	kg/t	0.1	Expert judgement
Coffee	kg/t	0.06885	Expert judgement
Meat	kg/t	0.03	Guidebook 2019 (Bouscaren, 1992)
Other Wine/ sparkling Wine	kg/hl	0.058	Expert judgement
Red Wine	kg/hl	0.08	IPCC GB 1996
Smoked Meat & Fish	kg/t	0.0023	Expert judgement
Spirits	kg/hl	2.93	Expert judgement

	Unit	EF	Source
Sugar	kg/t	0.898368	Expert judgement
White Wine	kg/hl	0.035	IPCC GB 1996

In the following table the EF of TSP, PM_{10} and $PM_{2.5}$ are presented.

Table 2: Particulate matter emission factors applied, in [kg/t]

	Value	Source
Sugar (TSP)	0.19	Expert judgement
Sugar (PM_{10})	0.10526	Expert judgement
Sugar ($PM_{2.5}$)	0.0589	Expert judgement
Coffee (TSP)	0.00905	Expert judgement
Coffee (PM_{10})	0.00318	Expert judgement
Coffee ($PM_{2.5}$)	0.0009055	Expert judgement
Dried fodder (TSP)	0.85	Expert judgement

Trends in emissions

Emissions of the food and drink industry are reported, in summary form, in the inventory in of the sectoral report for industrial processes. Emissions in detail for the resp. products are presented following tables:

Table 3: Trends of NMVOC emissions, in metric tonnes [t]

Product	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Animal fat	344.96	351.93	348.92	388.32	428.77	374.11	345.61	320.39	295.23	287.21	293.48	225.71	213.95
Animal food	2104.45	2141.73	2293.94	2338.86	2433.07	2511.94	2570.23	2607.38	2616.44	2651.66	2629.27	2486.80	2450.71
Beer	178.89	177.01	173.01	174.46	174.43	173.55	169.61	173.14	169.21	158.94	158.38	161.71	155.96
Bread production (total)	3865.46	4174.49	4037.89	4074.56	4154.79	4172.44	4180.89	4175.16	4214.30	4690.60	4132.74	4333.34	4318.31
Cake & cookies...	158.72	152.28	153.92	164.96	165.69	164.89	167.79	167.79	171.19	184.07	186.69	198.74	197.14
Coffee	37.20	37.53	38.22	36.60	35.32	37.35	37.96	37.96	39.39	39.35	38.65	36.67	34.98
Meat, fish	51.81	50.80	50.05	50.86	52.20	53.87	54.51	55.74	55.55	54.55	50.23	51.91	49.44
Spirituous beverages	3497.82	3535.31	3554.21	3456.59	3536.34	3545.82	3503.41	3595.14	3571.66	3538.05	3652.12	4267.17	4105.78
Sugar	3974.19	4004.04	3326.58	3599.98	3049.85	3267.01	3814.53	4071.99	3676.98	3507.03	3825.78	3998.29	3450.55
Wine (total)	534.34	522.81	484.25	514.38	521.64	490.74	416.16	537.85	450.35	453.25	473.12	505.68	476.54
TOTAL	**14,747.84**	**15,147.94**	**14,460.99**	**14,799.57**	**14,552.10**	**14,791.71**	**15,260.69**	**15,742.54**	**15,260.28**	**15,564.69**	**15,440.46**	**16,266.03**	**15,453.36**

Table 4: Trends of particulate matter emissions, in metric tonnes [t]

	Product	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
$PM_{2.5}$	Coffee	0.49	0.49	0.50	0.48	0.46	0.49	0.50	0.50	0.51	0.51	0.50	1.70	1.62
	Sugar	260.09	262.04	217.71	235.60	199.60	213.81	249.64	266.49	240.64	229.52	250.38	467.62	403.56
	SUM	**260.57**	**262.53**	**218.21**	**236.08**	**200.06**	**214.30**	**250.14**	**266.98**	**241.15**	**230.03**	**250.88**	**469.33**	**405.19**
PM_{10}	Coffee	1.73	1.74	1.78	1.70	1.64	1.73	1.76	1.76	1.83	1.83	1.80	0.48	0.46
	Sugar	464.80	468.30	389.06	421.04	356.70	382.09	446.13	476.24	430.04	410.17	447.45	261.67	225.82
	SUM	**466.53**	**470.04**	**390.84**	**422.74**	**358.34**	**383.83**	**447.89**	**478.00**	**431.87**	**411.99**	**449.24**	**262.15**	**226.28**
TSP	Coffee	4.9	5.0	5.0	4.8	4.7	4.9	5.0	5.0	5.2	5.20	5.11	4.8	4.6
	Dried fodder	205.7	210.0	191.3	168.3	146.2	146.2	198.9	207.4	180.2	180.20	187.00	187.0	187.0
	Sugar	839.0	845.3	702.3	760.0	643.9	689.7	805.3	859.6	776.3	740.37	807.66	844.1	728.4
	SUM	**1,049.61**	**1,060.21**	**898.58**	**933.13**	**794.72**	**840.83**	**1,009.20**	**1,072.06**	**961.65**	**925.77**	**999.77**	**1,035.93**	**920.07**

Recalculations

Recalculations were necessary due to the update of several production figures for 2021 and 2022.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

For purposes of updating the emission factors applied, a research project [5)] was launched in 2020, with the delayed results expected to be available for the next annual submission.

[1)] Destatis (2024a): Federal Statistical Office (Statistisches Bundesamt - Destatis): Tabelle 42131-0004“: “Produktionswert, -menge, -gewicht und Unternehmen der Vierteljährlichen Produktionserhebung: Deutschland, Jahre, Güterverzeichnis (9-Steller)”, (“manufacturing industry; production in the manufacturing industry”); https://www-genesis.destatis.de/datenbank/online/statistic/42131/table/42131-0004, Wiesbaden, 2024.
[2)] Destatis (2024b): Federal Statistical Office (Statistisches Bundesamt - Destatis): “Erzeugter Wein: Deutschland, Jahre, Rebsorte, Weinkategorien”, (“Wine produced: Germany, years, vine variety, wine categories”) https://www-genesis.destatis.de/datenbank/online/statistic/41254/table/41254-0001; Wiesbaden, 2024.
[3)] BMELV, annually: Federal Ministry of Food, Agriculture and Consumer Protection (BMELV): Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten; https://www.ble-medienservice.de/solr/search/index/?q=jahrbuch; Bonn, 2024
[4)] Theloke et al. (2008): Theloke, S., Wagner, S., Jepsen, D. Hackmack, U.: “Emissionen aus der Nahrungsmittelindustrie”, FKZ 206 42 101/01; https://oekopol.de/archiv-de/DE_450/; Hamburg & Dessau-Roßlau, 2008
[5)] ReFoPlan FKZ – 3720533040: „Aktualisierung der Datengrundlagen zu Emissionen aus der Nahrungsmittelindustrie”; on behalf of the Umweltbundesamt, ongoing

2.H.3 - Other



Germany does not yet report any activities or related emissions under this category.

2.I - Wood Processing

Category Code	Method	AD	EF
2.I	T1	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NA	-/-	NA	NA	-/-	-/-	-/-	NE	IE	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

This industrial sector essentially includes the production of chipboards. It's of minor meaning with view on emissions.

Chipboards are made from wood chips with added binders under the influence of pressure and heat. The main source of NMVOC emissions are the wood chips used, from which NMVOCs are emitted during drying due to the effect of heat. NMVOC can also be emitted from wood and binder during the pressing process.

CO emissions from the fuel use for production steam are allocated under 1.A.2.

Chipboards are produced in about 20 plants in Germany with the industrial sector being dominated by few larger companies.

Activity data

The activity data are taken from the national statistics [1)], but must be converted from volume to mass data for further use.

Table 1: Produced amounts, in 10^6 metric tonnes [t]

2015	2016	2017	2018	2019	2020	2021	2022	2023
4.402	4.56	4.703	4.322	4.489	4.431	4.776	4.366	4.059

Emissions factors

The emission factors of 0.9 kg/t for NMVOC and 0.3 kg/t for PM were estimated on the basis of expert judgements.

Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

[1)] Federal Statistical Office, reporting numbers until 2018: 1621 13 131; 1621 13 133; 1621 13 163; 1621 13 500, reporting numbers from 2019: 162112001, 162112002, 162112003, 162113160, 162114190, 162114500, converted and summarised in tonnes

2.J - Production of POPs

Short description

In Germany, the POP pesticides (Aldrin, Dieldrin, Chlordane, Toxaphene, Mirex, Endrin, Heptachlor, DDT) listed in Annex A & B of the Stockholm Convention are not specifically produced or applied (see). Lindane has not been produced in Germany since 1984 (in the former GDR since 1989).

Dioxins, furans and PAHs have never been produced by the chemical industry on a technical scale in Germany. They are by-products that can be formed unintentionally in all combustion processes in the presence of chlorine and organic carbon. Only HCB played some role just before 1990.

In the Federal Republic of Germany, the production of polychlorinated biphenyls was discontinued by Bayer AG in 1983 [16]. By the Chairman of the Council of Ministers of the GDR on March 6, 1984, with Order No. 54/84[17], stipulations were made for the protection of working people, for the controlled use of PCBs and for the harmless disposal and replacement of PCBs by the development and production of suitable PCB-free agents . Since the Stockholm Convention came into force in 2004, there has been a worldwide ban on these substances.

Thus, no emissions are reported for the period 1990 until today from the source category NFR 2.J (not occuring, NO).

16)
Peter Kredel: Herstellung und Verwendung von PCB in der chemischen Industrie. In: Gefahrstoffe – Reinhalt. Luft. 71, Nr. 1/2, 2011, S. 7–9.

17)
https://www.ddr-im-blick.de/jahrgaenge/jahrgang-1989/report/probleme-mit-pcb-1/

2.K - Consumption of POPs and Heavy Metals

Short description

Former pesticides: As stated in the chapter on NFR 2.J, POP pesticides (Aldrin, Dieldrin, Chlordane, Toxaphene, Mirex, Endrin, Heptachlor, DDT) listed in Annexes A & B of the Stockholm Convention have not been in use since 1989.

The PCP ban was enacted in 1989 with the PCP Prohibition Ordinance. The use of lindane was severely restricted in the 1980s; there is no longer any approved lindane-containing wood preservative on the market in Germany.

HCB: In the Federal Republic of Germany, HCB-containing pesticides may no longer be used since 1981; in the GDR, the ban has been in force since 1984. More information is given in chapter 3.D.f - Agriculture other including use of pesticides.

Dioxins and furans are neither produced or applied intentionally but are by-products that can be formed unintentionally in all combustion processes in the presence of chlorine and organic carbon.

PAHs occur as impurities of other substances or in uncontrolled combustion processes.

Therefore, no emissions of dioxins and furans, PAHs, and HCB would be reported.

PCBs: Source category 2.K considers PCB emissions from use of polychlorinated biphenyls (PCBs) in transformers, small and large capacitors, anti-corrosive paints and joint sealants. Since 1989, polychlorinated biphenyls (PCBs) may no longer be manufactured and placed on the market in Germany (PCB Prohibition Ordinance 1989, adopted in the Chemicals Prohibition Ordinance 1993). However, due to their long lifetime, PCBs can still enter the environment as longterm or secondary emissions, e.g. through open applications in buildings, use in wall paints, joint sealants, varnishes and applications as flame retardants.

However, data on open applications in buildings are subject to large uncertainties; in particular, the different amounts of PCBs used in eastern and western Germany and the many application sites (public, private, and industrial buildings) cannot be plausibly quantified. The figures of a research project we have investigated are not aplicable for reporting but for scientific discussion [1)].

An emission factor in the EEA/EMEP Guidebook 2023[2)] is only be reported for PCB. As the calculation simply is linked to the capita disregarding existing prohibitions this emission factor would lead to unjustified high emissions.

For this reason and to be consistent with the reporting Guidelines, the notation key NE for PCB and NA for the other pollutants is used in the NFR tables.

[1)] See research report (in german only):
https://www.umweltbundesamt.de/publikationen/analyse-der-novellierten-nec-richtlinie-bezueglich
[2)] EMEP/EEA, 2023: EMEP/EEA air pollutant emission inventory guidebook 2023, Copenhagen, 2023,
https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-k-consumption-of-pops/2-k-consumption-of-pops/view

2.L - Other Production, Consumption, Storage, Transportation or Handling of Bulk Products

Short description

Within the NFR tables, category 2.L is displayed to include emissions from “other production, consumption, storage, transportation or handling of bulk products”. Here, Germany reports particulate matter (PM) emissions from both the handling (loading and unloading) of bulk goods as well as diffuse PM emissions from industrial establishments.

Therefore, in the understanding of the inventory compiler, respective *emissions from storage, handling and transport of mineral, chemical and metal products* (NFRs 2.A.5.b, 2.B.10.b und 2.C.7.d) *are included* here.

Category Code	Method	AD	EF
2.L	T1	NS	CS
taking into account emissions from:			
2.L(a) Handling of bulk products	T1	NS	CS
2.L(b) Diffuse emissions from industrial establishments	T1	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

$PM_{2.5}$	**PM_{10}**	**TSP**
L/-	L/T	L/T

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Even though these emissions are reported as a sum under NFR 2.L, this report provides seperate specific information regarding emission from the handling of bulk products (2.L(a)) and from industrial establishments (2.L(b)). For these **detailed information**, please refer to the **sub-chapters** linked above.

Methodology

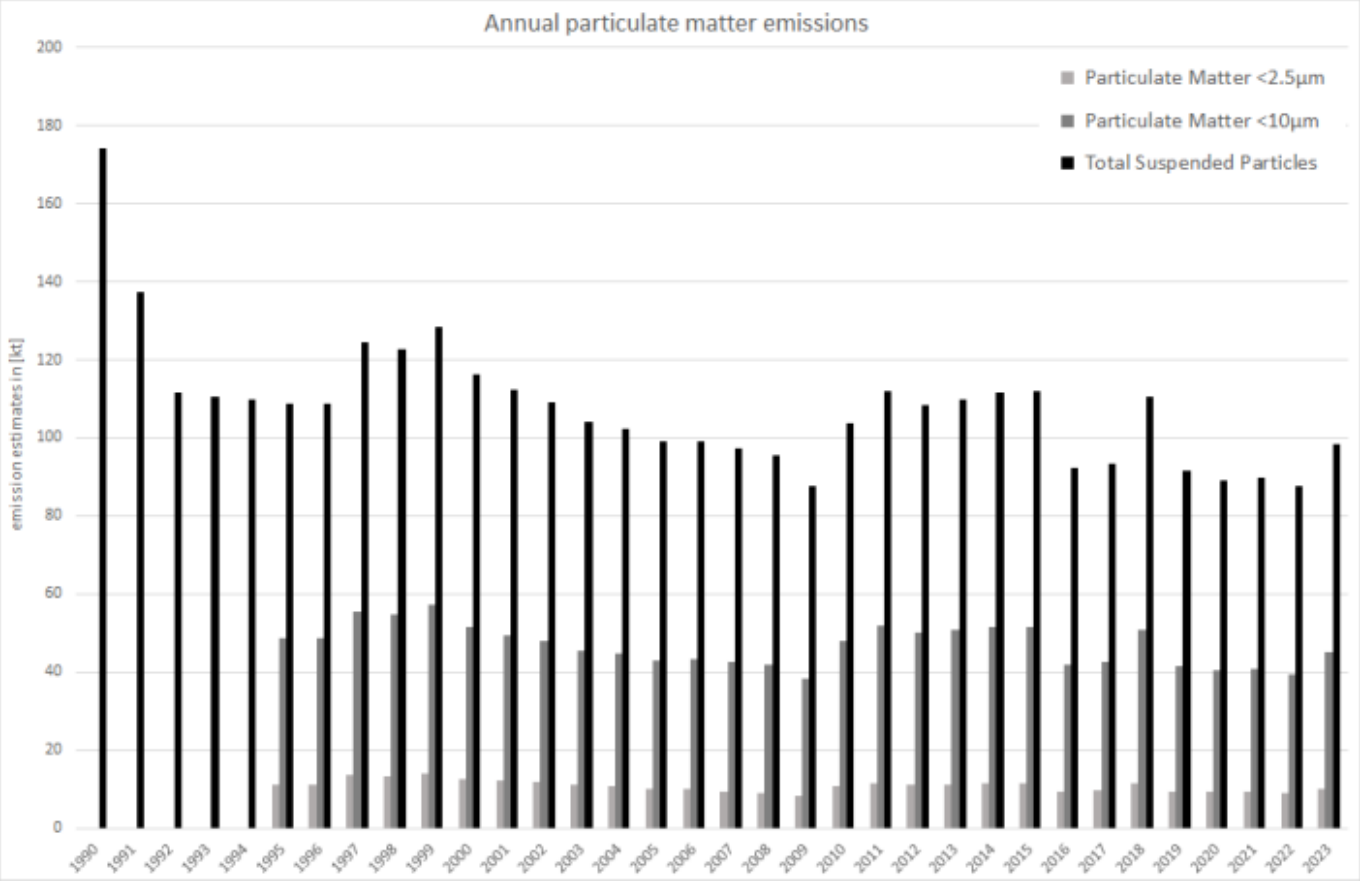
For specific information on applied methods, activity data and emission factors please refer to the sub-chapters linked above.

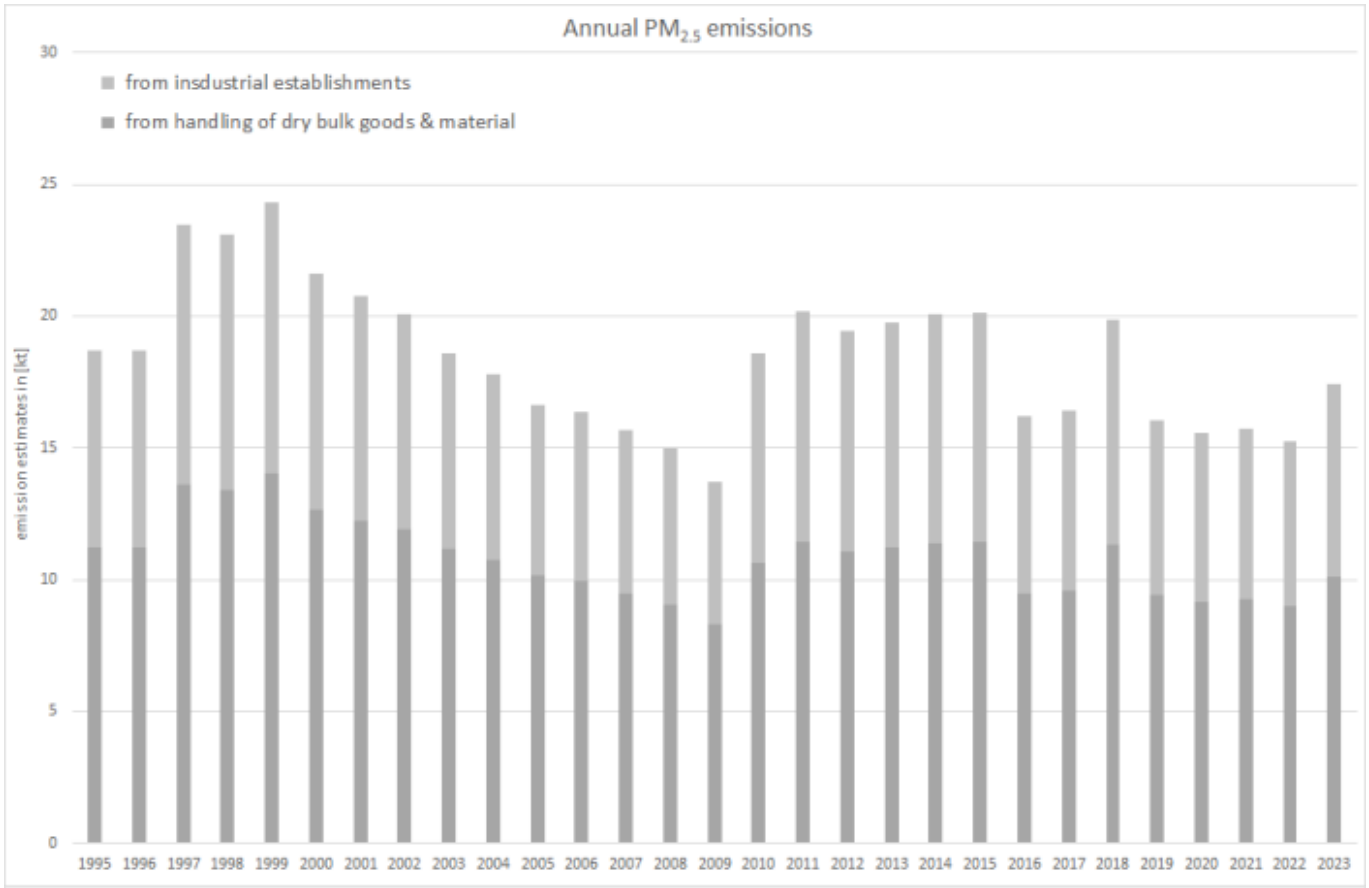
Discussion of emission trends

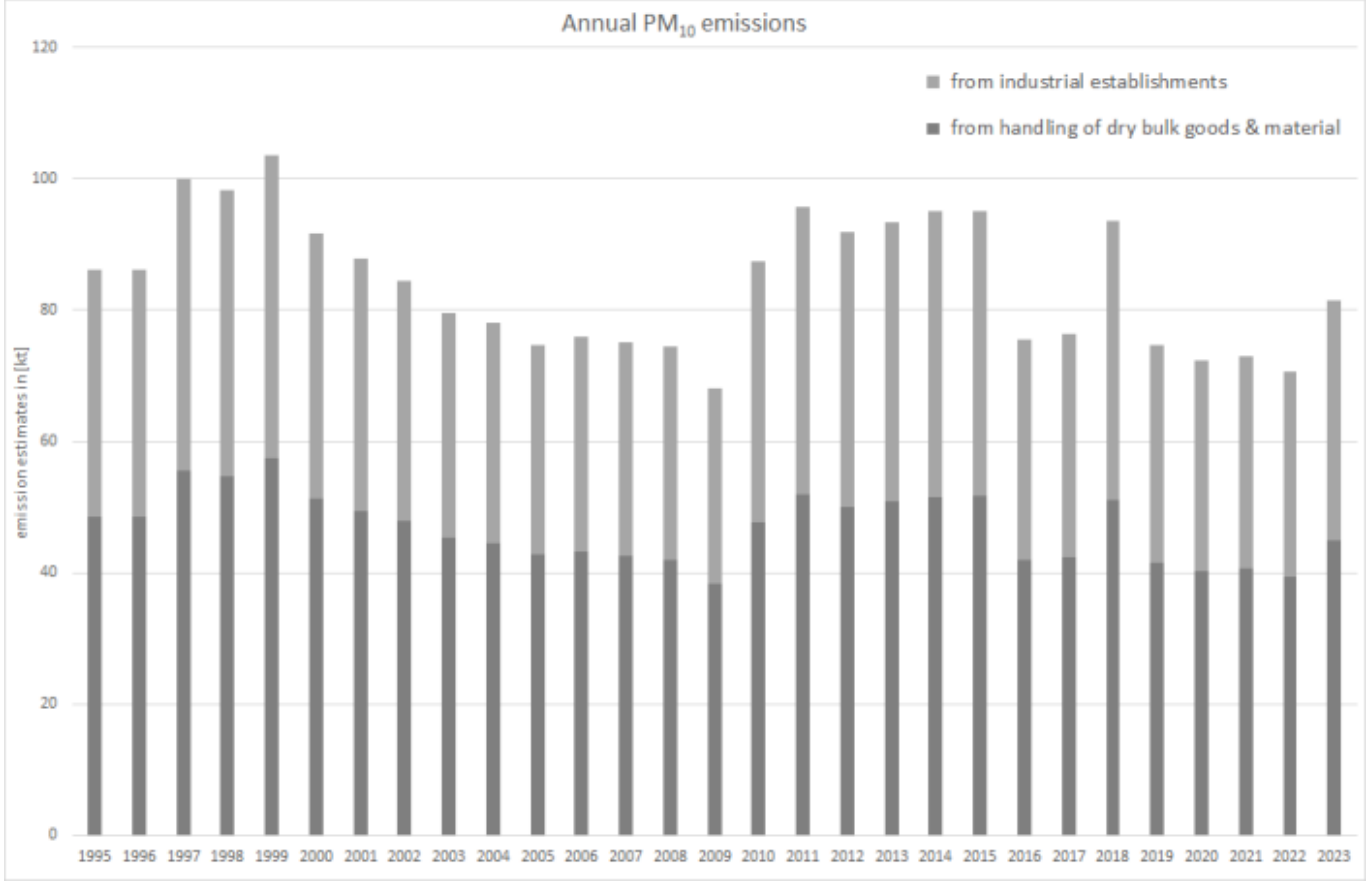
Table: Outcome of Key Category Analysis

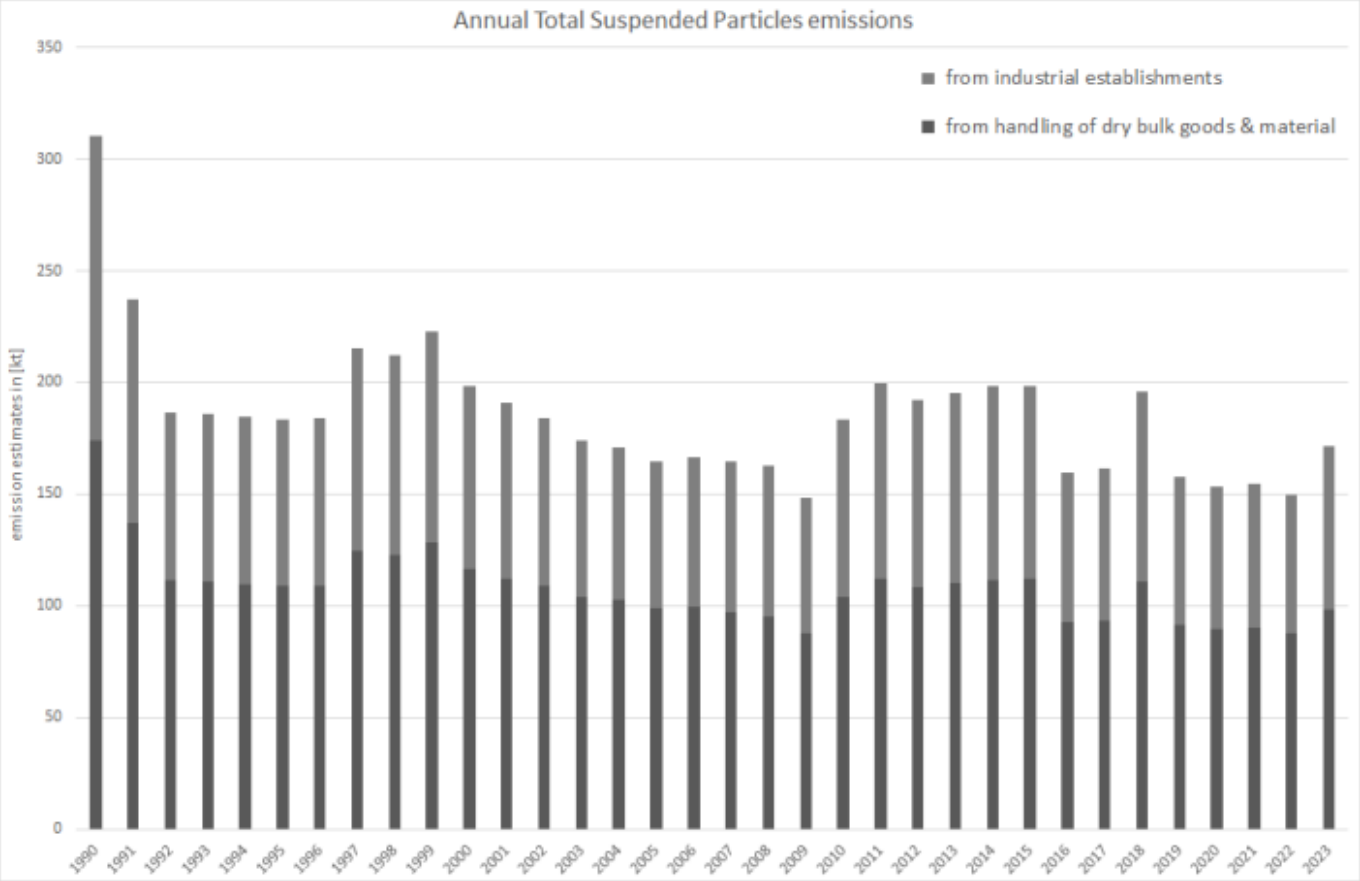
for:	**TSP**	**PM_{10}**	**$PM_{2.5}$**
by:	L/T	L/-	L/-

In general, diffuse particulate matter emissions depend strongly on the amounts of dry bulk goods handled and transported. In addition, due to efforts to prevent such particle emissions, the time series of the emission factors applied for all three fractions of particulate matter show a falling trend.




Annual PM2.5 emissions
from insdustrial establishments
from handling of dry bulk goods & material
emission estimates in [kt]
30
25
20
15
10
5
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023


Annual PM10 emissions
from industrial establishments
from handling of dry bulk goods & material
emission estimates in [kt]
120
100
80
60
40
20
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023



Recalculations

Recalulations against the previous submission result from a revised total number of inhabitants as applied as **activity data** for diffuse PM emissions from industrial establishments.

Table 2: Revised population data for Germany, 2022

	2022
current submission	82,711,282
previous submission	84,358,845
absolute change	-1,647,563
relative change	-1.95%

In contrast, amounts of dry bulk goods and products as well as all **emission factors** remain unrevised compared to last year's submission.

Table 3: Revised particulate-matter emissions 2022, in [kt]

	PM2.5	**PM10**	**TSP**	**PM2.5**	**PM10**	**TSP**	**PM2.5**	**PM10**	**TSP**
	2.L -Total			thereof: dry bulk goods			thereof: establishments		
current submission	9.01	39.5	87.6	6.23	31.2	62.3	2.78	8.34	25.2
previous submission	9.07	39.7	88.1	6.23	31.2	62.3	2.83	8.50	25.7
absolute change	-0.06	-0.17	-0.50	0.00	0.00	0.00	-0.06	-0.17	-0.50
relative change	-0.61%	-0.42%	-0.57%	0.00%	0.00%	0.00%	-1.95%	-1.95%	-1.95%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 8.1 - Recalculations.

Planned improvements



For improvements planned for NFR sub-categories 2.L(a) and 2.L(b) please refer to the corresponding sub-chapters linked above.

2.L(a) - Handling of Bulk Products

Short description

Under category *2.L(a) - Handling of Bulk Products* dust emissions from bulk material handling (loading and unloading) including agricultural bulk materials offsite the fields are reported. Emissions from quarrying and mining of minerals and from point source emissions are excluded.

Methodology

For 1990 to 1996, only simplified estimates without a differentiation of handled materials and products exist. For all following years, emissions are calculated using a tier1 method taking into account detailed data on handled materials and products.

Activity data

Official statistics are of limited use in determining handling of bulk products. There are only transport statistics available providing the amounts of several transported materials.

During a research project carried out by (Müller-BBM) [1)], activity data was derived from primary statistical data from the Federal Statistical Office for Germany (Satistisches Bundesamt, Destatis) and the Federal Motor Transport Authority (Kraftfahrt-Bundesamt, KBA). Here, data on goods transported by railways and ships is gathered by Destatis whereas data for road transport is collected by the KBA.

Here, for all years until 2009, the collection of data for transported goods followed the official **NST/R** (1968) **nomenclature and regulation** (Eurostat, 2015a) [2)].

As of 2010, statistical data following the newly implemented **NST-2007** [3)], [4)] **nomenclature and regulation** from Destatis and KBA is applied instead.

Table 1: Overview of primary activity data sources over time

1990-1996	simplified estimates without differentiation of handled materials
1997-2009	statistical data following NST/R nomenclature
as of 2010	statistical data following NST-2007 nomenclature

Here, NST/R allowed the distribution of a broad variety of goods and materials (e.g. barley, corn, oats, rice, rye, and wheat), whereas NST-2007 provides only a very condensed list of classes of goods (e.g. 'crops').

Due to these methodological breaks, activity data and emissions show inconsistencies (especially on the level of specific goods and materials) that cannot be eliminated at the moment. Nonetheless, on a aggregate level, these breaks are balanced out more or less automatically as the total amount of transported dry materials does not chnage too much with changing statistical approaches.

For estimating the amount of moved bulk materials as well as emissions from the loading and unloading of bulk materials, these primary activity data (PAD, including the amounts of imported and exported goods as well as goods transported within Germany) have to be calculated from the amounts of transported goods:

$$PAD_{(total\,material\,i)} = PAD_{(import\,material\,i)} + 2 \times PAD_{(domestic\,handling\,material\,i)} + PAD_{(export\,material\,i)}$$

where:

- $PAD_{(import\,material\,i)}$ = amount of imported good or material,
- $PAD_{(domestic\,handling\,material\,i)}$ = amount of good or material transported within Germany
- $PAD_{(export\,material\,i)}$ = amount of exported good or material

As the basic statistics provide only total amounts of imported, exported and domestically transported dry goods without any distinction into bulk and packed goods, the shares of bulk goods had to be estimated via expert judgement during the workshop mentioned above.

During this workshop, experts, for comparable kinds of dry bulk material, discussed specific shares displaying which part of the total amount of dry material *i* loaded and/or unloaded within Germany might be transported as bulk material thus causing PM emissions.

So the activity data finally used for estimating specific particulate matter emissions for every bulk material is calculated as a specific share *s* of the amount of this material *i* loaded and/or unloaded within Germany:

$$AD_{(bulk material i)} = PAD_{(total material i)} \times s_{(bulk share)}$$

where:

- $PAD_{(total material i)}$ = total amount of good or material imported to, transported within, and exported from Germany,
- $s_{(bulk share)}$ = percental share of a specific good/material that is considered to be handled as dry bulk good causing particulate matter emissions during handling

Table 2: Amounts of dry, dusty bulk goods handled in Germany 2010-2023, in tonnes

	transport mode	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
other herbal products	inland vessel	3,273,975	2,479,720	2,532,347	2,776,593	2,978,726	2,896,408	3,398,570	2,775,621	3,185,121	2,595,900
	railways	17,849,146	21,867,000	19,270,679	18,928,775	18,679,111	17,758,000	14,257,000	13,930,000	14,929,000	11,841,000
	heavy-duty vehicle	1,544,488	2,757,516	2,470,814	2,552,567	2,172,344	1,972,384	1,483,783	1,522,528	1,298,793	1,386,189
	sea-going vessel	69,407,200	86,441,400	76,251,684	77,289,169	99,899,785	82,985,300	82,091,500	73,636,700	80,938,771	77,535,124
raw mineral chemicals	inland vessel	9,827,059	9,273,000	9,627,577	9,885,631	10,634,917	9,158,000	8,714,000	8,238,000	7,877,000	6,220,000
	railways	6,794,922	2,366,579	2,573,770	2,696,029	11,798,872	11,909,168	11,706,333	11,957,508	11,484,122	8,643,716
	heavy-duty vehicle	78,928,400	82,363,000	10,043,513	11,351,314	63,713,624	11,315,500	9,742,600	7,608,000	7,944,572	49,320,612
	sea-going vessel	5,550,621	7,905,516	7,888,208	8,131,408	7,386,700	4,839,421	5,150,665	6,158,004	5,183,607	3,642,320
raw organic chemicals	inland vessel	16,287,803	21,094,000	18,661,643	18,339,593	0	17,607,000	17,718,000	18,922,000	16,764,000	16,059,000
	railways	6,299,350	57,126	114,803	175,726	6,667,823	6,528,823	6,025,705	6,242,593	5,843,685	5,793,783
	heavy-duty vehicle	11,345,600	4,570,800	0	828,916	12,601,908	0	0	532,800	598,840	12,277,973
	sea-going vessel	3,638,264	2,478,579	2,341,016	2,413,459	2,463,615	2,623,994	2,370,156	2,620,126	2,316,765	2,545,075
iron ore	inland vessel	2,409,311	1,361,655	2,003,004	2,129,778	1,560,991	1,870,568	1,635,431	1,646,949	1,540,486	1,604,070
	railways	22,499,503	6,721,000	6,610,955	6,456,917	8,421,754	6,743,000	4,712,000	3,633,000	3,456,000	2,978,000
	heavy-duty vehicle	802,164	48,778	43,760	135,197	25,450	21,898	18,396	136,867	545,520	258,722
	sea-going vessel	11,801,600	15,401,600	7,065,314	8,549,595	13,182,782	6,653,300	3,878,200	3,596,000	8,319,232	4,139,129
crops	inland vessel	9,816,233	11,243,918	10,046,500	9,546,963	7,715,977	8,128,252	9,593,182	9,174,271	9,175,097	7,969,907
	railways	2,982,548	4,583,000	3,545,040	3,759,205	2,985,786	3,169,000	4,513,000	5,223,000	5,415,000	4,918,000
	heavy-duty vehicle	9,319,143	12,142,981	10,735,948	8,851,781	7,672,262	7,985,888	9,630,445	7,423,593	6,861,301	6,889,485
	sea-going vessel	65,464,800	70,614,200	58,304,413	61,639,154	58,957,570	56,315,100	55,307,700	57,393,200	57,542,622	61,876,197
potatoes	inland vessel	2,852	0	465,039	381,098	349,419	645,000	506,000	399,000	288,000	166,000
	railways	1,782,712	4,133,053	5,180,094	5,368,877	5,275,005	5,506,351	5,509,211	5,289,677	4,708,901	3,364,175
	heavy-duty vehicle	97,539,400	99,568,200	75,685,582	69,634,714	99,763,916	69,628,300	74,421,000	75,421,200	67,185,245	88,464,233
	sea-going vessel	3,104,125	3,525,359	3,586,612	3,747,650	3,788,108	4,001,310	4,365,473	3,372,983	3,797,498	3,764,560
coal products	inland vessel	25,728,177	25,203,179	25,755,504	25,193,580	22,796,286	21,531,669	18,676,735	20,936,706	20,416,412	20,470,884
	railways	38,565,334	37,708,000	37,434,377	37,586,847	38,252,864	36,601,000	32,240,000	35,795,000	34,599,000	31,513,000
	heavy-duty vehicle	13,922,885	13,967,430	13,365,447	14,810,135	14,761,129	14,521,110	12,666,336	14,496,550	13,755,726	13,805,930
	sea-going vessel	203,800	0	1,764,223	534,846	1,680,885	731,400	0	1,035,800	0	1,968,726

	transport mode	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
products from grinding & shelling mills	inland vessel	760,174	305,202	281,603	255,398	197,705	202,054	138,138	154,680	158,954	137,626
	railways	4,122,535	3,424,000	3,619,997	3,581,858	3,224,654	2,756,000	3,000,000	4,297,000	4,969,000	4,061,000
	heavy-duty vehicle	117,224	409,515	256,924	323,622	311,822	392,516	406,221	480,587	490,794	607,817
	sea-going vessel	7,923,200	4,322,000	1,338,908	1,006,750	1,814,964	1,423,800	2,364,000	1,046,400	3,866,610	3,599,113
mineral fertilisers	inland vessel	56,517,180	43,958,000	43,837,499	39,960,787	41,345,431	43,057,000	44,816,000	50,082,000	51,545,000	49,114,000
	railways	40,518,020	31,927,501	33,178,046	36,072,381	35,475,139	38,522,204	36,093,810	33,268,472	34,596,242	29,332,344
	heavy-duty vehicle	1,655,747,400	1,853,177,400	1,669,958,849	1,672,131,248	1,838,142,737	1,639,276,500	1,609,497,100	1,633,052,300	1,605,183,983	1,577,704,165
	sea-going vessel	8,739,096	9,739,769	10,353,589	13,515,063	12,463,686	13,506,136	12,271,288	13,020,839	13,113,287	13,178,697
natural sands, gravel & stones	inland vessel	5,737,386	5,104,076	4,930,755	4,742,988	4,466,442	4,975,009	4,881,285	4,221,526	3,898,815	3,174,195
	railways	15,708,472	14,091,000	13,614,102	14,066,445	12,318,493	11,774,000	11,651,000	11,850,000	11,180,000	10,993,000
	heavy-duty vehicle	5,309,443	6,509,499	7,011,855	7,392,865	7,239,705	7,385,920	7,868,139	6,943,731	6,206,307	6,396,579
	sea-going vessel	37,454,600	71,366,600	28,434,989	30,619,530	68,151,044	29,142,700	28,658,700	26,005,100	26,816,891	61,307,868
non-iron ores	inland vessel	1,512,246	2,964,925	2,827,648	3,199,797	3,043,062	2,749,584	3,389,500	3,282,220	3,550,037	2,974,380
	railways	29,742	8,000	6,642	16,877	61,486	22,000	250,000	28,000	385,000	114,000
	heavy-duty vehicle	2,687,815	2,850,350	3,870,273	4,368,429	4,621,799	3,488,596	4,680,063	4,398,542	3,761,297	2,258,568
	sea-going vessel	705,600	0	0	827,676	512,051	0	675,600	0	0	485,527
raw coals	inland vessel	5,523,633	39,189,603	38,498,874	34,508,319	30,305,094	6,279,089	6,745,999	6,438,938	5,834,164	6,165,052
	railways	1,242,916	470,000	547,545	532,253	445,547	613,000	588,000	743,000	731,000	479,000
	heavy-duty vehicle	4,052,384	6,376,068	7,164,149	6,953,293	6,614,999	6,067,598	6,535,195	6,402,964	6,314,380	6,114,091
	sea-going vessel	20,847,400	34,166,200	22,918,493	24,118,587	35,511,100	18,815,200	18,718,500	25,919,300	22,471,870	27,708,882
secondary raw materials	inland vessel	1,383	0	0	1,056	0	49,119	46,427	0	597	0
	railways	17,135	0	0	4,581,528	4,896,748	0	0	0	8,000	14,000
	heavy-duty vehicle	29,296,456	21,170,067	20,406,870	22,490,149	20,701,636	25,168,423	22,127,609	18,406	17,061	21,834
	sea-going vessel	10,627,000	9,956,800	4,683,480	5,039,904	9,621,800	4,789,300	5,227,200	5,502,200	5,013,672	9,227,068
rock & saline salt	inland vessel	36,652,759	0	0	0	19,571	26,136,332	18,399,530	25,256,586	25,510,105	20,664,710
	railways	58,433,815	67,749,000	61,034,978	51,142,196	48,277,288	41,538,000	32,449,000	33,689,000	40,216,000	35,146,000
	heavy-duty vehicle	13,299,295	16,476,145	14,401,269	15,919,606	16,187,881	12,695,386	7,439,063	10,027,842	11,851,034	7,707,321
	sea-going vessel	10,561,400	13,275,800	11,858,051	16,057,484	12,593,015	12,603,300	6,404,100	13,025,600	11,662,471	10,496,670
nitrogen fertilisers	inland vessel	2,769,356	3,939,437	3,651,498	4,115,651	3,977,618	4,621,784	4,370,103	4,366,688	4,431,492	3,286,950
	railways	3,067,187	2,575,000	2,362,886	2,603,115	3,017,352	2,673,000	2,078,000	2,723,000	2,751,000	2,679,000
	heavy-duty vehicle	567,059	919,251	888,593	812,124	1,116,411	961,803	624,742	926,648	877,961	779,913
	sea-going vessel	21,579,000	7,887,600	7,238,776	10,591,977	11,820,822	8,527,200	5,613,400	12,493,000	7,482,911	9,334,781
white cement, lime, cement	inland vessel	5,047,097	5,810,444	5,057,435	4,173,386	3,427,249	3,502,952	3,465,765	3,552,873	3,328,845	2,507,790
	railways	422,570,000	490,299,000	161,493,436	171,462,235	502,448,809	175,973,100	164,093,200	121,392,900	81,280,591	427,926,405
	heavy-duty vehicle	25,614,264	22,113,000	21,261,312	22,147,649	20,565,387	17,627,000	14,626,000	16,501,000	17,558,000	15,610,000
	sea-going vessel	15,691,876	11,521,886	11,212,165	12,089,358	15,101,718	16,441,457	16,504,345	15,622,479	15,264,191	14,748,686
sugar beet	inland vessel	0	6,366,439	6,426,328	6,396,070	5,912,659	0	4,265	1,274	0	0
	railways	123,598	24,000	64,094	37,555	0	2,000	2,000	127,000	2,000	96,000
	heavy-duty vehicle	17	2,872	3,125	9,676	3,277	0	3,257	12,340	6,313	7,900
	sea-going vessel	26,946,200	36,601,000	22,159,060	32,853,554	31,023,482	32,540,800	31,424,000	31,685,800	46,174,132	40,603,995

sources: annual data deliveries DESTATIS & KBA (for heavy-duty vehicles) to the inventory compiler

Emission factors

Emission factors are based on the methodology according VDI guidelines 3790. The values used here originate from a research project by (Müller-BBM, 2011) [5)] taking into account information of an expert panel of industry and administration. For details see the [*https://www.umweltbundesamt.de/publikationen/konsistenzpruefung-verbesserungspotenzial project report] (German version only).

Within the study, PM emission factors are estimated for each material or good that might be transported as dry and unpacked bulk. These very specific EF are than assigned to the classes of materials/goods available from the different different statistics (NST/R, NST-2007) to form implied Ef for these class of bulk material.

As NST/R provided a wide variaty of goods and materials, whereas NST-2007 provides only a very condensed list of classes of goods, the very specific EF derived during the study and the joint expert workshop have been aggregated in order to match the classes of goods following NST-2007.

Table 2: specific emission factors applied for PM emissions from NST/R products, in [kg/t], as used for 2023 estimates

	TSP	PM_{10}	$PM_{2.5}$
Other herbal products	0.032000	0.016000	0.003200
Raw Chemicals: mineralic	0.041000	0.020500	0.004100
Raw organic chemicals	0.024000	0.012000	0.002400
Iron ore	0.057000	0.028500	0.005700
Crops	0.045000	0.022500	0.004500
Potatoes	0.007000	0.003500	0.000700
Coal products	0.019000	0.009500	0.001900
Grinding & shelling mills products	0.003000	0.001500	0.000300
Mineral fertilisers	0.024000	0.012000	0.002400
Natural sands, gravel, and stones	0.027000	0.013500	0.002700
Non-iron ores	0.066000	0.033000	0.006600
Raw coals	0.016000	0.008000	0.001600
Secondary raw materials	0.027000	0.013500	0.002700
Rock & saline salt	0.068000	0.034000	0.006800
Nitrogen fertilisers	0.024000	0.012000	0.002400
White cement, lime, cement	0.005000	0.002500	0.000500
Sugar beet	0.000240	0.000120	0.000024

Ratio TSP : PM_{10} : $PM_{2.5}$

The shares of PM_{10} and $PM_{2.5}$ of the entire amounts of emitted TSP have been set to fixed values used for the entire time series.

Assumptions:

1. TSP = 100%,
2. 50% of TSP are =< 10 µm. Therefore, the EF(PM_{10}) are assumed as 1/2 of the corresponding EF(TSP), and
3. 10% of TSP are =< 2.5 µm. Therefore, the EF($PM_{2.5}$) are assumed as 1/10 of the corresponding EF(TSP).

The ratios of TSP, PM_{10}, and $PM_{2.5}$ were also discussed in the research project mentioned above, but without generating any new data. Nonetheless, the ratios might be to low at the moment and will be checked furthermore.

Recalculations

For information on revised inventory data, please see the superordinate chapter.

Planned improvements

At the moment, no category-specific improvements are planned.

[1), 5)] Müller-BBM (2011): Bender, Dr. M., Gronewäller, L., Langer, D.: Konsistenzprüfung und Verbesserungspotenzial der Schüttgutemissionsberechnung - Umweltforschungsplan des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit, FKZ 3708 49 107 2 - FB 00 1453 UBA; Müller-BBM GmbH, https://www.umweltbundesamt.de/publikationen/konsistenzpruefung-verbesserungspotenzial, on behalf of the Umweltbundesamt, Planegg / Dessau-Roßlau, 2011.
[2)] Eurostat (2015a): Standard Goods Classification for Transport Statistics/Revised (1967) NST/R - URL
[3)] Eurostat (2015b): Standard Goods Classification for Transport Statistics, 2007 -URL
[4)] Destatis (2013): Federal Statistical Office (Statistisches Bundesamt - Destatis): Verkehr, NST-2007: Einheitliches Güterverzeichnis für die Verkehrsstatistik – 2007 - URL, Wiesbaden, 2013.

2.L(b) - Diffuse Emissions from Industrial Establishments

Short description

NFR category *2.L(b) - Diffuse Emissions from Industrial Establishments* includes also diffuse emissions from enterprises in general kind.

Methodology

As no detailed data are available and as *NFR 2.L(b)* is no key category, all emissions are calculated via a tier1 method. Estimations are based on an European method computing emissions per person of population.

Activity data

Table 1: Population development in Germany since 1990

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
79,753,227	81,307,715	81,456,617	81,336,663	80,284,071	82,175,684	82,521,653	82,792,351	83,019,213	83,166,711	83,155,031	83,237,124	82,711,282	82,711,282

Emission factors

Emission factors originate in the results of a research project with respect to the European RAINS model. - The EF time series for all three fractions of particulate matter show a falling trend.

Table 2: EF used for 2023 emission estimates, in [kg/capita]

Total suspended particles - TSP	0.3052
PM_{10}	0.1008
$PM_{2.5}$	0.0336

Discussion of emission trends

The diffuse particulate matter emissions reported here, depend on (a) the number of inhabitants in Germany, serving as activity data, and (b) on the trend in emission factors that shall reflect the efforts to prevent such particle emissions. Hence, the emission time-series for all three fractions of particulate matter show a downward trend.

Recalculations

For information on revised inventory data, please see the superordinate chapter.

Planned improvements

At the moment, no category-specific improvements are planned.

CHAPTER 5: NFR 3 - Agriculture (OVERVIEW)

NFR-Code	Name of Category
3.B	3.B Manure Management
3.D	3.D Agricultural Soils
3.F	3.F Field Burning Of Agricultural Residues
3.I	3.I Agricultural: Other

Short description

Emissions occurring in the agricultural sector in Germany derive from manure management (NFR 3.B), agricultural soils (NFR 3.D) and agriculture other (NFR 3.I). Germany does not report emissions in category field burning (NFR 3.F) (key note: NO), because burning of agricultural residues is prohibited by law (see Rösemann et al., 2025)[18)].

The pollutants reported are:

- ammonia (NH_3),
- nitric oxides (NO_x),
- volatile organic compounds (NMVOC),
- particulate matter ($PM_{2.5}$, PM_{10} and TSP) and
- hexachlorobenzene (HCB).

No heavy metal emissions are reported.

The calculations for the present IIR 2024 were finished before the release of the EMEP (2023) guidebook. Therefore, methodological changes in the EMP (2023) guidebook were not considered for the present submission.

In 2023 the agricultural sector emitted 527.0 Gg of NH_3, 99.5 Gg of NO_x, 301.3 Gg of NMVOC, 61.0 Gg of TSP, 35.4 Gg of PM_{10} and 5.4 Gg of $PM_{2.5}$ and 0.30 kg HCB. The trend from 1990 onwards is shown in the graph below. The sharp decrease of emissions from 1990 to 1991 is due to a reduction of livestock population in the New Länder (former GDR) following the German reunification. The increase of NH_3 emissions since 2005 is mostly due to the expansion of anaerobic digestion of energy crops, especially the application of the digestion residues. This emission source also affects NO_x emissions. The decrease of NH_3 emissions since 2015 is mostly due to a decline in the amounts of mineral fertilizer sold and stricter regulations concerning application of urea fertilizers, as well as declining livestock numbers Further details concerning trends can be found in Rösemann et al. (2025) chapter “Emissions results submission 2025”.

As depicted in the diagram below, in 2023 92.6 % of Germany’s total NH_3 emissions derived from the agricultural sector, while nitric oxides reported as NO_x contributed 11.8 % and NMVOC 30.9 % to the total NO_x and NMVOC emissions of Germany. Regarding the emissions of $PM_{2.5}$, PM_{10} and TSP the agricultural sector contributed 7.0 % ($PM_{2.5}$), 19.5 % (PM_{10}) and 18.3 % (TSP) to the national particle emissions. HCB emissions of pesticide use contributed 7.6 % to the total German emissions.

Mitigation measures

The agricultural inventory model can represent several abatement measures for emissions of NH_3 and particles. The measures comprise:

- changes in animal numbers and amount of applied fertilizers
- air scrubbing techniques: yearly updated data on frequencies of air scrubbing facilities and the removal efficiency are provided by KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft / Association for Technology and Structures in Agriculture) and also based on the agricultural census 2020. The average removal efficiency of NH_3 is 80 % for swine and 70 % for poultry, while for TSP and PM_{10} the rates are set to 90 % and for $PM_{2.5}$ to 70 % for both animal categories. For swine two types of air scrubbers are distinguished: first class systems that remove both NH_3 and particles, and second class systems that remove only particles reliably and have an ammonia removal efficiency of 20%.
- reduced raw protein content in feeding of fattening pigs: the German animal nutrition association (DVT, Deutscher Verband Tiernahrung e.V.) provides data on the raw protein content of fattening pig feed, therefore enabling the inventory to depict the changes in N-excretions over the time series. The time series is calibrated using data from

official and representative surveys conducted by the Federal Statistical Office.

- reduced raw protein content in feeding and feed conversion rates of broilers: the German animal nutrition association (DVT, Deutscher Verband Tiernahrung e.V.) provides data on the raw protein content of fattening broiler feed, and feed conversion rates of broilers. This makes it possible to model the changes in N-excretions over the timeseries.
- low emission spreading techniques of manure: official agricultural censuses survey the prevalence of different manure spreading techniques and how fast organic fertilizers are incorporated into the soil. Germany uses distinct emission factors for different methods, techniques and incorporation durations.
- covering of slurry storage: agricultural censuses survey the prevalence of different slurry covers. Germany uses distinct emission factors for the different covers.
- use of urease inhibitors: for urea fertilizer the German fertilizer ordinance prescribes the use of urease inhibitors or the direct incorporation into the soil from 2020 onwards. The NH_3 emission factor for urea fertilizers is therefore reduced by 70% from 2020 onwards for the direct incorporation, according to Bittman et al. (2014, Table 15)[19)]. For the use of urease inhibitors the NH_3 emission factor is reduced by 60% from 2020 onwards, see Rösemann et al. (2025), Chapter 5.2.1.2.

For NO_x and NMVOC no mitigation measures are included.

Reasons for recalculations

(see Chapter 8.1 - Recalculations)

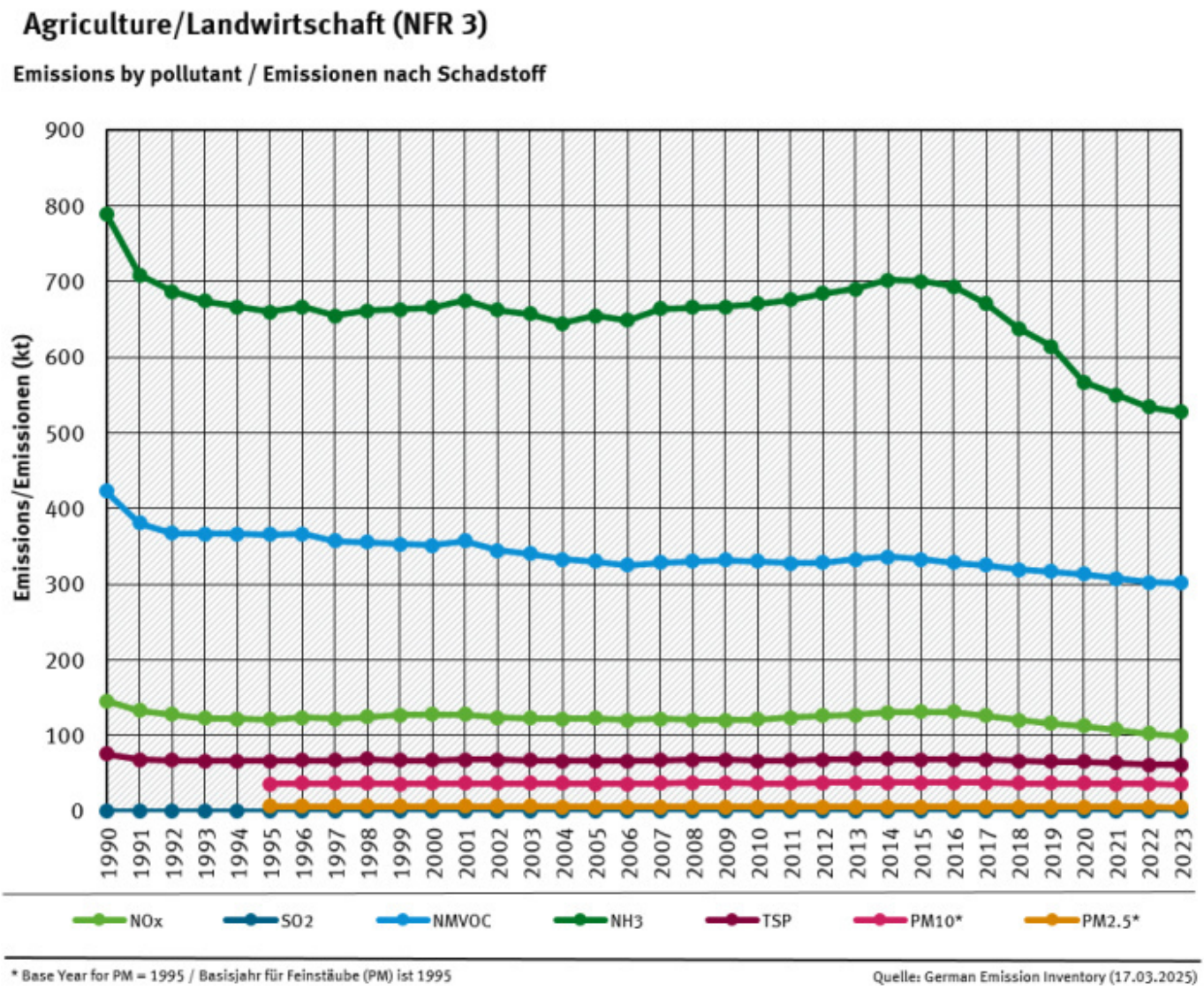
The following list summarizes the most important reasons for recalculations. Recalculations result from improvements in input data and methodologies (for details see Rösemann et al. (2025), Chapter 1.3).

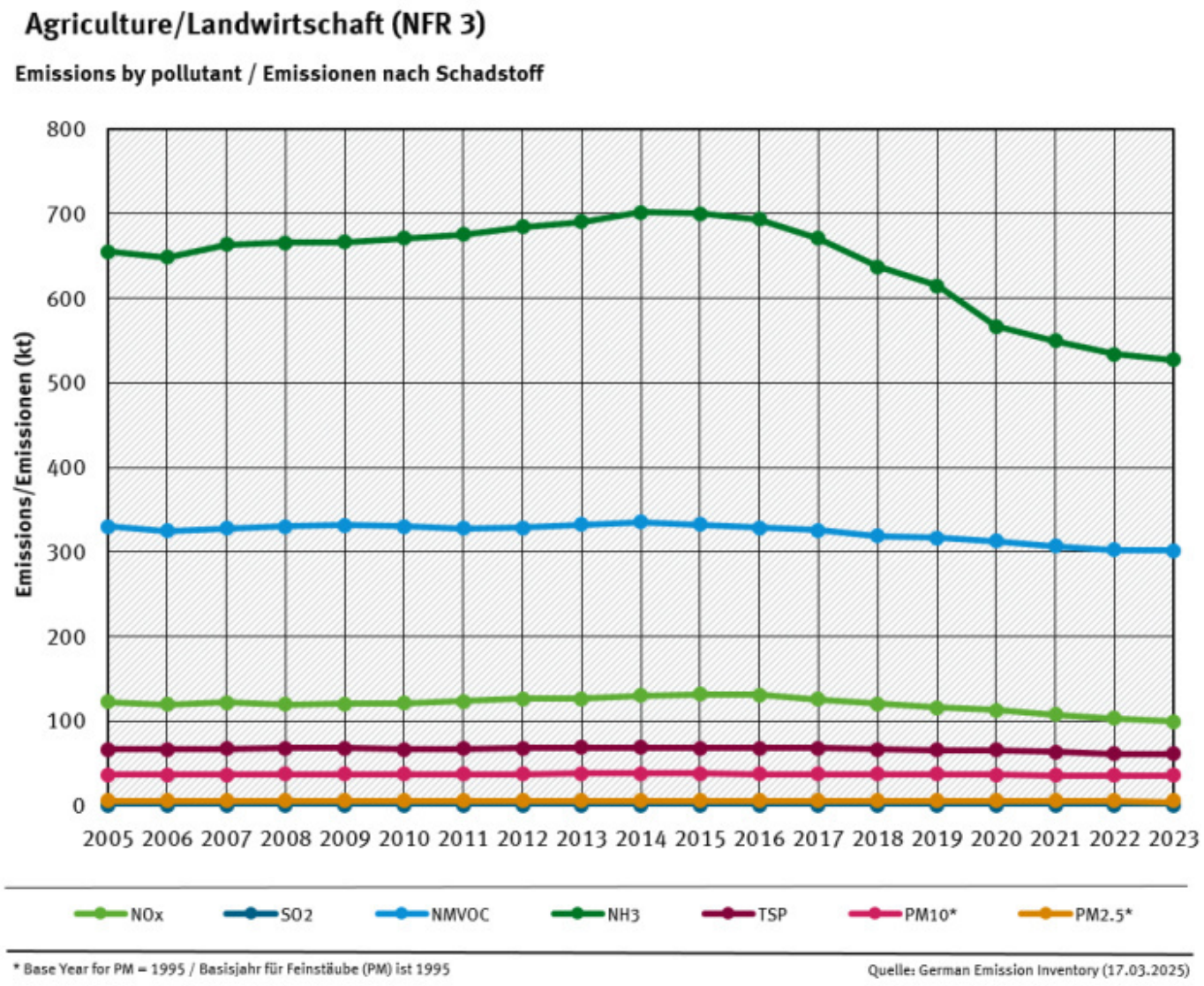
1. Mineral fertilizers: The NH3 emission factors for mineral fertilizers in EMEP (2023) were used for the first time in the present submission.
2. Crop residues: NH3 emissions from crop residues are calculated for the first time according to the tier 2 method from EMEP (2023). To facilitate this, cover crops are now included in the inventory data. Cover crops are also a newly reported source of PM emissions from soils.
3. Cattle and pigs: improved emission factors for cattle and pig housing were introduced based on national research projects.
4. Horses: The animal numbers were corrected in all years and all districts by a factor of 2.75 to include horses which are kept outside of agricultural holdings and not counted by agricultural census. All horses are reported under 3.B as permitted by EMEP (2023) Section 4.2.
5. Transformation processes in storage: The previous assumption for untreated slurry that 10 % of the TAN entering storage is converted to Norg (immobilization) was dropped because no sufficient scientific evidence could be found for this.
6. Manure Management emission factors for N2O, NOx and N2: N2O emission factors were adopted from the IPCC Refinement (2019). The N2O EF for solid manure storage doubles, which then also applies to the corresponding NOx and N2 EFs.
7. Dairy cows: Milk yield and slaughter weights for 2022 have been slightly corrected in the official statistics.
8. Heifers: 2022 slaughter weights have been slightly corrected in the official statistics.
9. Male beef cattle: In some years, slaughter ages and slaughter weights have been updated in the HIT database.
10. Numbers of laying hens, pullets and broilers were corrected in the years before 2013. The numbers are higher than in earlier submissions..
11. Sows: For several federal states, confidential data for number of piglets per sow and year has been replaced.
12. Fattening pigs: for several federal confidential data for growth rates, start weights and final weights has been replaced. For Saxony and Saxony-Anhalt (no more recent data available than 2016 or 2017) the corresponding data from the neighboring federal state of Thuringia was adopted instead of keeping the last known value as was previously the case.
13. Poultry: amounts of straw were corrected for all poultry categories
14. Broilers: Update of the national gross production of broiler meat in 2022.
15. Laying hens and pullets: due to new weight data for laying hens for 2021, the starting and final weights of laying hens have been recalculated for the entire timeseries. Since the initial weight of the laying hens corresponds to the final weight of the pullets, this also has (small) effects on the energy requirements and excretion of the pullets.
16. Animal numbers horses, poultry, goats for 2021 and 2022: The previously extrapolated animal numbers for 2021 and 2022 have been replaced by interpolated animal numbers, as new figures from the agricultural structure survey are available for 2023.

17. Application of inorganic fertilizers: The mitigating factor for urea emissions if applied with urease inhibitor (since the year 2020) was reduced from 70 % to 60 %. Correction of amounts applied in some years before 2008 due to a mistake in calculation of the mean value of the three years going into the moving average.
18. Application of sewage sludge: Replacement of extrapolated activity data in 2022 with data from the Federal Statistical Office and corrections of activity data for years after 2006.
19. Anaerobic digestion: Update of activity data as of 2013 concerning gastight storage data. This applies to both digested energy crops and digested animal manure.
20. Imported manure: The amounts of imported manure from the Netherlands have been updated for years after 2017.
21. Compost and digested waste: input data for 2022 has been updated.
22. Distribution data 1990 – 1999: RAUMIS distribution data is only available for the years 1991, 1995 and 1999. The data for the intervening years (1992 – 1994 and 1996 – 1998 have now been generated by using linear interpolation (1990 = 1991).

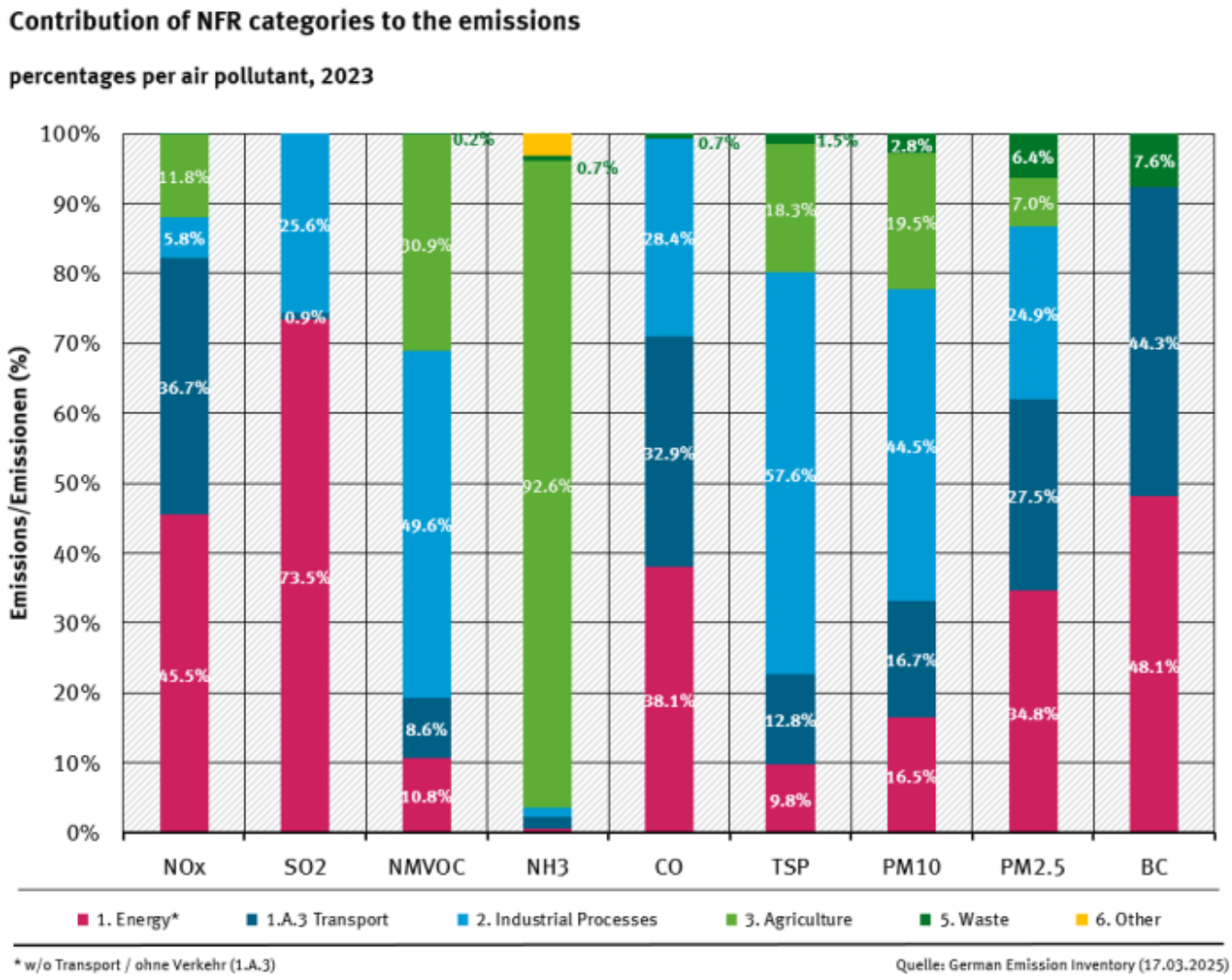
Visual overview

Emission trends for main pollutants in *NFR 3 - Agriculture*:





Contribution of NFRs 1 to 6 to the National Totals, for 2021



Specific QA/QC procedures for the agriculture sector

Numerous input data were checked for errors resulting from erroneous transfer between data sources and the tabular database used for emission calculations. The German IEFs and other data used for the emission calculations were compared with EMEP default values and data of other countries (see Vos et al., 2024). Changes of data and methodologies are documented in detail (see Vos et al. 2024, Chapter 1.3).

A comprehensive review of the emission calculations was carried out by comparisons with the results of Submission 2023 and by plausibility checks.

Once emission calculations with the German inventory model Py-GAS-EM are completed for a specific submission, activity data (AD) and implied emission factors (IEFs) are transferred to the CSE database (Central System of Emissions) to be used to calculate the respective emissions within the CSE. These CSE emission results are then cross-checked with the emission results obtained by Py-GAS-EM.

Furthermore, in addition to UNFCCC, UNECE and NEC reviews, the Py-GAS-EM model is continuously validated by experts of KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft, Association for Technology and Structures in Agriculture) and the EAGER group (European Agricultural Gaseous Emissions Inventory Researchers Network).

18)
Rösemann, C., Vos, C., Haenel, H.-D., Dämmgen, U., Döring, U., Wulf, S., Eurich-Menden, B., Freibauer, A., Döhler, H., Schreiner, C., Osterburg, B., Fuß,R. (2025) Calculations of gaseous and particulate emissions from German agriculture 1990 – 2023 : Report on methods and data (RMD) Submission 2024. www.eminv-agriculture.de

19)
Bittman, S., Dedina, M., Howard C.M., Oenema, O., Sutton, M.A., (eds) (2014): Options for Ammonia Mitigation. Guidance from the UNECE task Force on Reactive Nitrogen. Centre for Ecology and Hydrology, Edinburgh, UK

3.B - Manure Management

Short description

NFR-Code	Name of Category	Method	AD	EF
3.B	**Manure Management**	**see sub-category details**		
consisting of / including source categories				
3.B.1.a & 3.B.1.b	Cattle	T3 (NH_3), T2 (NO_x , TSP, PM_{10} , $PM_{2.5}$, NMVOC)	NS, RS	CS (NH_3 , NO_x), D (TSP, PM_{10} , $PM_{2.5}$, NMVOC)
3.B.2, 3.B.4.d, 3.B.4.e	Sheep, Goats, Horses	T2 (NH_3 , NO_x , TSP, PM_{10} , $PM_{2.5}$), T1 (NMVOC)	NS, RS	CS (NH_3 ,NO_x), D (TSP, PM_{10} , $PM_{2.5}$, NMVOC)
3.B.3	Swine	T3 (NH_3), T2 (NO_x , TSP, PM_{10} , $PM_{2.5}$), T1 (NMVOC)	NS, RS	CS (NH_3 , NO_x), D (TSP, PM_{10} , $PM_{2.5}$, NMVOC)
3.B.4.a	Buffalo	until 1995: NO, since 1996: IE (in 3.B.1.b)		
3.B.4.f	Mules and asses	IE (in 3.B.4.e)		
3.B.4.g i-iv	Poultry	T2 (NH_3 , NO_x , TSP, PM_{10} , $PM_{2.5}$), T1 (NMVOC)	NS, RS	CS (NH_3 , NO_x), D (TSP, PM_{10} , $PM_{2.5}$, NMVOC)
3.B.4.h	Other animals (Deer, Rabbits, Ostrich)	T2 (NH_3, NO_x), T1 (TSP, PM_{10} , $PM_{2.5}$, NMVOC)	AS, M	CS (NH_3 , NO_x), D (TSP, PM_{10} , $PM_{2.5}$, NMVOC)

	NO_x	**NMVOC**	SO_2	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	CO	Heavy Metals	PAHs	HCB	PCBs
3.B.1.a	-/-	**L/-**	NA	**L/-**	**L/-**	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.1.b	-/-	**L/T**	NA	**L/T**	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.2	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.3	-/-	-/-	NA	**L/T**	-/-	-/-	**L/-**	NA	NA	NA	NA	NA	NA
3.B.4.d	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.4.e	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.4.g.i	-/-	-/-	NA	-/-	-/-	-/-	**L/-**	NA	NA	NA	NA	NA	NA
3.B.4.g.ii	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.4.g.iii	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.4.g.iv	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled

C	Confidential

Country specifics



In 2023, NH_3 emissions from category 3.B (manure management) were 37.3 % from total agricultural emissions, which is equal to ~ 196.5 kt NH_3. Within those emissions 46.5 % originate from cattle manure (~ 91.3 kt), 31.6 % from pig manure (ca. 62.1 kt), and 11.7 % from poultry manure (~ 22.9 kt). Calculations take into account the impact of anaerobic digestion of manure on the emissions.

NO_x emissions from category 3.B (manure management) contribute only 1.6 % (~ 1.6 kt) to the total agricultural NO_x emissions. They are calculated proportionally to N_2O emissions, see Rösemann et al. (2025) [20)].

NMVOC emissions from category 3.B (manure management) contributed 96.9 % (292.1 kt) from total agricultural NMVOC emissions (301.3 kt).

In 2023, manure management contributed, respectively, 61.2 % (37.3 kt), 33.0 % (11.7 kt) and 66.3 % (3.6 kt) to the total agricultural TSP, PM_{10} and $PM_{2.5}$ emissions (TSP: 61.0 kt, PM_{10}: 35.4 kt, $PM_{2.5}$: 5.4 kt, respectively).

Activity data for all pollutants

The Federal Statistical Agency and the Statistical Agencies of the federal states carry out surveys in order to collect, along with other data, the head counts of animals. The results of these surveys are used for emission calculations, for details see Rösemann et al, 2025, Chapter 2.3.

The animal population figures used in the inventory are presented in Table 1. Buffaloes are included in the cattle population figures, mules and asses are included in the horse population figures (IE), see Rösemann et al. (2025), Chapter 2.3. In the first years after the German reunification in 1990 animal livestock decreased markedly. The head counts for cattle continued to decrease significantly until 2006/2007, followed by a more or less stable period until 2014. Since 2015 a slight decrease occurred. In 2023, dairy cattle numbers are 58.4 % of 1990 numbers, while the total population of other cattle is at 54.2 % of 1990. Swine numbers decreased until 1995 and then increased slightly. Since 2014 a new decrease occurred which became significant between 2020 and 2022 (total pig numbers were reduced by around 18 % within two years). In 2023 this trend did not continue. 2023 swine numbers are 66.1 % of 1990 numbers. The 2022 numbers of horses, sheep and goats are, respectively, at 97.4 %, 56.6 % and 180.7 % of 1990.

Figures for broilers and turkeys are showing a massive increase since 1990. Since the year 2013, there have been only minor changes of total poultry numbers. In total, 2023 poultry population figures are at 146.9 % of 1990.

Emissions of deer, rabbits, ostrich and fur-bearing animals are reported since submission 2024. The underlying animal numbers of these categories were estimated in different ways because there are no surveys which collect those animal numbers. However, the impact of those animal categories on the total emissions is small.

A detailed description of the animal numbers used can be found in Rösemann et al. (2025), chapter 2.3.

Table 1: Population of animals, in [1,000 individuals]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
dairy cattle	6.354,6	5.229,4	4.569,8	4.236,4	4.183,1	4.284,6	4.217,7	4.199,0	4.100,9	4.011,7	3.921,4	3.832,7	3.809,7	3.712,8
other cattle	13.133,4	10.660,5	9.968,9	8.800,4	8.628,7	8.350,8	8.248,9	8.082,2	7.848,2	7.627,9	7.380,5	7.206,9	7.187,2	7.123,4
buffalo	NO	NO	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
mules and asses	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
horses	1.373,5	1.743,9	1.373,7	1.398,1	1.269,9	1.233,1	1.215,4	1.223,4	1.231,5	1.239,5	1.247,6	1.277,8	1.308,0	1.338,2
sheep	3.266,1	2.990,7	2.743,3	2.643,1	2.245,0	1.866,9	1.851,0	1.863,2	1.846,0	1.813,6	1.780,3	1.794,8	1.805,7	1.847,6
goats	90,0	100,0	140,0	170,0	149,9	135,9	138,8	142,8	146,9	150,9	154,9	157,5	160,0	162,6
swine	26.502,5	20.387,3	21.767,7	22.742,8	22.244,4	22.978,5	22.761,2	22.920,8	22.019,2	21.596,4	21.622,0	19.728,6	17.692,3	17.525,3
laying hens	53.450,5	47.575,8	48.640,0	43.641,6	41.700,5	50.619,3	51.935,5	52.571,1	53.206,6	53.842,1	54.477,6	54.921,5	55.365,4	55.809,3
broilers	35.393,0	46.625,9	61.940,7	76.045,0	98.389,7	94.909,4	93.791,3	93.458,7	93.126,1	92.793,5	92.461,0	91.004,5	89.548,1	88.091,6
turkeys	5.029,2	6.742,0	8.893,1	10.611,1	11.344,0	12.658,5	12.359,9	12.164,7	11.969,5	11.774,3	11.579,1	10.718,9	9.858,6	8.998,3
pullets	17.210,8	16.149,2	17.284,1	16.050,9	14.827,0	13.828,3	12.921,8	12.736,3	12.550,7	12.365,1	12.179,6	12.253,0	12.326,5	12.399,9
ducks	2.013,7	1.933,7	2.055,7	2.352,2	3.164,3	2.410,8	2.236,4	2.209,1	2.181,9	2.154,6	2.127,4	1.949,3	1.771,2	1.593,1
geese	781,5	617,0	404,8	329,5	278,1	400,8	329,0	327,7	326,3	324,9	323,5	354,2	385,0	415,7
deer	155,8	204,0	252,3	261,5	270,7	279,9	281,7	283,5	285,4	287,2	289,1	290,9	292,7	294,6
rabbits	1.851,4	1.565,6	1.268,9	997,0	864,2	720,7	691,2	642,7	608,3	593,9	548,4	470,0	430,6	422,8
ostrich	NO	1,2	2,5	3,7	4,9	7,7	7,4	7,4	7,9	7,4	7,9	6,1	5,1	4,6
fur animals	179,9	179,9	179,9	153,5	121,7	34,4	24,7	15,0	5,3	5,3	NO	NO	NO	NO
Other animals: no data available														

Additional data

Emission calculations in accordance with a Tier 2 or Tier 3 method require data on animal performance (animal weight, weight gain, milk yield, milk protein content, milk fat content, numbers of births, numbers of eggs and weights of eggs) and on the relevant feeding details (phase feeding, feed components, protein and energy content, digestibility and feed efficiency). To subdivide officially recorded total numbers of turkeys into roosters and hens, the respective population percentages need to be known. Details on data requirements for the modelling of emissions from livestock husbandry in the German inventory can be found in Rösemann et al. (2025), Chapter 2.

Most of the data regarding feed and performance is not available from official statistics and was obtained from literature, from publications by agricultural associations, from regulations for agricultural consulting in Germany and from expert judgments.

For 1991, 1995 and 1999, frequency distributions of feeding strategies, husbandry systems (shares of pasturing/stabling; shares of various housing methods), storage types as well as techniques of farm manure spreading were obtained with the help of the RAUMIS agricultural sector model (Regionalisiertes Agrar- und UmweltInformationsystem für Deutschland/ Regionalised agricultural and environmental information system for Germany). RAUMIS has been developed and is operated by the Institute of Rural Studies of the Thünen Institute (Federal Research Institute for Rural Areas, Forestry and Fisheries). For an introduction to RAUMIS see Weingarten (1995)[21)]; a detailed description is provided in Henrichsmeyer et al. (1996)[22)].

RAUMIS did not model complete time series but only selected years. RAUMIS data for the years 1991, 1995, and 1999 are used in the inventory for the respective years. For 1990, the data for 1991 is adopted, for the intervening years (1992-1994 and 1996-1998) data gaps were closed by linear interpolation on district level.

For the year 2009, respective data are used that were derived from the 2010 official agricultural census and the simultaneous survey of agricultural production methods (Landwirtschaftliche Zählung 2010, Statistisches Bundesamt/ Federal Statistical Office) as well as the 2011 survey on manure application practices (Erhebung über Wirtschaftsdüngerausbringung, Statistisches Bundesamt/ Federal Statistical Office). The gaps between the latest RAUMIS model data (1999) and the first official data (2009) were closed by linear interpolation on district level.

For the year 2015, data on techniques of farm manure spreading from the 2016 official agricultural census (Agrarstrukturerhebung 2016, Statistisches Bundesamt / Federal Statistical Office) are used. The gaps between the latest RAUMIS model data (1999) and the first official data (2009) were closed by linear interpolation on district level. For the year 2019 data from the 2020 official agricultural census (Landwirtschaftszählung 2020, LW20) are used for housing systems, storage systems and manure spreading systems. For 2010 to 2018 the housing and storage systems data was linearly interpolated between the censuses of 2010 and 2020.The data on manure spreading techniques was linearly interpolated between the census data from 2009 and 2015, and for 2016 to 2018 between the censuses conducted in 2016 and 2020. In addition, it was taken into account that, as of 2012, slurry spread on bare soil has to be incorporated within four hours.

The data from the 2020 official agricultural census (DESTATIS, 2020)[23)] is being used for subsequent years until more current data is available.

For a description of the RAUMIS data, the data from official surveys and additional data from other sources see Rösemann et al. (2025), Chapter 2.5. Time series of frequency distributions of housing systems, storage systems and application techniques as well as the corresponding emission factors are provided in NID 2025, Chapter 17.3.1.

NH_3 and NO_x

Method

N in manure management

N excretion

In order to determine NH_3 and NO_x emissions from manure management of a specific animal category, the individual N excretion rate must be known as well as, for NH_3, the TAN content of the N excretions. Default excretion rates are provided by IPCC Guidelines and default TAN contents can be found in the EMEP Guidebook, 2023[24)]. However, the German agricultural emission inventory uses N mass balances to calculate the N excretions and the TAN contents of almost all reported animal categories. N mass balance calculations (see below) consider N intake with feed, N retention due to growth, N contained in milk and eggs, and N in offspring. Table 2 presents national means of N excretions and TAN contents. For methodological details and mass balance input data see Rösemann et al. (2025), Chapter 4.2 as well as Chapter 4.1.2.

Table 2: National means of N excretions and TAN contents

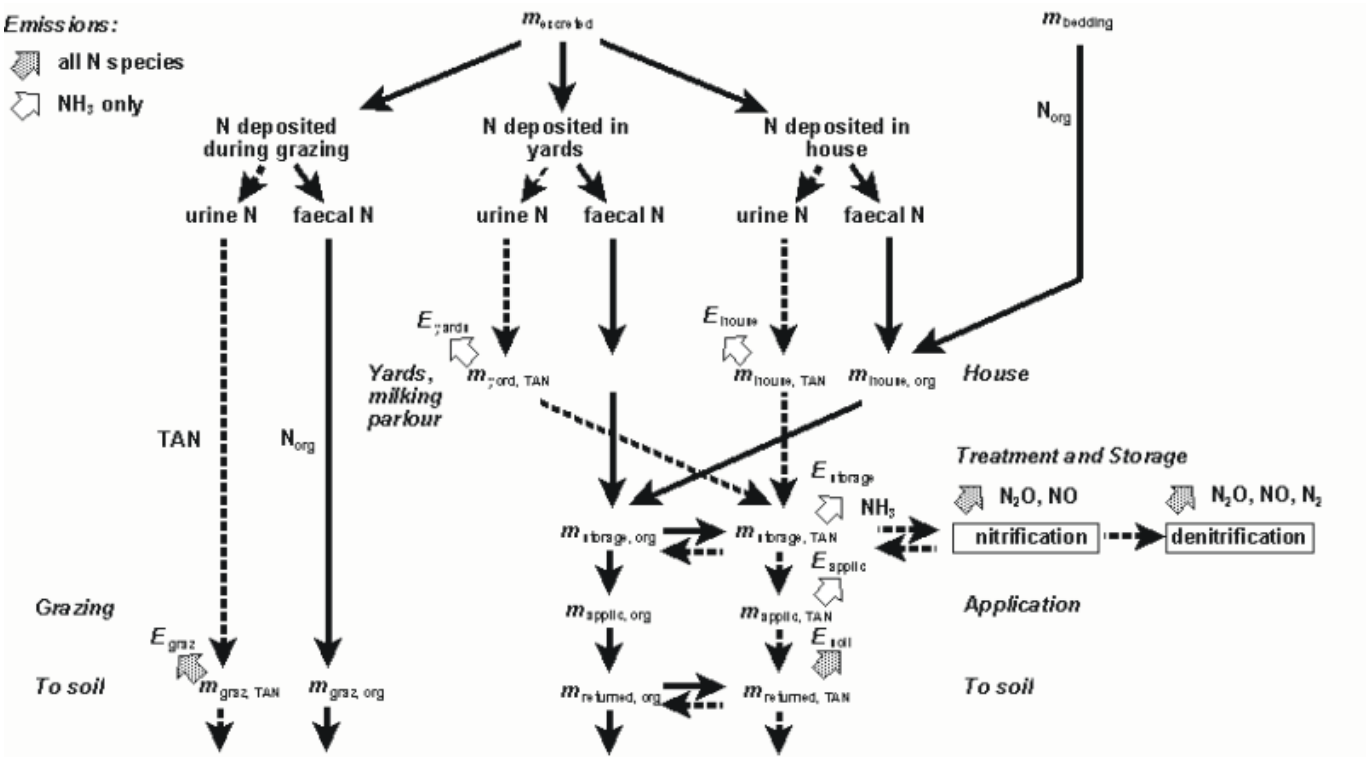
	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
	mean N excretions in kg per animal place													
dairy cattle	92.0	97.9	103.8	108.9	110.2	112.8	114.1	113.8	116.1	119.1	121.4	122.0	121.2	124.6
other cattle	37.9	39.9	41.3	41.2	42.1	42.5	42.5	42.7	42.9	43.4	43.7	43.9	43.9	44.2
horses	48.2	48.1	49.0	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
sheep	7.7	7.7	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
goats	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
swine	13.0	13.4	13.2	13.0	12.8	12.7	12.7	12.6	12.6	12.5	12.4	12.6	12.5	12.6
laying hens	0.81	0.78	0.76	0.79	0.86	0.88	0.89	0.89	0.89	0.89	0.90	0.90	0.90	0.90
broilers	0.48	0.37	0.37	0.36	0.35	0.40	0.40	0.40	0.41	0.40	0.39	0.39	0.40	0.41
turkeys	2.0	2.0	2.0	2.2	2.2	2.3	2.3	2.3	2.2	2.2	2.1	2.1	2.1	2.1
pullets	0.38	0.35	0.32	0.33	0.33	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
ducks	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
geese	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
deer	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
rabbits	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
ostrich	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60
fur animals	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59
	mean TAN contents in %													
dairy cattle	58.0	55.0	53.0	51.3	49.9	48.5	48.2	48.0	47.3	46.9	46.5	46.5	46.6	46.0
other cattle	65.5	65.7	65.7	65.7	66.0	66.3	66.4	66.4	66.4	66.4	66.4	66.3	66.3	66.3
horses	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
sheep	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
goats	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
swine	72.0	71.7	71.1	71.8	72.3	71.6	71.4	71.2	71.1	71.0	70.8	70.9	70.8	70.6
laying hens	70.2	69.6	69.0	69.3	70.0	70.2	70.1	70.1	70.2	70.2	70.1	70.1	70.2	70.3
broilers	60.8	58.9	56.4	53.5	50.0	46.9	46.5	46.1	45.7	45.2	44.8	44.8	44.8	44.8
turkeys	64.7	64.7	63.0	63.9	63.0	63.5	63.5	63.5	63.0	63.0	62.1	62.1	62.1	62.1
pullets	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4
ducks	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9
geese	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
deer	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
rabbits	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
ostrich	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
fur animals	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0

N mass flow and emission assessment

The calculation of the emissions of NH_3, N_2O, NO_x and N_2 from German animal husbandry is based on the so-called N mass flow approach (e. g. Dämmgen and Hutchings, 2008 [25)]). This approach differentiates between N excreted with faeces (organic nitrogen Norg, i. e. undigested feed N) and urine (total ammoniacal nitrogen TAN, i. e. fraction of feed N metabolized). The N flow within the manure management system is treated as depicted in the figure below. This method reconciles the requirements of both the Atmospheric Emission Inventory Guidebook for NH_3 emissions (EMEP, 2023), and the IPCC guidelines for greenhouse gas emissions (IPCC (2006)[26)]. Reidy et al. (2008),[27)], showed for several European countries (Germany, the Netherlands, Switzerland, United Kingdom) that their N-flow based inventory models yielded, in spite of national peculiarities, comparable results as long as standardised data sets for the input variables were used.

Not explicitly shown in the N mass flow scheme is air scrubbing in housing and anaerobic digestion of manure. These issues are separately described further below. Note that emissions from grazing and application are reported in sector 3.D.



General scheme of N flows in animal husbandry

m: mass from which emissions may occur. Narrow broken arrows: TAN (total ammoniacal nitrogen); narrow continuous arrows: organic N. The horizontal arrows denote the process of immobilisation in systems with bedding occurring in the house, and the process of mineralisation during storage, which occurs in any case. Broad arrows denote N-emissions assigned to manure management (E_{yard} NH_3 emissions from yards; E_{house} NH_3 emissions from house; $E_{storage}$ NH_3, N_2O, NO_x and N_2 emissions from storage; E_{applic} NH_3 emissions during and after spreading; E_{graz} NH_3, N_2O, NO_x and N_2 emissions during and

after grazing; E_{soil} N_2O, NO_x and N_2 emissions from soil resulting from manure input).

The model allows tracing of the pathways of the two N fractions after excretion. The various locations where excretion may take place are considered. The partial mass flows through the livestock systems are represented. During storage Norg can be transformed into TAN and vice versa. Both, the way and the magnitude of such transformations may be influenced by manure treatment processes like, e. g., anaerobic digestion where a considerable fraction of Norg is mineralized to TAN. For details see Rösemann et al. (2025), Chapter 4.2. Wherever NH_3 is emitted, its formation is related to the amount of the TAN present. N_2O emissions are related to the total amount of N available (Norg + TAN). NO_x emissions (i. e. NO emissions) are calculated proportionally to the N_2O emissions, see section 'Emission factors'. Note that the N_2O, NO_x and N2 emissions from the various storage systems include the respective emissions from the related housing systems.

Air scrubber systems in swine and poultry housings

For pig and poultry production the inventory model considers the effect of air scrubbing. Data on frequencies of air scrubbing facilities and the removal efficiency are provided by KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft / Association for Technology and Structures in Agriculture) supplemented by data from the 2020 agricultural census. The average removal efficiency of NH_3 is 80 % for swine and 70 % for poultry, while for TSP and PM_{10} the rates are set to 90 % and for $PM_{2.5}$ to 70 % for both animal categories. For swine two types of air scrubbers are distinguished: systems of “first class” that remove both NH_3 and particles, and ”second class” systems that remove only particles reliably and have a NH_3 removal efficiency of 20%.

According to KTBL, 7.6 % of all pig places were equipped with ”first class” systems in 2023, another 12.6 % were equipped with “second class” systems. For poultry 0.9 % of all laying hen places and 2.4 % of all broiler places were equipped with air scrubbers that remove both NH_3 and particles. The amounts of NH_3-N removed by air scrubbing are completely added to the pools of total N and TAN for landspreading. For details see Rösemann et al. (2025), Chapter 4.2.2.

Anaerobic digestion of manure

According to IPCC (2006), anaerobic digestion of manure is treated like a particular storage type. In the German Inventory it comprises three sub-compartments (pre-storage, fermenter and storage of digestates). For details see Rösemann et al. (2025), Chapters 2.6 and 4.2.5. The resulting digestates are considered as liquid. Two different types of digestates storage systems are considered: gastight storage and open tank. For open tanks formation of a natural crust because of co-fermentation with energy crops is taken into account. Furthermore, the modelling of anaerobic digestion and spreading of the digestates takes into account that the amount of TAN in the digestates is higher than in untreated slurry and that the frequencies of spreading techniques differ from those for untreated slurry.

NH_3 and NO emissions occur from pre-storage of solid manure, from non-gastight storage of digestates and from application of digestates (NH_3 emissions and NO emissions from application of digested manure are reported in 3.Da.2.a). There are no such emissions from pre-storage of slurry, from the fermenter and from gastight storage of digestates. Note that NH_3 and NO emissions calculated with respect to the digestion of animal manures do not comprise the contributions by co-digested energy crops. The latter are dealt with separately in 3.D.a.2.c and 3.I.

Emission Factors

Application of the N mass flow approach requires detailed emission factors for NH_3, N_2O, NO_x and N_2 describing the emissions from the various housing and storage systems.

The detailed NH_3 emission factors are, in general, related to the amount of TAN available at the various stages of the N flow chain. The emission factors for laying hens, broilers, pullets, ducks and turkeys are related to N. Most NH_3 emission factors are country-specific but some are taken from EMEP (2023). No specific NH_3 emission factors are known for the application of digested manure. However, due to co-fermentation with energy crops, the viscosity of digested manure resembles that of untreated cattle slurry. Hence, the emission factors for untreated cattle slurry are adopted for the application of digested manure. For the detailed emission factors of livestock husbandry see Rösemann et al. (2025), Chapter 4.3.

The detailed emission factors for N_2O, NO_x and N_2 relate to the amount of N available which is N excreted plus, in case of solid manure systems, N input with bedding material. The N_2O emission factors are taken from IPCC (2006). The emission factors for NO_x and N_2 are approximated as being proportional to the N_2O emission factors, i.e. the NO-N and N_2 emission factors are, respectively, one-tenth and three times the value of the N_2O-N emission factor, see Rösemann et al. (2025),

chapter 4.2.4. This proportionality is also applied to anaerobic digestion of manure, where N_2O emissions occur from pre-storage of solid manure and non-gastight storage of digestates with the emission factors being those used for normal storage of solid manure and the storage of untreated slurry with natural crust provided by IPCC (2006). Note that the inventory model calculates NO rather than NOx. The conversion of NO emissions into NO_x emissions is achieved by multiplying the NO emissions with the NO_2/ NO molar weight ratio of 46/30. This relationship also holds for NO and NO_x emission factors.

Table 3 shows the implied emission factors of NH_3 and NO_x for the various animal categories (housing and storage) These emission factors normalize emissions from an animal category as the ratio of the total emission to the respective number of animals. The overall German NH_3 IEF for manure application is reported in section 3.D.a.2.a.

Table 3: IEF for NH_3 & NO_x from manure management, in [kg per animal place]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Ammonia														
dairy cattle	9.5	9.7	10.4	11.3	11.7	11.9	12.1	12.1	12.3	12.6	12.7	12.7	12.6	12.8
other cattle	5.7	5.8	5.9	6.2	6.6	6.3	6.2	6.2	6.1	6.1	6.1	6.1	6.1	6.1
horses	13.5	13.5	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
sheep	0.83	0.82	0.84	0.83	0.84	0.83	0.83	0.83	0.82	0.83	0.83	0.82	0.82	0.82
goats	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62
swine	4.54	4.44	4.32	4.24	4.05	3.82	3.77	3.72	3.69	3.63	3.59	3.63	3.54	3.54
laying hens	0.213	0.205	0.210	0.208	0.136	0.129	0.128	0.127	0.125	0.124	0.122	0.122	0.121	0.121
broilers	0.143	0.108	0.104	0.098	0.088	0.091	0.091	0.090	0.091	0.089	0.086	0.086	0.085	0.087
turkeys	0.797	0.797	0.800	0.877	0.836	0.848	0.848	0.849	0.825	0.824	0.772	0.773	0.763	0.762
pullets	0.125	0.116	0.106	0.105	0.101	0.094	0.094	0.095	0.096	0.096	0.095	0.097	0.095	0.096
ducks	0.193	0.193	0.193	0.192	0.189	0.182	0.182	0.182	0.182	0.182	0.182	0.183	0.182	0.182
geese	0.386	0.386	0.385	0.384	0.381	0.377	0.377	0.377	0.377	0.377	0.376	0.377	0.376	0.377
deer	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
rabbits	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228
ostrich	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765
fur animals	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123
Nitrogen oxides														
dairy cattle	0.140	0.135	0.147	0.155	0.152	0.142	0.142	0.141	0.143	0.145	0.145	0.143	0.143	0.147
other cattle	0.064	0.068	0.071	0.076	0.079	0.078	0.078	0.078	0.078	0.079	0.079	0.078	0.078	0.078
horses	0.169	0.169	0.172	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171
sheep	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
goats	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
swine	0.014	0.016	0.015	0.016	0.017	0.014	0.014	0.014	0.014	0.013	0.013	0.013	0.013	0.013
laying hens	0.00027	0.00026	0.00025	0.00029	0.00035	0.00035	0.00035	0.00035	0.00034	0.00033	0.00032	0.00031	0.00031	0.00031
broilers	0.00016	0.00012	0.00012	0.00013	0.00014	0.00016	0.00016	0.00016	0.00016	0.00015	0.00014	0.00014	0.00014	0.00015
turkeys	0.00068	0.00068	0.00071	0.00085	0.00094	0.00097	0.00095	0.00094	0.00090	0.00087	0.00080	0.00077	0.00078	0.00078
pullets	0.00013	0.00012	0.00011	0.00012	0.00014	0.00014	0.00014	0.00014	0.00014	0.00013	0.00013	0.00012	0.00012	0.00012
ducks	0.00024	0.00024	0.00024	0.00026	0.00027	0.00028	0.00028	0.00028	0.00027	0.00027	0.00026	0.00025	0.00025	0.00025
geese	0.00025	0.00025	0.00025	0.00028	0.00032	0.00032	0.00031	0.00031	0.00030	0.00029	0.00028	0.00027	0.00027	0.00027
deer	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
rabbits	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269
ostrich	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126
fur animals	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508

Trend discussion for Key Sources

Dairy cattle, other cattle and swine are key sources of NH_3 emissions from manure management. The time series of the total NH_3 emissions from all three categories are predominantly driven by the development of the animal numbers, see Table 1.

However, the effect of decreasing animal numbers is partly compensated by the continuously increasing animal performance. This leads to increasing N excretions per animal, see Table 2, which, in principle, is reflected by increasing implied emission factors, see Table 3. Increasing dairy cattle emissions since 2010 are also due to a sharp decline of tied housing systems, which have a lower NH_3 emission factor than loose housing systems. For swine the IEF is decreasing over time due to lower raw protein contents in feed and the use of air scrubbing systems that, to a high degree, remove NH_3 from the housings.

For NO_x there are no key categories.

Recalculations

All timeseries of the emission inventory have completely been recalculated. Tables 4 and 5 compare the recalculated time series for NH_3 and NO_x from 3B with the respective data of last year's submission.

For NH3 there are two main reasons for very different emissions compared to last year's submission: the new emission factors for housing systems **(recalculation No. 3)** results in significantly lower emissions for cattle housing systems and slightly lower emissions for pig housing systems. The correction of the numbers of horses **(recalculation No. 4)** more than doubles the emissions of the other animals. Many of the other recalculations have much smaller effects, see main page of the agricultural sector). Overall the opposing changes partially cancel each other out and result in slightly higher emissions up to 2014 and slightly lower emissions thereafter compared with last year's submission.

The total emissions of NOx for all years are much higher than those of submission 2024. The main reason for this is the doubling of the N2O emission factors for solid storage systems in IPCC 2019, which results directly in a doubling of the NOx emission factor **(recalculation No. 6)**. Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 4: Comparison of NH_3 emissions [kt] with previous submission

NFR TOTAL EMISSIONS															
	Submission	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Total	**current**	300.67	252.12	248.41	248.80	242.06	237.98	233.87	231.70	224.95	220.40	216.51	208.17	197.88	196.54
	previous	296.69	245.32	244.46	244.89	240.30	238.12	234.24	232.05	225.13	220.64	216.70	208.65	199.17	
	absolute change	3.99	6.79	3.95	3.91	1.76	-0.14	-0.37	-0.36	-0.19	-0.24	-0.19	-0.49	-1.29	
	relative change [%]	1.34	2.77	1.62	1.60	0.73	-0.06	-0.16	-0.15	-0.08	-0.11	-0.09	-0.23	-0.65	
dairy cattle	**current**	60.08	50.88	47.58	47.96	49.01	51.16	50.96	50.81	50.34	50.41	49.61	48.53	48.11	47.56
	previous	62.10	53.93	50.69	51.58	53.29	56.24	56.10	56.02	55.58	55.80	55.01	53.91	53.32	
other cattle	**current**	75.09	61.37	58.84	54.43	57.07	52.45	51.18	49.73	47.86	46.37	45.09	44.10	43.95	43.75
	previous	81.36	66.68	63.90	59.08	61.81	57.39	56.11	54.62	52.67	51.15	49.77	48.75	48.60	
swine	**current**	120.20	90.53	93.99	96.33	90.18	87.72	85.80	85.33	81.27	78.46	77.66	71.70	62.66	62.12
	previous	120.10	90.66	94.17	96.62	90.65	88.38	86.47	86.02	81.94	79.10	78.37	72.37	63.46	
poultry	**current**	23.31	22.67	26.16	28.07	26.00	27.82	27.37	27.17	26.72	26.32	25.23	24.50	23.43	22.93
	previous	22.93	22.33	25.83	27.77	25.78	28.01	27.57	27.36	26.90	26.53	25.48	25.53	25.66	
other animals	**current**	22.00	26.67	21.85	22.00	19.81	18.82	18.56	18.66	18.75	18.84	18.92	19.32	19.73	20.18
	previous	10.21	11.72	9.87	9.84	8.77	8.10	7.99	8.03	8.04	8.06	8.06	8.10	8.14	

Table 5: Comparison of NO_x emissions [kt] with previous submission

NFR TOTAL EMISSIONS															
	Submission	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Totals	**current**	2.403	2.119	2.023	2.014	1.980	1.878	1.848	1.822	1.783	1.750	1.716	1.658	1.619	1.621
	previous	1.734	1.558	1.521	1.514	1.497	1.448	1.434	1.418	1.392	1.376	1.354	1.308	1.272	
	absolute change	0.67	0.56	0.50	0.50	0.48	0.43	0.41	0.40	0.39	0.37	0.36	0.35	0.35	
	relative change [%]	38.55	35.99	32.96	33.03	32.25	29.68	28.90	28.47	28.10	27.17	26.79	26.75	27.29	
dairy cattle	**current**	0.892	0.708	0.672	0.658	0.634	0.607	0.600	0.590	0.585	0.580	0.570	0.549	0.544	0.545
	previous	0.671	0.597	0.570	0.551	0.527	0.518	0.516	0.511	0.510	0.512	0.507	0.493	0.485	

other cattle	**current**	0.843	0.726	0.711	0.668	0.684	0.652	0.642	0.630	0.613	0.600	0.582	0.565	0.561	0.558
	previous	0.690	0.604	0.587	0.551	0.554	0.548	0.546	0.540	0.531	0.525	0.510	0.497	0.495	
swine	**current**	0.360	0.319	0.332	0.372	0.367	0.332	0.322	0.318	0.300	0.286	0.281	0.258	0.224	0.222
	previous	0.281	0.256	0.270	0.313	0.317	0.283	0.275	0.270	0.254	0.242	0.240	0.222	0.195	
poultry	**current**	0.026	0.025	0.029	0.034	0.042	0.048	0.047	0.047	0.046	0.044	0.042	0.040	0.040	0.039
	previous	0.026	0.025	0.028	0.034	0.042	0.046	0.046	0.046	0.045	0.045	0.044	0.043	0.044	
other animals	**current**	0.282	0.340	0.279	0.281	0.253	0.240	0.236	0.238	0.239	0.240	0.241	0.246	0.251	0.257
	previous	0.067	0.076	0.065	0.064	0.057	0.053	0.052	0.052	0.052	0.052	0.052	0.053	0.053	

Planned improvements

No improvements are planned at present.

NMVOC

In 2023, NMVOC emissions from manure management amount to 292.1 kt which is 96.9 % of total NMVOC emissions from the agricultural sector. 84.2 % thereof originate from cattle, 15.8 % from other animals.

Method

The Tier 2 methodology provided by EMEP (2023)-3B-26 was used to assess the NMVOC emissions from manure management for dairy cattle and other cattle. For all other animals the Tier 1 methodology (EMEP (2023)-3B-17) was used. The use of the Tier 2 methodology yields NMVOC emissions which formally could be reported in the sectors 3.D.a.2.a (application of manure to soils) and 3.D.a.3 (grazing emissions). However, to be congruent with the NMVOC emissions for other animal categories, Germany reports these emissions in the NMVOC emissions reported from manure management (3.B). For the NFR codes 3.D.a.2.a and 3.D.a.3 the key note IE is used for NMVOC emissions.

Activity data

Animal numbers serve as activity data, see Table 1.

Emission factors

For the Tier 2 methodology applied to dairy cattle and other cattle the following data was used:

- gross feed intake in MJ per year, country specific data from the annual reporting of greenhouse gas emissions, see NID 2025, Chapter 5.1.3.3,
- proportion x_{house} of the year the animals spend in the livestock building: country specific data, being equal to 1 – x_{graz} with x_{graz} the proportion of the year spent on pasture, see NID 2025, Chapter 17.3.1,
- $FRAC_{silage}$: 1 as proposed by EMEP (2023)-3B-27, since silage feeding for cattle is considered dominant in Germany
- $FRAC_{silage\ store}$: 0.25 as proposed by EMEP (2023)-3B-27 for European conditions
- $EF_{NMVOC,\ silage_feeding}$, $EF_{NMVOC,\ house}$, $EF_{NMVOC,\ graz}$ are taken from EMEP (2023)-3B-31, table 3.11 as 0.0002002, 0.0000353 and 0.0000069 kg NMVOC/MJ feed intake, respectively,
- $EF_{NH_3,storage}$, $EF_{NH_3,building}$ and $EF_{NH_3,application}$ are taken from the NH_3 reporting (see above and 3.D).

For all other animal categories the Tier 1 emission factors for NMVOC were used as provided in EMEP (2023)-3B-17, Table 3.4. For horses the emission factors for feeding with silage was chosen, for all other animals the emission factors for feeding without silage. Due to missing country-specific emission factors or emission factors that do not correspond to the inventory's animal categories, the emission factors provided in EMEP (2023)-3B-17, Table 3.4, were used to define specific emission factors for weaners, boars, lambs, ponies/light horses and pullets, ostriches, and deer see Rösemann et al. (2025), Chapter 4.3.3. The implied emission factors given in Table 4 relate the overall NMVOC emissions to the number of animals in each animal category. The IEFs for dairy cattle and other cattle are much higher than the EMEP Tier 1 EF, which are 17.937 kg NMVOC for dairy cattle and 8.902 kg NMVOC for other cattle. The only possible explanation for those huge differences is that the EMEP Tier 2 and Tier 1 methods are not consistent.

The IEFs for the other categories provided in Table 4 correspond to the EMEP Tier 1 emission factors, except for horses, sheep and swine. These categories comprise subcategories with different emission factors so that their overall IEFs in Table 4 represent subpopulation-weighted national mean values. Note that other poultry in Germany includes not only geese and ducks but also pullets. For pullets no default EF is given in the EMEP guidebook (EMEP, 2023), hence the EF of broilers has been adopted (because of similar housing). This assumption significantly lowers the overall IEF of other poultry in Table 4 the IEFs are listed separately for each poultry category). The IEF of the sheep category is significantly lower than the EMEP Tier 1 emission factor, because for lambs the EF is assumed to be 40% lower compared to an adult sheep in accordance with the difference in N excretion between lambs and adult sheep.

Table 6: IEF for NMVOC from manure management, in [kg NMVOC per animal place]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
dairy cattle	32.381	34.560	37.506	38.686	39.301	40.134	40.491	40.392	41.163	41.941	42.488	42.615	42.331	43.425
other cattle	12.399	12.297	12.406	12.250	12.240	11.898	11.818	11.780	11.757	11.781	11.842	11.923	11.899	11.915
horses	6.497	6.491	6.688	6.660	6.644	6.646	6.648	6.651	6.654	6.657	6.660	6.659	6.658	6.657
sheep	0.131	0.131	0.132	0.132	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131
goats	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542
swine	0.695	0.698	0.690	0.682	0.669	0.651	0.649	0.648	0.648	0.648	0.642	0.645	0.643	0.644
laying hens	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165
broilers	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
turkeys	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
pullets	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
ducks	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
geese	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
deer	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
rabbits	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
ostrich	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
fur animals	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941

Trend discussion for Key Sources

Dairy cattle and other cattle are key sources of NMVOC emissions from manure management. The total NMVOC emissions from both animal categories strongly correlate with the animal numbers given in Table 1 (dairy cattle: $R^2 = 0.89$; other cattle: $R^2 = 0.99$).

Recalculations

All timeseries of the emission inventory have completely been recalculated. Table 7 compares the recalculated time series of the NMVOC emissions from 3.B with the respective data of last year's submission. The recalculated total emissions are higher. For dairy cattle and other cattle emissions are higher due to changes of NH3 emissions which have impact on the Tier 2 methodology which is applied for cattle NMVOC emissions. For other animals the emissions are also higher. This is largely due to the correction of horse headcounts (**recalculation No. 4**). The new animal numbers for poultry and goats in 2021 and 2022 (**recalculation No. 15**) have a smaller effect., see main page of the agricultural sector). Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 7: Comparison of NMVOC emissions [kt] with previous submission

NFR TOTAL EMISSIONS															
	Submission	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Total	**current**	415.22	357.45	342.28	320.98	320.35	322.59	318.93	315.55	311.20	307.95	303.73	297.43	293.26	292.11
	previous	391.38	333.81	320.75	300.65	301.28	304.35	301.05	297.97	293.90	290.92	287.04	281.57	278.18	
	absolute change	23.85	23.64	21.52	20.33	19.07	18.24	17.88	17.57	17.30	17.03	16.69	15.87	15.07	
	relative change [%]	6.09	7.08	6.71	6.76	6.33	5.99	5.94	5.90	5.89	5.85	5.82	5.63	5.42	
dairy cattle	**current**	205.77	180.73	171.39	163.89	164.40	171.96	170.78	169.61	168.80	168.25	166.61	163.33	161.27	161.23
	previous	196.60	170.95	161.94	154.86	155.76	163.45	162.41	161.42	160.76	160.36	158.93	155.86	153.87	

other cattle	**current**	162.85	131.10	123.68	107.80	105.62	99.36	97.49	95.21	92.27	89.86	87.40	85.93	85.52	84.87
	previous	153.85	124.43	117.46	102.42	100.55	94.85	93.11	91.00	88.24	85.98	83.68	82.29	81.92	
other animals	**current**	46.61	45.63	47.21	49.29	50.33	51.27	50.67	50.73	50.12	49.83	49.72	48.17	46.47	46.01
	previous	40.93	38.42	41.36	43.36	44.96	46.05	45.53	45.55	44.91	44.58	44.43	43.42	42.39	

Planned improvements

No improvements are planned at present.

Particle emissions

In 2022, **TSP** emissions from manure management amount to 64.4 % of total emissions from the agricultural sector. Of these emissions 24.7 % originate from cattle, 32.0 % from pigs, and 42.6 % from poultry.

36.6 % of total **PM_{10}** emissions from the agricultural sector are caused by manure management, where 35.7 % originate from cattle, 14.6 % from pigs, and 48.7 % from poultry.

68.6 % of total **$PM_{2.5}$** emissions from the agricultural sector are caused by manure management, where 78.0 % originate from cattle, 2.3 % from pigs, and 18.0 % from poultry.

Method

EMEP (2013-3B-26) provided a Tier 2 methodology. In the 2023 Guidebook (EMEP, 2019), this methodology has been replaced by a Tier 1 methodology. However, EF for cattle derived with the EMEP 2013 Tier 2 methodology remained unchanged. Therefore, the EMEP 2013[28)] methodology was kept for cattle. For swine the EMEP 2013 methodology was formally kept but the EMEP 2019 Tier 1 EF was used both for slurry and solid based manure management systems. The same was done with the EMEP 2016 EFs for laying hens (used for cages and perchery). In case the EMEP 2023 EFs are simply rounded EMEP 2013 EFs, the unrounded EMEP 2013 EFs were kept. For rabbits the EFs from The Netherlands' inventory were adopted (Huis In't Veld et al, 2011)[29)], for ostriches the EFs of goats were used. The inventory considers air scrubber systems in swine and poultry husbandry. For animal places equipped with air scrubbing the emission factors are reduced according to the removal efficiency of the air scrubber systems (90 % for TSP and PM_{10}, 70 % for $PM_{2.5}$). For details see Rösemann et al. (2025), Chapter 4.2.2.

Activity data

Animal numbers serve as activity data, see Table 1.

Emission factors

Tier 1 emission factors for TSP, PM_{10} and $PM_{2.5}$ from livestock husbandry are provided in EMEP (2023)-3B-18, Table 3.5 and 55, Table A1.7. For cattle the Tier 2 emission factors provided in EMEP (2013)-3B-29, Table 3-11 were used, because they differentiate between slurry and solid manure systems and were also used to develop the EMEP 2023 Tier 1 emissions factors. They are also provided in EMEP (2023)-3B-53, Table A1.7.

The implied emission factors given in Table 5 relate the overall TSP and PM emissions to the number of animals in each animal category. The Guidebook does not indicate whether EFs have considered the condensable component (with or without).

Table 8: IEF for TSP, PM_{10} & $PM_{2.5}$ from manure management

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Total suspended particles (TSP)														
dairy cattle	1.2124	1.4016	1.4542	1.4727	1.4969	1.5360	1.5455	1.5541	1.5630	1.5721	1.5721	1.5723	1.5722	1.5723
other cattle	0.5194	0.5107	0.5014	0.4903	0.4798	0.4762	0.4759	0.4756	0.4755	0.4748	0.4746	0.4750	0.4755	0.4744
horses	0.3514	0.3512	0.3558	0.3552	0.3548	0.3549	0.3549	0.3550	0.3551	0.3551	0.3552	0.3552	0.3551	0.3551

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
sheep	0.0484	0.0478	0.0489	0.0486	0.0489	0.0482	0.0482	0.0482	0.0480	0.0482	0.0482	0.0481	0.0478	0.0480
goats	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914
swine	0.8260	0.8366	0.8320	0.8218	0.7929	0.7505	0.7455	0.7391	0.7317	0.7217	0.7243	0.7069	0.6880	0.6885
laying hens	0.1898	0.1898	0.1890	0.1881	0.1869	0.1856	0.1853	0.1854	0.1846	0.1841	0.1838	0.1835	0.1830	0.1828
broilers	0.0400	0.0400	0.0400	0.0400	0.0400	0.0399	0.0397	0.0396	0.0395	0.0394	0.0394	0.0392	0.0392	0.0391
turkeys	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100
pullets	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400
ducks	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400
geese	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400
deer	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
rabbits	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107
ostrich	0.0278	0.0278	0.0278	0.0278	0.0278	0.0278	0.0278	0.0278	0.0278	0.0278	0.0278	0.0278	0.0278	0.0278
fur animals	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180
PM_{10}														
dairy cattle	0.5557	0.6426	0.6667	0.6752	0.6862	0.7042	0.7086	0.7125	0.7166	0.7208	0.7208	0.7209	0.7208	0.7209
other cattle	0.2403	0.2363	0.2320	0.2267	0.2218	0.2201	0.2200	0.2199	0.2198	0.2195	0.2194	0.2196	0.2198	0.2193
horses	0.1619	0.1619	0.1639	0.1636	0.1634	0.1634	0.1635	0.1635	0.1635	0.1635	0.1636	0.1636	0.1636	0.1635
sheep	0.0194	0.0192	0.0196	0.0195	0.0196	0.0193	0.0193	0.0193	0.0192	0.0193	0.0193	0.0193	0.0192	0.0192
goats	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368
swine	0.1241	0.1255	0.1244	0.1225	0.1173	0.1099	0.1088	0.1079	0.1068	0.1053	0.1051	0.1029	0.1001	0.1001
laying hens	0.0400	0.0399	0.0398	0.0396	0.0393	0.0391	0.0390	0.0390	0.0389	0.0388	0.0387	0.0386	0.0385	0.0385
broilers	0.0200	0.0200	0.0200	0.0200	0.0200	0.0199	0.0198	0.0198	0.0198	0.0197	0.0197	0.0196	0.0196	0.0196
turkeys	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100
pullets	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
ducks	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400
geese	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400
deer	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
rabbits	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107
ostrich	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112
fur animals	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0000	0.0000	0.0000	0.0000
$PM_{2.5}$														
dairy cattle	0.3616	0.4181	0.4338	0.4393	0.4465	0.4582	0.4610	0.4636	0.4663	0.4690	0.4690	0.4690	0.4690	0.4690
other cattle	0.1574	0.1548	0.1520	0.1487	0.1456	0.1444	0.1443	0.1442	0.1442	0.1440	0.1439	0.1440	0.1442	0.1439
horses	0.1027	0.1026	0.1039	0.1038	0.1036	0.1037	0.1037	0.1037	0.1037	0.1037	0.1038	0.1037	0.1037	0.1037
sheep	0.0059	0.0059	0.0060	0.0060	0.0060	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059
goats	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112
swine	0.0056	0.0057	0.0056	0.0055	0.0053	0.0050	0.0050	0.0049	0.0049	0.0049	0.0048	0.0048	0.0047	0.0047
laying hens	0.0030	0.0030	0.0030	0.0030	0.0030	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029
broilers	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
turkeys	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
pullets	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
ducks	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180
geese	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320
deer	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
rabbits	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021
ostrich	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034
fur animals	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0000	0.0000	0.0000	0.0000

Trend discussion for Key Sources

Swine and laying hens are key sources of TSP emissions from manure management. The total TSP emissions from swine mainly follow the animal numbers given in Table 1 for the earlier years of the time series. However, due to increases in places equipped with air scrubbing and different emission factors of the different housing systems of the four swine subcategories (sows with piglets, weaners, fattening pigs, boars) and the varying population shares in those housing systems the R^2 of the linear regression is lower than 1 (0.75). For laying hens (R^2 = 0.98) and broilers (R^2 = 0.99), due to the

low prevalence of air scrubbing systems TSP emissions almost perfectly correlate with the animal numbers provided in Table 1.

Recalculations

The following table 9 shows the effects of recalculations on emissions of particulate matter. Visible differences occur in every year, these are largely due to the correction of the numbers of horses (**recalculation No. 4**). The new animal numbers for poultry and goats in 2021 and 2022 (**recalculation No. 15**) shows a smaller effect. See main page of the agricultural sector. Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 9: Comparison of particle emissions (TSP, PM_{10} & $PM_{2.5}$)[kt] with previous submission

	Submission	1990	1995	2000	2005	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Total Suspended Particles (TSP)	**current**	50.36	43.31	44.13	43.37	42.70	43.91	43.57	43.54	42.51	41.80	41.67	39.63	37.71	37.32
	previous	50.06	42.92	43.82	43.05	42.42	43.63	43.28	43.25	42.22	41.52	41.37	39.59	38.05	
	absolute change	0.31	0.39	0.31	0.32	0.29	0.28	0.28	0.28	0.29	0.28	0.29	0.04	-0.34	
	relative change [%]	0.61	0.91	0.71	0.73	0.68	0.65	0.65	0.65	0.68	0.68	0.71	0.11	-0.89	
PM_{10}	**current**	14.50	13.12	13.25	13.09	13.32	13.60	13.42	13.37	13.12	12.93	12.79	12.32	11.91	11.69
	previous	14.36	12.94	13.11	12.94	13.19	13.48	13.30	13.24	12.99	12.80	12.66	12.34	12.12	
	absolute change	0.14	0.18	0.14	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.13	-0.02	-0.21	
	relative change [%]	0.99	1.39	1.09	1.12	1.00	0.96	0.96	0.97	0.99	1.01	1.04	-0.18	-1.70	
$PM_{2.5}$	**current**	5.11	4.61	4.32	4.04	4.03	4.10	4.05	4.03	3.95	3.88	3.79	3.70	3.66	3.58
	previous	5.02	4.50	4.22	3.95	3.95	4.02	3.97	3.94	3.87	3.79	3.71	3.64	3.62	
	absolute change	0.09	0.11	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.06	0.04	
	relative change [%]	1.79	2.53	2.15	2.34	2.12	2.02	2.02	2.05	2.10	2.16	2.22	1.70	1.07	

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

Uncertainty

Details are described in chapter 1.7.

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3.D - Agricultural Soils

Short description

NFR-Code	Name of Category	Method	AD	EF
3.D	**Agricultural Soils**			
consisting of / including source categories				
3.D.a.1	Inorganic N-fertilizers (includes also urea application)	T2 (NH_3), T1 (NO_x)	NS, RS	D (NH_3), D (NO_x)
3.D.a.2.a	Animal manure applied to soils	T2, T3 (NH_3), T1 (NO_x)	M	CS (NH_3), D (NO_x)
3.D.a.2.b	Sewage sludge applied to soils	T1 (NH_3, NO_x)	NS, RS	D (NH_3), D (NO_x)
3.D.a.2.c	Other organic fertilisers applied to soils (including compost)	T2 (NO_x, NH_3)	M	CS
3.D.a.3	Urine and dung deposited by grazing animals	T1 (NH_3, NO_x)	NS, RS	D
3.D.a.4	Crop residues applied to soil	T2 (NH_3)	NS, RS	D
3.D.c	Farm-level agricultural operations including storage, handling and transport of agricultural products	T2 (TSP, PM_{10}, $PM_{2.5}$)	NS, RS	D
3.D.d	Off-farm storage, handling and transport of bulk agricultural products	NA & NR (Black Carbon only)		
3.D.e	Cultivated crops	T2 (NMVOC)	NS, RS	D
3.D.f	Use of pesticides	T2 (HCB)	NS	D

	NO_x	**NMVOC**	SO_2	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	CO	Heavy Metals	PAHs	**HCB**	PCBs
3.D.a.1	**L/T**	NA	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.a	**L/-**	IE	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.b	-/-	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.c	-/-	NA	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.3	-/-	IE	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.4	NA	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.c	NA	NA	NA	NA	**L/-**	**L/-**	**L/-**	NA	NA	NA	NA	NA	NA
3.D.e	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.f	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**-/-**	NA

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific

PS	Plant Specific
M	Model / Modelled
C	Confidential

Country specifics



NH_3 and NO_x

In 2023, agricultural soils emitted 328.7 kt NH_3 or 62.4 % of the total agricultural NH_3 emissions in Germany (527.0 kt NH_3). The main contributions to the total NH_3 emissions from agricultural soils are the application of manure (3.D.a.2.a), with 185.0 kt (56.3 %), the application of synthetic N-fertilizers (3.D.a.1) with 61.8 kt (18.8 %), and the application of other organic N-fertilizers (3.D.a.2.c) with 58.4 kt (17.8 %).

N excretions on pastures (3.D.a.3) have a share of 15.1 kt NH_3 (4.6 %), emissions from crop residues (3.D.a.4) are 6.9kt NH_3 (2.1 %), and the application of sewage sludge (3.D.a.2.b) 1.6 kt NH_3 (0.5 %).

In 2023, agricultural soils were the source of 98.3 % (97.8 kt) of the total of NO_x emissions in the agricultural category (99.5 kt). The NO_x emissions from agricultural soils are primarily due to application of inorganic fertilizer (3.D.a.1) (40.9 kt) and manure (3.D.a.2.a) (36.7 kt) Application of other organic N-fertilizers (3.D.a.2.c) contributes 14.6 kt, 5.2 kt are due to excretions on pastures (3.D.a.3). Emissions from application of sewage sludge (3.D.a.2.b) contribute 0.5 kt.

NMVOC

In 2023, the category of agricultural soils contributed 9.2 kt NMVOC or 3.1 % to the total agricultural NMVOC emissions in Germany (301.3 kt NMVOC). The only emission source was cultivated crops (3.D.e).

TSP, PM_{10} & $PM_{2.5}$

In 2023, agricultural soils contributed, respectively, 38.8 % (23.7 kt), 67.0 % (23.7 kt) and 33.7 % (1.8 kt) to the total agricultural TSP, PM_{10} and $PM_{2.5}$ emissions (61.0 kt, 35.4 kt, 5.4 kt, respectively). The emissions are reported in category 3.D.c (Farm-level agricultural operations including storage, handling and transport of agricultural products).

3.D.a.1 - Inorganic N-fertilizers

The calculation of NH_3 and NO_x (NO) emissions from the application of synthetic fertilizers is described in Vos et al. (2024),

Chapters 5.2.1.2 and 5.2.2.2 1)[1)].

Activity Data

German statistics report the amounts of fertilizers sold which are assumed to equal the amounts that are applied. Since the 2021 submission, storage effects are approximated by applying a moving average to the sales data (moving centered three-year average, for the last year a weighted two-year average, which assigns 2/3 of the weight to the last year). Since the year 2022, data for the sales of urea that is stabilized with urease inhibitor is available. It cannot be published because of data-privacy issues. Therefore, the emissions are calculated and provided by the federal statistical office using the emission factors as described below. The activity data are published in aggregate for urea, urea+inhibitor and nitrogen solutions to maintain confidentiality. For details see Rösemann et al. (2025), Chapter 2.8.

Table 1: AD for the estimation of NH_3 and NO_x emissions from application of synthetic fertilizers

Application of inorganic fertilizers in [Gg N]														
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Application of fertilizers (total)	2,195	1,723	1,922	1,797	1,635	1,736	1,731	1,622	1,499	1,404	1,327	1,245	1,123	1,037
calcium ammonium nitrate	1,368	1,044	982	824	689	618	605	571	543	520	497	470	422	385
urea and ammonia nitrate urea solutions (AHL)	369	403	508	526	542	590	604	539	460	385	342	318	293	282
ammonium phosphates	85	55	66	55	64	84	82	77	65	64	58	51	41	35
other NK and NPK	246	162	175	126	63	67	62	54	52	51	51	47	40	35
other straight fertilizers	127	60	191	266	277	377	377	381	378	383	379	359	328	300

Methodology

NH_3 emissions from the application of synthetic fertilizers are calculated using the Tier 2 approach according to EMEP (2023)-3D-16ff [30)], distinguishing between various fertilizer types, see Table 2. For NO_x, the Tier 1 approach described in EMEP (2023) [10]-3D-15 is applied.

Emission factors

The emission factors for NH_3 depend on fertilizer type, see EMEP (2023)-3D-17. Table 2 lists the EMEP emission factors for the fertilizers used in the inventory. In order to reflect average German conditions, the emission factors for cool climate and a pH value lower than 7 was chosen. For urea fertilizer the German fertilizer ordinance prescribes the use of urease inhibitors or the immediate incorporation into the soil from 2020 onwards. The NH_3 emission factor for urea fertilizers is therefore reduced by 70% from 2020 onwards for the immediate incorporation of urea, according to Bittman et al. (2014, Table 15)[31)]. For the use of urease inhibitors the emission factor for urea fertilizer is reduced by 60%. For details see Rösemann et al. (2025)[32)], Chapter 5.2.1.2.

Table 2: Synthetic fertilizers, emission factors in kg NH_3 per kg fertilizer N

Fertilizer type	**EF**
calcium ammonium nitrate	0.024
ammonia nitrate urea solutions (AHL)	0.087
urea (up to 2019)	0.195
urea (from 2020 with urease inhibitor)	0.078
urea (from 2020 if incorporated)	0.0585
ammonium phosphates	0.084
other NK and NPK	0.084
other straight fertilizers	0.084

For NO_x, the simpler methodology by EMEP (2023)-3D-13 was used. The emission factor 0.040 from EMEP, 2023-3D, Table 3.1 has the unit of [kg N_2O per kg fertilizer N] and was derived from [33)].

The German inventory uses the emission factor 0.012 kg NO-N per kg N derived from Stehfest and Bouwman (2006) directly. This is equivalent to an emission factor of 0.03943 kg NO_x per kg fertilizer N (obtained by multiplying 0.012 kg NO-N per kg N with the molar weight ratio 46/14 for NO_2: NO). The inventory uses the unrounded emission factor.

Table 3: Emission factor for NO_x emissions from fertilizer application

Emission factor	kg NO-N per kg fertilizer N	kg NO_x per kg fertilizer N
EF_{fert}	0.012	0.039

Trend discussion for Key Sources

Since 2016, fertilizer sales have fallen dramatically (by around a third). Emissions have fallen accordingly. This is even more pronounced for NH_3 than for NO_x, as total NH_3 from the application of mineral fertilizers is, until the year 2019, very strongly correlated with the amount of urea applied ($R^2 = 0.72$), the sales of which have decreased more than for all other mineral fertilizers. Since 2020 the negative trend is reinforced as urea fertilizer have to be either used with urease inhibitors or have to be incorporated into the soil directly, which reduces emissions.

Recalculations

Table REC-1 shows the effects of recalculations on NH_3 and NO_x emissions. The enormous differences for NH_3 emissions are due to the use of the new EMEP (2023)[34)] emission factors (**recalculation No. 1**). Concerning NO_x, emissions differences only occur in 2022, resulting from applying the moving average to sales data (see activity data).

Table 4: Comparison of NH_3 and NO_x emissions [kt] with previous submission

NH3 and NOx emissions from fertilizer application, in Gg															
	Submission	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Ammonia	current	129.55	102.80	130.65	134.39	136.77	155.61	157.68	144.31	128.19	114.66	77.56	73.59	67.18	61.79
	previous	78.71	69.55	85.64	86.36	88.43	97.89	99.73	89.25	76.79	65.63	36.64	35.02	33.44	
	absolute change	50.83	33.25	45.01	48.03	48.34	57.73	57.95	55.06	51.40	49.03	40.92	38.57	33.73	
	relative change [%]	64.58	47.80	52.56	55.62	54.66	58.97	58.10	61.69	66.94	74.71	111.70	110.13	100.87	
Nitrogen oxides	current	86.53	67.93	75.77	70.84	64.48	68.46	68.24	63.95	59.11	55.34	52.31	49.08	44.29	40.89
	previous	86.53	67.93	75.77	70.84	64.48	68.46	68.24	63.95	59.11	55.34	52.31	49.08	45.46	
	absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1.18	
	relative change [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2.59	

Planned improvements

No improvements are planned at present.

3.D.a.2.a - Animal manure applied to soils

In this sub-category Germany reports the NH_3 and NO_x (NO) emissions from application of manure (including application of anaerobically digested manure). An overview is given in Rösemann et al. (2025)[35)], Chapters 5.2.1.2 and 5.2.2.2. Germany uses the Tier 2 methodology for estimating NMVOC emissions for cattle in sector 3.B (manure management). The use of this methodology yields NMVOC emissions which formally could be reported in the sectors 3.D.a.2.a and 3.D.a.3 (grazing emissions). However, to be congruent with the NMVOC emissions for other animal categories, Germany reports these emissions in the NMVOC emissions reported from manure management (3.B). For the NFR codes 3.D.a.2.a and 3.D.a.3 the notation key IE is used for NMVOC emissions.

Activity data

The calculation of the amount of N in manure applied is based on the N mass flow approach (see 3.B). It is the total of N excreted by animals in the housing and the N imported with bedding material minus N losses by emissions of N species from housing and storage. Hence, the amount of total N includes the N contained in anaerobically digested manures to be applied to the field.

The frequencies of application techniques and incorporation times as well as the underlying data sources are described in Rösemann et al. (2025) [36)], Chapter 2.5. The frequencies are provided. in the NID 2025[37)], Chapter 17.3.1.

Table 5: AD for the estimation of NH_3 and NO_x emissions from application of manure

Application of manure in [kt N]													
1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
1,165	1,032	1,007	978	980	1,020	1,014	1,010	996	989	980	956	930	930

Methodology

NH_3 emissions from manure application are calculated separately for each animal species in the mass flow approach by multiplying the respective TAN amount with NH_3 emission factors for the various manure application techniques. For details see [3-b-manure-management 3.B] and Rösemann et al. (2025)[38)], Chapter 5.2.1.2. For NO_x emissions from manure application the inventory calculates NO-N emissions (see Rösemann et al. (2025) [39)], Chapter 5.2.2.2, that are subsequently converted into NO_x emissions by multiplying with the molar weight ratio 46/14. The Tier 1 approach for the application of synthetic fertilizer as described in EMEP (2023)-3D-13 is used.

Emission factors

The following table shows the time series of the overall German NH_3 IEF defined as the ratio of total NH_3-N emission from manure application to the total amount of N spread with manure.

Table 6: IEF for NH_3–N from application of manure

IEF in [kg NH3-N per kg N in applied manure]													
1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
0.227	0.212	0.204	0.190	0.183	0.174	0.172	0.170	0.167	0.165	0.161	0.162	0.165	0.164

Trend discussion for Key Sources

Both NH_3 and NO_x emissions from the application of animal manures are key sources. Total NO_x is calculated proportionally to the total N in the manures applied which decreased remarkably from 1990 to 1991 due to the decline in animal numbers following the German reunification (reduction of livestock numbers in Eastern Germany). In the 1990s and 2000s this was followed by a weakened decline in animal manure amounts. From 2010 to 2014 there was a slight increase and since then the amount of N in manure applied has been declining again, see Table 6. The NO_x emissions follow these trends. For total NH_3 emissions there is a negative trend. This is due to the decreasing amounts of animal manures and the increasing use of application practices with lower NH_3 emission factors.

Recalculations

For all years, the total emissions of NH_3 and NO_x from application of manure are slightly higher than those of last year's submission.

These differences are predominantly caused by a higher estimate of manure N, which is applied, compared to the last submission. Many of the recalculations have an effect on this. The two most important ones are **No. 3** (lower NH_3 emission factors for cattle and pig housing result in more N available for spreading) and **No. 4** (correction of horse numbers by a factor of 2.75), both of which increase emissions see main page of the agricultural sector, list of recalculation reasons. Further details on recalculations are described in Rösemann et al. (2025) [40)], Chapter 1.3.

Table 7: Comparison of NH_3 and NO_x emissions [kt] with previous submission

	Submission	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**

	Submission	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Ammonia	current	320.57	265.78	249.01	225.69	217.80	215.60	211.87	208.09	202.39	197.93	192.18	188.44	185.70	185.00
	previous	286.21	232.97	220.16	199.38	193.95	191.94	188.84	185.61	180.61	176.70	171.37	168.12	165.79	
	absolute change	34.37	32.82	28.85	26.31	23.85	23.66	23.03	22.48	21.79	21.23	20.81	20.31	19.91	
	relative change [%]	12.01	14.09	13.11	13.20	12.30	12.33	12.20	12.11	12.06	12.02	12.15	12.08	12.01	
Nitrogen oxides	current	45.94	40.69	39.69	38.54	38.63	40.23	39.98	39.81	39.26	38.98	38.66	37.68	36.65	36.65
	previous	44.59	38.90	38.23	37.05	37.25	38.81	38.57	38.39	37.83	37.52	37.19	36.22	35.22	
	absolute change	1.35	1.79	1.46	1.49	1.38	1.42	1.41	1.42	1.43	1.46	1.47	1.46	1.43	
	relative change [%]	3.04	4.60	3.83	4.02	3.72	3.66	3.65	3.70	3.79	3.88	3.95	4.02	4.06	

Planned improvements

No improvements are planned at present.

3.D.a.2.b – Sewage sludge applied to soils

The calculation of NH_3 and NO_x (NO) emissions from application of sewage sludge is described in Rösemann et al. (2025) [41)], Chapters 5.2.1.2 and 5.2.2.2.

Activity data

N quantities from application of sewage sludge were calculated from data of the German Environment Agency and (since 2009) from data of the Federal Statistical Office.

Table 8: AD for the estimation of NH_3 and NO_x emissions from application of sewage sludge

Application of sewage sludge in [kt N]													
1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
27	35	33	27	26	19	19	14	13	16	14	12	12	12

Methodology

A Tier 1 methodology is used (EMEP, 2023, 3D, Chapter 3.3.1). NH_3 and NO_x emissions are calculated by multiplying the amounts of N in sewage sludge applied with the respective emission factors.

Emission factors

EMEP (2023)-3.D, Table 3-1 provides a Tier 1 emission factor for NH_3 (0.13 kg NH_3 per kg N applied) emissions from application of sewage sludge. The German inventory uses the equivalent emission factor in NH_3-N units which is 0.11 kg NH_3-N per kg N applied (cf. the derivation of the emission factor described in the appendix of EMEP (2023)-3D, page 35). For NO_x the same emission factor like for the application of synthetic fertilizer was used (see Table 3).

Trend discussion for Key Sources

NH_3 and NO_x emissions from the application of sewage sludge are no key sources.

Recalculations

There were no recalculations concerning sewage sludge except the replacement of extrapolated activity data in 2022 with

data from the Federal Statistical Office. Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 9: Comparison of NH_3 and NO_x emissions [kt] with previous submission

	Submission	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Ammonia	**current**	3.66	4.71	4.40	3.66	3.51	2.52	2.51	1.87	1.78	2.14	1.85	1.61	1.61	1.61
	previous	3.66	4.71	4.40	3.66	3.51	2.52	2.51	1.87	1.78	2.14	1.85	1.61	1.61	
	absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	
	relative change [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	
Nitrogen oxides	**current**	1.08	1.39	1.30	1.08	1.04	0.74	0.74	0.55	0.52	0.63	0.55	0.47	0.48	0.48
	previous	1.08	1.39	1.30	1.08	1.04	0.74	0.74	0.55	0.52	0.63	0.55	0.47	0.47	
	absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	relative change [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	

Planned improvements

No improvements are planned at present.

3.D.a.2.c - Other organic fertilizers applied to soils

This sub category contains the total of Germany's NH_3 and NO_x (NO) emissions from application of - residues from digested energy crops, - residues from digested waste, - compost from biowaste, - compost from green waste, and - imported animal manures. For details see Rösemann et al. (2025), Chapters 5.2.1.2 and 5.2.2.2.

Activity data

Activity data is the amount of N in residues from anaerobic digestion of energy crops and waste and of compost from biowaste and green waste when leaving storage, as well as the amount of N in imported animal manures. For energy crops this is the N contained in the energy crops when being fed into the digestion process minus the N losses by emissions of N species from the storage of the residues (see 3.I). N losses from pre-storage are negligible and there are no N losses from fermenter (see Rösemann et al. (2025), Chapter 5.1). For residues from digested waste, compost from biowaste and compost from green waste the amount of N was derived from the waste statistics of the Federal Statistical Office (see Rösemann et al. (2025), Chapter 2.8). For imported manure the amounts of N were derived from statistics published by CBS (Statistics Netherlands) and RVO (Rijksdienst voor Ondernemend Nederland) The imported manure is categorized into cattle slurry, pig slurry, poultry manure, horse manure and mixed solid manure. Only imported manures from The Netherlands are taken into account, as for other countries the amounts of imported manures are unknown as are the amounts of exported manure. For details see Rösemann et al. (2025), Chapter 2.8.

Table 10: AD for the estimation of NH_3 and NO_x emissions emissions from application of other organic fertilizers

	Application of other organic fertilizers in kt N													
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Residues, digested energy crops	0.05	0.59	5.12	43.36	158.69	289.08	287.80	283.33	279.45	279.98	286.48	281.57	302.37	302.37
Residues, digested waste	0.00	0.00	1.55	4.97	10.46	15.05	13.97	13.79	14.00	13.75	13.40	15.13	15.62	16.83
Compost, biowaste	4.51	19.54	31.87	28.82	22.64	22.59	23.34	21.90	25.14	24.31	25.42	22.98	23.10	20.87
Compost, greenwaste	1.13	4.90	7.67	9.46	11.27	13.67	14.29	14.87	14.92	15.89	16.74	15.95	15.93	14.99
Imported manure	5.19	19.26	15.56	21.48	27.41	27.53	30.26	26.95	22.17	20.82	17.75	14.95	14.99	15.44
TOTAL	**10.87**	**44.30**	**61.77**	**108.09**	**230.47**	**367.92**	**369.65**	**360.83**	**355.67**	**354.76**	**359.80**	**350.58**	**372.01**	**370.50**

Methodology

The NH_3 emissions are calculated the same way as the NH_3 emissions from application of animal manure (3.D.a.2.a). The frequencies of application techniques and incorporation times as well as the underlying data sources are provided e. g. in the NID 2025, Chapter 17.3.1. It is assumed that residues of digested waste are applied in the same way and have the same emission factors as residues from digested energy crops. For compost from biowaste and green waste it is assumed that they are applied in the same way and have the same emission factors as cattle solid manure. The amounts of TAN in the residues from digested energy crops applied are obtained from the calculations of emissions from the storage of the digested energy crops (3.I). The amounts of TAN in the residues from digested waste, compost from biowaste and compost from green waste are derived from industry data (provided by Bundesgütegemeinschaft Kompost, BGK). For the imported manures it is assumed that the different imported manure types (see above) were applied in the same way as the corresponding domestic animal manure types. Mixed manure was treated like solid manure from goats, sheep and horses. Corresponding TAN contents were derived from publications of the German federal states. As published TAN contents vary strongly, for each imported manure type the maximum of published TAN contents was assumed to prevent an underestimation of the NH_3 emissions. For details see Rösemann et al. (2025), Chapter 2.8.

For NO_x emissions the Tier 1 approach for the application of synthetic fertilizer as described in EMEP (2023)-3D-13 is used. The inventory calculates NO emissions that are subsequently converted into NO_x emissions by multiplying with the molar weight ratio 46/30.

Emission factors

For NH_3 the emission factors for untreated cattle slurry were adopted for residues from digested energy crops and residues from waste. The emission factors for cattle solid manure were adopted for compost from biowaste and compost from green waste, see Rösemann et al. (2025), Chapters 5.2.1.2 and 5.2.2.2. For imported manures the corresponding emission factors of the same type of domestic manure were used.

As the NO_x method for fertilizer application is used for the calculation of NO_x emissions from the application of residues, the emission factor for fertilizer application was used (see Table 3).

Table 11: IEF for NH_3-N emissions from application of other organic fertilizers

	IEF in kg NH3-N per kg N of other organic fertilizers													
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Residues, digested energy crops	0.182	0.182	0.183	0.183	0.183	0.153	0.150	0.147	0.144	0.141	0.139	0.139	0.140	0.140
Residues, digested waste	0.000	0.000	0.192	0.193	0.193	0.171	0.164	0.156	0.163	0.162	0.163	0.162	0.160	0.157
Compost, biowaste	0.042	0.037	0.038	0.036	0.034	0.032	0.032	0.032	0.029	0.033	0.034	0.036	0.037	0.033
Compost, greenwaste	0.016	0.014	0.014	0.014	0.013	0.015	0.015	0.020	0.013	0.012	0.012	0.012	0.013	0.012
Imported manure	0.209	0.204	0.201	0.185	0.175	0.153	0.148	0.147	0.147	0.147	0.143	0.144	0.145	0.152
TOTAL	**0.120**	**0.109**	**0.092**	**0.130**	**0.160**	**0.141**	**0.138**	**0.135**	**0.131**	**0.129**	**0.127**	**0.127**	**0.129**	**0.130**

Trend discussion for Key Sources

The application of other organic fertilizers is a key source for NH_3. Emissions are dominated by the emissions from digested energy crops. They have become important since about 2005 and have risen sharply until 2013. Since then, they have changed little each year and tend to decrease slightly in the last few years. The latter is mostly due to the increasing use of application practices with lower NH_3 emission factors.

Recalculations

Recalculations after 2013 are mainly due to the update of activity data. Concerning NH_3 emissions, small differences occur in all years. This is because the underlying spatial distribution of imported manure is different, which results in different IEFs compared to last year's submission. Another reason is the interpolation of RAUMIS distribution data before 1999 (see main page of the agricultural sector, list of recalculation **reasons, 19, 20 and 21**, and Rösemann et al. (2025), Chapter 1.3).

Table 12: Comparison of NH_3 and NO_x emissions from application of other organic fertilizers [kt] with previous submission

	Submission	1990	1995	2000	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Ammonia	current	1.58	5.87	6.89	17.02	44.70	63.07	61.72	59.21	56.73	55.57	55.40	54.25	58.24	58.35
	previous	1.55	5.89	6.90	17.03	44.69	63.03	61.69	59.17	56.51	55.28	55.04	53.83	54.21	
	absolute change	0.02	-0.02	-0.01	-0.01	0.02	0.04	0.03	0.04	0.22	0.29	0.35	0.42	4.03	
	relative change [%]	1.57	-0.36	-0.10	-0.05	0.03	0.06	0.05	0.07	0.40	0.53	0.64	0.78	7.43	
Nitrogen oxides	current	0.20	1.75	2.44	4.26	9.09	14.51	14.57	14.23	14.02	13.99	14.19	13.82	14.67	14.61
	previous	0.20	1.75	2.44	4.26	9.09	14.50	14.57	14.22	13.97	13.93	14.12	13.75	13.92	
	absolute change	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.05	0.06	0.07	0.08	0.75	
	relative change [%]	0.00	0.00	0.00	0.00	0.00	0.04	0.06	0.07	0.35	0.43	0.48	0.55	5.35	

Planned improvements

No improvements are planned at present.

3.D.a.3 - Urine and dung deposited by grazing animals

The calculation of NH_3 and NO_x (NO) emissions from N excretions on pasture is described in Rösemann et al. (2025), Chapters 5.2.1.1 and 5.2.2.1.

Activity data

Activity data for NH_3 emissions during grazing is the amount of TAN excreted on pasture, while for NO_x emissions it is the amount of N excreted.

The TAN excretions are derived by multiplying the share of N excretion on pastures with the N excretions and TAN contents provided in 3.B, Table 2.

Table 13: Shares of N excretions on pasture, in [%]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Dairy cows	20.3	15.6	12.7	11.4	10.0	8.6	8.3	8.0	7.6	7.4	7.4	7.4	7.4	7.4
Other cattle	15.1	17.3	18.9	19.0	19.6	20.5	20.7	20.9	21.2	21.4	21.5	21.4	21.4	21.7
Sheep	55.1	55.5	55.1	55.4	54.8	55.4	55.4	55.4	55.6	55.5	55.4	55.5	55.8	55.6
Goats	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2
Horses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Laying hens	0.1	0.1	0.5	1.0	1.7	2.3	2.4	2.3	2.5	2.6	2.8	2.7	2.9	3.0
Deer	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ostriches	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0

Methodology

NH_3 emissions from grazing are calculated by multiplying the respective animal population (3.B, Table 1) with corresponding N excretions and relative TAN contents (3.B, Table 2) and the fraction of N excreted on pasture (Table 13). The result is multiplied with the animal specific emission factor (Table 14). NO emissions are calculated the same way with the exception that the emission factor is related to N excreted instead of TAN.

Emission Factors

The emission factors for NH_3 are taken from EMEP (2023)-3B-29, Table 3.9. They relate to the amount of TAN excreted on pasture. For laying hens, deer and ostriches there are no emission factors given in this table. Germany uses for laying hens an emission factor of 0.35 kg NH_3-N per kg TAN excreted, based on an expert judgement from KTBL (see Rösemann et al. 2025, Chapter 5.2.1.1). The same EF is used by UK. It was also used for ostriches. For deer the emission factor of sheep was adopted.

Following the intention of EMEP, 2023-3D, Table 3.1, the inventory uses for NO_x the same emission factor as for the

application of synthetic fertilizer (see Table 3). In order to obtain NO_x emissions (as NO_2) the NO-N emission factor of 0.12 kg NO-N per kg N excreted is multiplied by 46/14.

Table 14: Emission factors for emissions of NH_3 and NO from grazing

Dairy cows	0.14 kg NH3-N per kg TAN excreted
Other cattle	0.14 kg NH3-N per kg TAN excreted
Horses	0.35 kg NH3-N per kg TAN excreted
Sheep, goats	0.09 kg NH3-N per kg TAN excreted
Laying hens	0.35 kg NH3-N per kg TAN excreted
Deer	0.09 kg NH3-N per kg TAN excreted
Ostriches	0.35 kg NH3-N per kg TAN excreted
All animals	0.012 kg NO-N per kg N excreted

Trend discussion for Key Sources

Emissions from urine and dung deposited by grazing animals are no key sources.

Recalculations

For all years, totals of NH_3 and NO_x emissions from grazing are slightly higher than those of last year's submission.

The main reason for that is the correction of the horse animal numbers by a factor of 2.75 (see main page of the agricultural sector, list of recalculations, **No. 4)**. Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 15: Comparison of NH_3 and NO_x emissions [kt] with previous submission

	NH3 and NOx emissions from grazing, in Gg													
	Submission	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Ammonia	**current**	24.58	21.15	18.79	17.00	16.26	15.94	15.73	15.56	15.33	15.19	15.00	14.85	14.93	15.09
	previous	22.37	18.35	16.55	14.73	14.19	13.94	13.76	13.57	13.33	13.17	12.96	12.75	12.78	
	absolute change	2.21	2.80	2.24	2.28	2.07	2.01	1.98	1.99	2.00	2.02	2.03	2.10	2.15	
	relative change [%]	9.86	15.25	13.55	15.46	14.56	14.39	14.37	14.68	15.04	15.33	15.67	16.43	16.86	
Nitrogen oxides	**current**	8.84	7.38	6.66	6.00	5.72	5.55	5.47	5.40	5.30	5.24	5.17	5.11	5.11	5.17
	previous	8.50	6.95	6.31	5.64	5.40	5.24	5.17	5.09	4.99	4.93	4.86	4.78	4.78	
	absolute change	0.34	0.43	0.35	0.35	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.32	0.33	
	relative change [%]	4.01	6.23	5.50	6.24	5.91	5.92	5.92	6.05	6.21	6.33	6.47	6.78	7.01	

Planned improvements

No improvements are planned at present.

3.D.a.4 - Crop residues applied to soil

The calculation of NH_3 from crop residues is described in Rösemann et al. (2025), Chapter 5.2.1.3. According to EMEP (2023) NH_3 emissions are only occurring in a significant amount from crop residues on the soil surface, which are present more than three days and have an N content of more than 0.0132 kg N per kg dry matter. This means that there are no NH_3 emissions from most crop residues of the most commonly used crops in Germany. The major source of the emissions are residues of grassland cuts.

Activity data

The NH_3 emissions are calculated proportionally to the amounts of N stored in the above-ground biomass, according to EMEP (2023).This requires the knowledge of the areas of cultivation, of crop yields and of the N contents of the above ground crop residues.

Table 16: AD for the estimation of NH_3 emissions from crop residues

N in aboveground crop residues in Gg N													
1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
433	431	468	479	461	467	465	493	397	439	449	472	460	471

Methodology

According to EMEP (2023) the NH_3 emissions from crop residues can be neglected when the crop residues are on the field for less than three days. Thus the first step in the emission calculation is determining which share of the crop residues of each crop are incorporated into the soil or removed in the first three days after harvesting the crop. The remaining amounts are multiplied with their respective N contents and the resulting amounts of N are then multiplied with the NH_3-emission factor.

Emission factors

According to the methodology given in EMEP (2023) the emission factor for the NH_3 emissions from crop residues applied to the soil is zero if the N content of the above ground crop residues is below or equal to the threshold of 0.0132 kg N per kg dry matter. In all other cases the NH_3 emission factor is determined using the following linear regression, see EMEP (2023):

$$EF_NH_{3x}=(410\times N_{above\ dmx}-5.42)\div 100$$

Where x is the according crop and N_{above} dm is the N content of the above ground dry matter. The implied emission factors provided in the following table are defined as ratio of the total NH_3-N emissions from crop residues to the total N in aboveground crop residues.

Table 17: IEF for NH_3-N emissions from crop residues

IEF in kg NH3-N per kg N in aboveground crop residues													
1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
0.017	0.014	0.013	0.012	0.012	0.011	0.012	0.012	0.011	0.012	0.012	0.013	0.012	0.012

Trend discussion for Key Sources

NH_3 emissions from crop residues are no key source.

Recalculations

There are no recalculations because this source is reported the first time.

Table 18: Comparison of NH_3 emissions [kt] with previous submission

		NH3 emissions from crop residues, in Gg													
	Submission	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
NH3	current	8.70	7.32	7.14	7.06	6.55	6.43	6.95	7.11	5.47	6.27	6.51	7.35	6.62	6.89
	previous	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	

Planned improvements

No improvements are planned at present.

3.D.c - Farm-level agricultural operations including storage, handling and transport of agricultural products

In this category Germany reports TSP, PM_{10} and $PM_{2.5}$ emissions from crop production according to EMEP (2023)-3D-22. For details see Rösemann et al. (2025), Chapter 5.2.4.

Activity data

The activity data is the total area of agricultural land (arable land, grassland and horticultural land) including areas with cover crops. This data is provided by official statistics.

Table 19: Agricultural land (including areas with cover crops), in [1000*ha]

Agricultural land (including areas with cover crops) in 1000*ha													
1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
17,542	16,285	16,457	16,555	17,010	17,447	17,484	17,532	17,509	17,559	17,498	17,431	17,386	17,367

Methodology

The Tier 2 methodology used is described in EMEP (2023)-3D-22.

Emission factors

Emission factors given in EMEP (2023)-3D-18, Tables 3.6 and 3.8 are used with the exception of „Harvesting“ PM_{10}-factors for Wheat, Rye, Barley and Oat which were taken from the Danish IIR. These Guidebook-EFs are obviously too high by a factor of 10 and were corrected in the Danish IIR.

The missing default-EFs for „other arable“ in the 2023 EMEP/EEA Guidebook were replaced with the average of the EFs of wheat, rye, barley and oat, as it was done in the Danish IIR. The PM_{10} EFs were also used as TSP EFs. The Guidebook does not indicate whether EFs have considered the condensable component (with or without). For details on country specific numbers of agricultural crop operations see Rösemann et al. (2025), Chapter 5.2.4.

Table 20: Implied emission factors for PM emissions from agricultural soils, in kg ha^{-1}

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
TSP	1.42	1.41	1.42	1.41	1.39	1.38	1.37	1.37	1.37	1.36	1.36	1.36	1.36	1.36
PM_{10}	1.42	1.41	1.42	1.41	1.39	1.38	1.37	1.37	1.37	1.36	1.36	1.36	1.36	1.36
$PM_{2.5}$	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.11

Trend discussion for Key Sources

TSP and PM_{10} are key sources. Emissions depend on the areas covered, crop types and number of crop operations. With the exception of the numbers of soil cultivations, which is slightly decreasing, these data are relatively constant. Overall this is reflected in a slight decline of emissions in the last 12 years.

Recalculations

For all years, totals of TSP, PM_{10} and $PM_{2.5}$ emissions are higher than those of last year’s submission. This is mostly due to the introduction of cover crops to the calculation method (see main page of the agricultural sector, list of recalculations, No. 2). Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 21: Comparison of particle emissions (TSP, PM_{10} & $PM_{2.5}$) [kt] with previous submission

TSP, PM10, PM2.5 emissions from crop production, in Gg															
	Submission	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
TOTAL SUSPENDED PARTICLES (TSP)	**current**	24.88	22.99	23.38	23.27	23.64	24.06	24.03	24.07	23.92	23.94	23.73	23.70	23.71	23.69
	previous	23.45	21.67	22.13	22.01	22.02	21.81	21.65	21.61	21.38	21.32	21.04	21.00	21.02	
	absolute change	1.43	1.32	1.25	1.25	1.63	2.25	2.38	2.46	2.54	2.62	2.69	2.69	2.69	
	relative change [%]	6.09	6.09	5.66	5.70	7.38	10.32	10.98	11.37	11.86	12.26	12.81	12.83	12.82	

PM_{10}	**current**	24.88	22.99	23.38	23.27	23.64	24.06	24.03	24.07	23.92	23.94	23.73	23.70	23.71	23.69
	previous	23.45	21.67	22.13	22.01	22.02	21.81	21.65	21.61	21.38	21.32	21.04	21.00	21.02	
	absolute change	1.43	1.32	1.25	1.25	1.63	2.25	2.38	2.46	2.54	2.62	2.69	2.69	2.69	
	relative change [%]	6.09	6.09	5.66	5.70	7.38	10.32	10.98	11.37	11.86	12.26	12.81	12.83	12.82	
$PM_{2.5}$	**current**	1.90	1.78	1.85	1.85	1.87	1.88	1.87	1.87	1.85	1.84	1.81	1.81	1.82	1.82
	previous	1.81	1.70	1.77	1.77	1.77	1.74	1.72	1.72	1.69	1.68	1.65	1.65	1.66	
	absolute change	0.09	0.08	0.08	0.08	0.10	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.17	
	relative change [%]	4.92	4.84	4.42	4.41	5.73	8.06	8.61	8.92	9.37	9.74	10.22	10.22	10.16	

Planned improvements

No improvements are planned at present.

3.D.e - Cultivated crops

In this category Germany reports NMVOC emissions from crop production according to EMEP (2023)-3D-21. For details see Rösemann et al. (2025), Chapter 5.2.3.

Activity data

The *total area of arable land and grassland* applied as activity data is provided by official statistics.

Table 22: Arable land and grassland, in [1000 ha]

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
16,506	15,312	15,498	15,561	15,734	15,719	15,662	15,647	15,570	15,563	15,447	15,376	15,336	15,322

Methodology

The Tier 2 methodology described in EMEP (2023)-3D-21ff is used.

Emission Factors

The emission factors for wheat, rye, rape and grass (15°C) given in EMEP (2023)-3D-21, Table 3.4 were used. For all grassland areas the grass (15°C) EF is used, for all other crops except rye and rape the EF of wheat is used.

The implied emission factors provided in the following table are defined as ratio of the total NMVOC emissions from cultivated crops to the total area given by activity data.

Table 23: IEF for NMVOC emissions from crop production, in [kg ha-1]

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
0.47	0.53	0.57	0.59	0.61	0.63	0.62	0.62	0.50	0.55	0.59	0.61	0.58	0.60

Trend discussion for Key Sources

NMVOC emissions from crop production are no key sources.

Recalculations

There were no recalculations. Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 24: Comparison of NMVOC emissions [kt] with previous submission

	Submission	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
NMVOC	**current submission**	7.69	8.19	8.79	9.17	9.53	9.91	9.69	9.74	7.82	8.56	9.16	9.44	8.91	9.23
	previous submission	7.69	8.19	8.79	9.17	9.53	9.91	9.69	9.74	7.82	8.56	9.16	9.44	8.91	
	absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	relative change [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

Uncertainty

Details are described in chapter 1.7.

[30], [34]
EMEP/EEA air pollutant emission inventory guidebook 2023, EEA Report No 06/2023, https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023.
[31]
Bittman, S., Dedina, M., Howard C.M., Oenema, O., Sutton, M.A., (eds) (2014): Options for Ammonia Mitigation. Guidance from the UNECE task Force on Reactive Nitrogen. Centre for Ecology and Hydrology, Edinburgh, UK.
[32], [35], [36], [38], [39], [40], [41]
Rösemann, C., Vos, C., Haenel, H.-D., Dämmgen, U., Döring, U., Wulf, S., Eurich-Menden, B., Freibauer, A., Döhler, H., Schreiner, C., Osterburg, B., Fuß,R. (2025) Calculations of gaseous and particulate emissions from German agriculture 1990 – 2023 : Report on methods and data (RMD) Submission 2025. https://git-dmz.thuenen.de/vos/emissionsagriculture2025/-/wikis/home
[33]
Stehfest E., Bouwman L. (2006): N2O and NO emission from agricultural fields and soils under natural vegetation: summarizing available measurement data and modelling of global emissions. Nutr. Cycl. Agroecosyst. 74, 207 – 228.
[37]
NID (2025): National Inventory Report 2025 for the German Greenhouse Gas Inventory 1990-2022. Available in April 2025.

3.D.f - Agriculture: Other (including use of pesticides)

Country Specifics

So far, the only activity and emissions reported in 3.D.f - Agriculture: Other are the application of pesticides and the resutling emission of HCB.

Background



Hexachlorobenzene (HCB) is one of the listed persistent organic pollutants covered by the Aarhus Protocol on Persistent Organic Pollutants from 2009, Annex III[42], the Stockholm Convention[43] and Directive 2016/2284 (NECD), Annex I from 2016[44]. These conventions and directives oblige parties to reduce their emissions of dioxins, furans, polycyclic aromatic hydrocarbons (PAHs) and hexachlorobenzene (HCB) below their levels in 1990.

In Germany, the application of HCB as a pesticide, in a pure form, was prohibited in 1977 and thus no HCB emissions were reported until the 2016 reporting.

However, HCB can occur as an impurity in active substances such as:

- Lindane ($C_6H_6Cl_6$): Gamma-Hexachlorocyclohexane (a.k.a. γ-HCCH)
- DCPA ($C_{10}H_6Cl_4O_4$): Dimethyl-Tetrachloroterephthalate (a.k.a. Dacthal)
- PCP (C_6HCl_5O): Pentachlorophenol (a.k.a. Santophen, Pentachlorol, Chlorophen, Chlon, Dowicide 7, Pentacon, Penwar, Sinituho, Penta)
- Atrazine ($C_8H_{14}ClN_5$): 2-Chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine
- Simazine ($C_7H_{12}ClN_5$): 2,4-Bis(ethylamino)-6-chloro-1,3,5-triazine
- Propazine ($C_9H_{16}ClN_5$): 2,4-Bis(isopropylamino)-6-chloro-1,3,5-triazine
- PCNB ($C_6Cl_5NO_2$): 1,2,3,4,5-Pentachloro-6-nitrobenzene (a.k.a. Pentachlornitrobenzol or Quintozine)
- **Chlorothalonil** ($C_8Cl_4N_2$): 2,4,5,6-Tetrachlorobenzene-1,3-dicarbonitrile (short: TCPN)
- **Tefluthrin** ($C_{17}H_{14}ClF_7O_2$): rac-(2,3,5,6-Tetrafluoro-4-methylphenyl)methyl (1R,3R)-2,2-dimethyl-3-[(1Z)-2-chloro-3,3,3-trifluoroprop-1-en-1-yl]cyclopropane-1-carboxylate
- **Picloram** ($C_6H_3Cl_3N_2O_2$): 4-Amino-3,5,6-trichloropyridine-2-carboxylic acid (a.k.a Tordon, Grazon)

Only Tefluthrin and Picloram are continued to be used in approved pesticides in Germany (cf. Table 1) with Tefluthrin not being emission relevant as it is applied on seed in closed storage buildings (communication by Syngenta Agro, 2015 [45]). In 2022, analyses were carried out for HCB contamination in the crop protection product Force 20 CS. HCB contamination could not be detected. Thus, it is not considered in the amount of reported HCB emissions.

Tabel 1: Chlorothalonil: Trade names, approval numbers and intended applications; last update September 2022

Plant protection product	Approval number	Application for	no longer approved in Germany
BRAVO 500	043138-00	Wheat	•
Sambarin	033705-00	Wheat	•
Pugil 75 WG	004486-00	Wheat	•
AMISTAR Opti	005748-00	Wheat, barley und rye	•
Tattoo C	005805-00	Potatoes	•
CREDO	006542-00	Wheat, barley	•
Simbo Extra	004124-00	Wheat, barley	•
ZAKEO Opti	005748-61	Wheat, barley und rye	•
Daconil 2787 Extra	023138-00	Golf course greens, tees, and fairways, ornamental turfgrass and ornamental herbs, shrubs and trees.	•

Table 2: Picloram: Trade names, approval numbers and intended applications; last update September 2022

Plant protection product	Approval number	Application for
Barca 334 SL	008772-00	Rapeseed (summer/winter)
Belkar	008778-00	Rapeseed (winter)
Chaco	00A402-00	Rapeseed (winter)
EFFIGO	005866-00	Rapeseed (winter), maize, round cabbage
Gajus	008943-00	Rapeseed (winter)
Gala 334 SL	008772-60	Rapeseed
GF-2545	008089-00	Rapeseed (winter)
Runway	006872-00	Rapeseed (winter)

Sources: https://psm-zulassung.bvl.bund.de/psm/jsp/, https://www.proplanta.de/Pflanzenschutzmittel/Liste/

HCB has never been contained in co-formulants of approved pesticides (communication of the Federal Office of Consumer Protection and Food Safety (BVL, 2015)[46)].

In the past, some applicants listed maximum HCB concentrations in technical active substances in certain lindane-containing substances. The concentrations given amounted to ≤ 0.1 g/kg, a level oriented to the detection limits of the analysis method used at the time. Substances conforming to that maximum concentration were approved only through 1989 or 1990 (in one case, through 1995).

Obligations to report substance quantities sold did not take effect until 1998. For the other relevant active substances, the BVL has no information on HCB as an impurity. However, publications in recent years have included data from 1977 onward (BVL 2022) [47)]. Therefore, data on the active ingredients atrazine, simazine, propazine, and quintozine are also available and were included in the 2023 reporting.

Methodology

The emissions were calculated in keeping with the method proposed in the EMEP (2019) [48)] (3Df/3I-5, chapter 3, Tier 1 approach).

$$EM_{pest} = \Sigma m_{pest_i} \times EF_{pest_i}$$

To estimate the emission of HCB which is present as an impurity, an impurity factor (IF) has to be considered in the calculation:

$$EM_{pest} = \Sigma m_{pest_i} \times IF_{(j,i)} \times EF_{pest_i}$$

where:

- EM_{pest} = total HCB emission of active substance (in [mg/a], reported in [kg/a] here),
- m_{pest} = mass of individual active substance applied (in [kg/a]),
- $IF_{j,i}$ = impurity factor of the jth active substance in the ith active substance (in [mg/kg])
- EF_{pest}= EF for individual active substance (volatile fraction of applied amount of the active substance).

A modeled emission factor is used for Germany (see description of Emission factors). According to the definition of the Tier 2 Approach [49)] (EMEP Guidebook 2019) the method can be described as Tier 2.

Activity data

As activity data, domestic sales of pesticides with the active substances chlorothalonil, picloram, lindane as well as atrazine, simazine, propazine and quintozine compiled by the BVL were used (reports pursuant to § 64 of the Plant Protection Act (PflSchG, 2012) [50)]; (cf. Table II, domestic sales). Since 2018, domestic sales of all active substances have been published [51)] or https://gis.bvl.bund.de/.

Table 3: Domestic sales of active substances, as of 1987, in t/a

	Chlorthalonil	Picloram	Lindane	Atrazine	Simazine	Propazine	Quintozine
1987	260.2	0.4	129.1	2,106.2	176.8		0.3
1988	313.9	0.5	151.8	2,074.6	210.5		
1989	234.9	0.6	90.6	1,093.0	195.3		
1990	317.3		120.4	751.9	185.7		
1995	55.6		26.2				
1996	82.5		36.9				
1997	76.0		29.0		0.8		
1998	16.7				0.2		
1999	149.9						
2000	109.3						
2005	857.2						
2010	620.7	1.9					
2015	886.0	3.5					
2016	1,148.1	4.3					
2017	1,418.8	4.1					
2018	860.8	3.9					
2019	911.8	7.5					
2020	105.2	9.4					
2021		11.3					
2022		13.0					
2023		6.1					

HCB Impurities

The HCB quantities are calculated in light of the maximum permitted concentrations of HCB impurities established by legal acts of the EU [52)] defines, for certain active substances and in connection with their approval, maximum levels of impurities that are of toxicological or ecotoxicological concern or that are of special concern due to the environmental risks they pose. Since the implementing regulation is a directly applicable law, the maximum levels are binding throughout Europe. In addition, in special cases the BVL may define maximum levels for impurities that the regulation does not cover. Conformance with such maximum levels is then included as a necessary condition for approval of relevant pesticides. The approach is a highly conservative one that probably overestimates the actual emissions.

Chlorothalonil

Before 2006 there was no legal regulation in Germany on the maximum content of HCB in the active substance chlorothalonil. However, with the implementation of Directive 91/414/EEC [53)], manufacturers had to analyse their technical active substance for possible relevant impurities and, where appropriate, indicate a maximum level. These maximum levels had to be maintained. Information about the levels specified for chlorothalonil for the years 1990 and 1999 for Germany are not known. As described in the FAO specification (2015, p. 49, [54)]) Chlorothalonil was reviewed by IPCS (INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY) in the Environmental Health Criteria (EHC) series in 1996. The limit for HCB in the FAO specification in 1998 for chlorothalonil was 0.3 g/kg and manufacturer stated in that report that the company had improved the manufacturing process (see FAO Specification, 2015, p. 51). Thus, a maximum HCB concentration of 300 mg/kg (IPCS, 1996 [55)]) is considered for the years 1990 until 1999 for Germany.

Directive 2005/53/EC [56)], which entered into force on 1 March 2006, established a maximum permitted HCB concentration of 10 mg/kg in chlorothalonil as a technical active substance. Due to a review by the FAO 288/2005 (see FAO 2015, p.22 and p. 51) and taking into account the results of batch samples testing the impurity the max. concentration was raised again up to 0.04 g/kg. Thus, the standard was raised to 40 mg/kg in Directive 2006/76/EC [57)]). According to the current FAO Specifications and Evaluations for Agricultural Pesticides, Chlorothalonil (2020)[58)] continues to be reported at 40 mg/kg (see Table 1, p. 18).

For the years as of 2000, the specified maximum HCB concentrations in chlorothalonil differ considerably from pesticide to pesticide – in some cases despite the EU-regulation, the values differ from year to year for the same pesticide. For the year 2000, an intermediate value (170 mg/kg) was calculated by linear interpolation.

According to information from the BVL (October 2021, personal communication), the maximum content of HCB in chlorothalonil was increased from 10 to 40 mg/kg in the products “AMISTAR Opti” and “CREDO” due to subsequently applied for active substance sources. Likewise, an additional potential active substance source (production site) was also reported retroactively. For the years 2001 to 2017, the value of 40 mg/kg (for the reporting 2022) is used for the maximum content of HCB.

For the years from 2018 onwards, the information from the authorisation holders (Syngenta Agro, 2015) is used for the maximum concentration of 10 mg/kg, as only the product “AMISTAR Opti” was still on the market.

Picloram

For picloram, a maximum concentration of 50 mg/kg has been specified for some pesticides. Relevant pesticides were introduced in Germany beginning in 2006. Picloram was added to Annex I with the Commission Directive 2008/69/EC [59)] and the HCB impurity is still set to 50 mg/kg (FAO, 2012 [60)]). For 2023, the same amount as for previous years is assumed.

Lindane

The data on lindane sales were compared by the BVL with historical data from the former GDR statistics and published since 2020 (see Table II). For the years after 1997 no data are available because the application of lindane was phased out in 1998.

For lindane, a maximum concentration of 100 mg/kg was specified for the years 1990 through 1994. For the years after 1994 a lower concentration (50 mg/kg) was assumed which is based on compiled information of Bailey (2001)[61)] (cf. Table III).

Other active substances atrazine, simazine, propazine and quintozine

The BVL has no information on past or current concentrations of impurities in the active substances atrazine, simazine, propazine and quintozine that have been placed on the market. For this reason, the information on impurity levels compiled in the EMEP/EEA Guidebook 2019 is used (cf. Table III).

Table 4: Maximum concentrations of HCB impurities in relevant active substances, in mg/kg

	Chlorothalonil	Picloram	Lindane	Atrazine	Simazine	Propazine	Quintozine
1987-1994	300	50	100	2.5	1	1	500
1995-1997	300	50	50	1	1	1	500
1998 - 1999	300	50	n/a	n/a	1	n/a	n/a
2000	170	50	n/a	n/a	n/a	n/a	n/a
2001 - 2017	40	50	n/a	n/a	n/a	n/a	n/a
2018 - 2023	10	50	n/a	n/a	n/a	n/a	n/a

In recent years, the total HCB quantities in pesticide active substances (cf. Table V) have been affected primarily by sales of chlorothalonil.

While this results from the large quantities of chlorothalonil-containing pesticides sold, it is also due to the high chlorothalonil concentrations in such pesticides and to the high permitted maximum HCB concentrations (0.3 g/kg), in chlorothalonil as a technical active substance, that applied prior to 2000. Due to the revised data, changes in HCB quantities

occur.

The maximum HCB quantity for picloram, in the period under consideration, were lower, respectively, than the relevant quantities for chlorothalonil. For this reason, fluctuations in sales of picloram have very little impact on maximum HCB quantities.

Emission factor

The HCB emission factor was modeled by using the Pesticide Leaching Model (PELMO 3.31) which is also used for the European registration process of pesticides. The one-dimensional pesticide leaching model has been extended to predict the pesticide volatilisation after agricultural applications under field conditions (Ferrari et al., 2005 [62)]) however, it is also able to calculate the behaviour of impurities in the products. The model was developed by the Fraunhofer Institute for Molecularbiology and Applied Ecology (IME).

Due to its volatility behaviour in the presence of water vapor even at low temperatures, ambient HCB is usually found in the vapour phase and appears to volatilize from plant and soil surfaces during the first 24 hours after application (Klein, M., 2017) [63)]. As a test substance chlorothalonil was used in the simulation. The simulation conditions are defined after annual applications in potatoes 14 days before harvest. A detailed description of the input parameters is available (Klein, M., 2017). It is assumed that the HCB volatilisation of the impurity in picloram is the same.

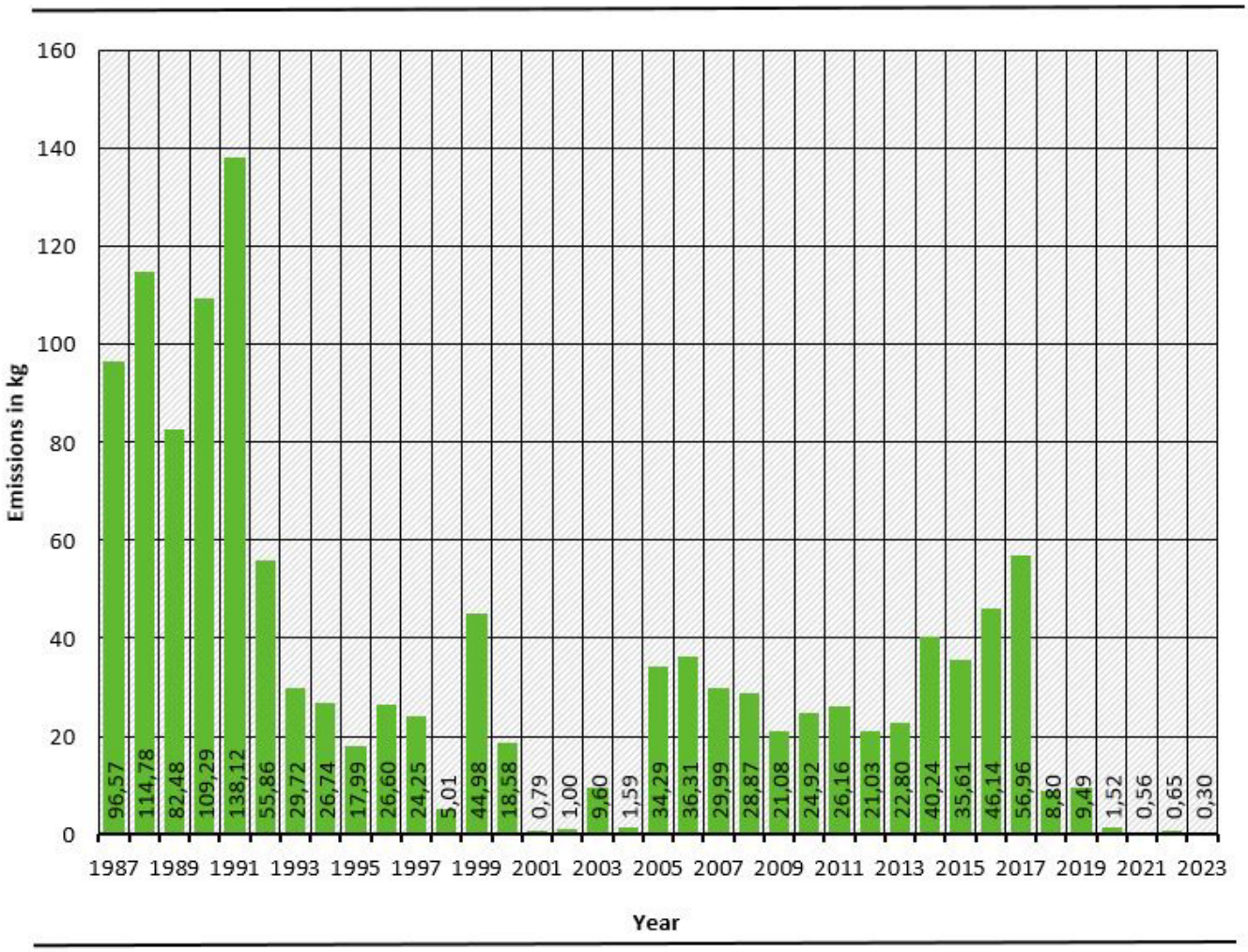
The result of the emission factor is 1 or 100% and represents a fraction that has to be multiplied with the concentration of the applied compound.

Trend discussion for Key Sources

The following chart gives an overview of the emission trend of HCB (see Picture 1). HCB emissions were fully recalculated from 1987 onwards including atrazine, simazine, propazine and quintozine. HCB emissions are reported in the NFR tables beginning in 1990.

HCB emissions are mainly dominated by the share of chlorothalonil. According to the BVL (2021a) [64)], a possible explanation for the increase in HCB emissions from 2005 onwards would be the re-approval of “Bravo 500” in December 2004 against Septoria in wheat and then for the first time against phytophthora in potatoes. It is possible that the first “sell-out” took place in 2014, as the end of approval for “Bravo 500” was originally 30.04.2016 with a sales deadline of 30.10.2016 and a phase-out period for users until 30.10.2017. The end of the EU active substance authorisation for chlorothalonil was later extended to 31.10.2018 and again to 31.10.2019, and with it the authorisations for the plant protection products in Germany. With the Implementing Regulation (EU) 2019/677 23), the BVL revoked the last three approvals for plant protection products containing chlorothalonil on 31 October 2019[65)]. A sell-off period until 30 April 2020 applied. Often, in the last years before the end of the approval, the remaining stocks are brought onto the market, which leads to higher sales than in previous years. No active ingredient of chlorothalonil was sold in 2021. This means that chlorothalonil is off the market for the time being. According to the German Federal Office of Consumer Protection and Food Safety (BVL)[66)], the EU authorization (http://data.europa.eu/eli/reg_impl/2023/2592/oj) for picloram has been extended beyond the end of 2023. Subsequent applications from the European Food Safety Authority (EFSA) must be submitted by December 1, 2025.

Picture 1: Annual trend of HCB emissions in Germany in the sector agriculture, in kg



Source: Umweltbundesamt 2024, National Inventory submission 2025

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were made compared to the last submission.

Uncertainty

For the calculation of emissions consumption figures (i. e. statistical figures) are used. Therefore, a standard error of HCB content is assumed as 2.5 % for the emission inventory. The 95% confidence interval is therefore 5 %. A normal distribution is assumed.

The uncertainty for the emission factor was determined using the PELMO model. For this purpose, the applied amounts of HCB on the plant surface were calculated with a vapour pressure reduced by a factor of 10. In addition, the meteorological conditions for modelling were selected in such a way that a range of possible emission factors for different locations was distributed across Europe (from Porto, Portugal, to Jokioinen in Finland). This results in a minimum and maximum emission factor. The maximum range was 30 %; the arithmetic mean was 10 % uncertainty (personal communication, Klein, 2017). A conservative approach and thus 30 % uncertainty is chosen for the calculation of uncertainties. The BVL also prepares a quality report on the quantities sales volumes of plant protection products[67)]. This report was prepared in accordance with the guidelines for quality reports of the Federal Statistical Office. It describes the procedure for compiling the annual statistics on plant protection products exported plant protection products and the active substances they contain. active

substances contained therein.

Planned improvements



Currently, no source-specific improvements are planned.

42)
Aarhus Protocol on Persistent Organic Pollutants (2009), United Nation: Aarhus Protocol on Long-range Transboundary Air Pollution, Persistent Organic Pollutants, 1998 - Amendment - (on Annexes V and VII) Decision 2009. Status In force (since Dec 13, 2010), Annex III.

43)
Stockholm Convention (2001): The Stockholm Convention on Persistent Organic Pollutants, opened for signature May 23, 2001, UN Doc. UNEP/POPS/CONF/4, App. II (2001), reprinted in 40 ILM 532 (2001) [hereinafter Stockholm Convention]. The text of the convention and additional information about POPs is available online at the United Nations Environment Programme's (UNEP's) POPs website

44)
Directive 2016/2284/EU: Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC

45)
Syngenta Agro (2015), Dep. „Zulassung und Produktsicherheit", personal communication

46)
BVL (2015) (Bundesamts für Verbraucherschutz und Lebensmittelsicherheit Braunschweig): persönliche Mitteilung der Wirkstoffdaten, 2015.

47)
BVL 2022, " Absatz an Pflanzenschutzmitteln in der Bundesrepublik Deutschland Ergebnisse der Meldungen gemäß § 64 Pflanzenschutzgesetz für das Jahr 2017, korrig. Version von Nov 2018, Tab 3.2, https://www.bvl.bund.de/SharedDocs/Downloads/04_Pflanzenschutzmittel/01_meldungen_par_64/meld_par_64_2017.pdf;jsessionid=575C3CE6FEC9CF7B81387944C90C6972.1_cid372?__blob=publicationFile&v=2

48)
EMEP (2019): EMEP/EEA air pollutant emission inventory guidebook – 2019, EEA Report No 13/2019, https://www.eea.europa.eu/publications/emep-eea-guidebook-2019.

49)
Tier 2 is similar to Tier 1 but uses more specific emission factors developed on the basis of knowledge of the types of processes and specific process conditions that apply in the country for which the inventory is being developed. Tier 2 methods are more complex, will reduce the level of uncertainty, and are considered adequate for estimating emissions for key categories.

50)
PflSchG (2012): Gesetz zur Neuordnung des Pflanzenschutzgesetzes, Bundesgesetzblatt (BGBl), Jahrgang 2012, Teil I, Nr. 7, § 64.

51)
see Excel Table "Absatzmengen an Wirkstoffen in Pflanzenschutzmitteln von 1987 bis 2023". https://www.bvl.bund.de/DE/Arbeitsbereiche/04_Pflanzenschutzmittel/01_Aufgaben/02_ZulassungPSM/03_PSMInlandsabsatzAusfuhr/psm_PSMInlandsabsatzAusfuhr_node.html

52)
Commission Implementing Regulation (EU) No 540/2011 ((COMMISSION IMPLEMENTING REGULATION (EU) No 540/2011 of 25 May 2011 implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards the list of approved active substances. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32011R0541

53)
Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the market, https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:31991L0414

54)
FAO (2015): FAO (Food and Agriculture Organization of the United Nations) Specifications and Evaluations for Chlorothalonil, p 51. http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/jmps/ps-new/en/

55)
IPCS (1996), Chlorothalonil. Environmental Health Criteria, 183. 145pp. WHO, Geneva, Switzerland. ISBN 92-4-157183-7. C12138614.7.

56)
Directive 2005/53/EC: Commission Directive 2005/53/EC of 16 September 2005 amending Council Directive 91/414/EEC to include chlorothalonil, chlorotoluron, cypermethrin, daminozide and thiophanate-methyl as active substances 2005/53/EC C.F.R. (2005).

[57]
Directive 2006/76/EC: Commission Directive 2006/76/EC of 22 September 2006 amending Council Directive 91/414/EEC as regards the specification of the active substance chlorothalonil (Text with EEA relevance) 2006/76/EC C.F.R. (2006
[58]
FAO (2020): FAO (Food and Agriculture Organization of the United Nations) Specifications and Evaluations for Chlorothalonil, http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/jmps/ps-new/en/#C
[59]
Directive 2008/69/EC: Commission Directive 2008/69/EC of 1 July 2008 amending Council Directive 91/414/EEC to include clofentezine, dicamba, difenoconazole, diflubenzuron, imazaquin, lenacil, oxadiazon, picloram and pyriproxyfen as active substances 2008/69/EC C.F.R. (2008).
[60]
FAO (2012): FAO (Food and Agriculture Organization of the United Nations) Specifications and Evaluations for Picloram, Table 2, p. 23. http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/jmps/ps-new/en/
[61]
Bailey, R. E., (2001): Global hexachlorobenzene emissions. Chemosphere, 43(2), 167-182.
[62]
Ferrari, F., Klein, M., Capri, E., & Trevisan, M. (2005). Prediction of pesticide volatilization with PELMO 3.31. Chemosphere, 60 (5), 705-713
[63]
Klein, M. (2017), Calculation of emission factors for impurities in organic pesticides with PELMO. Personel communication. Description available, Umweltbundesamt, FG V 1.6,Emissionssituation.
[64]
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[65]
cf. BVL; 2019: BVL - Fachmeldungen - Widerruf der Zulassung von Pflanzenschutzmitteln mit dem Wirkstoff Chlorthalonil zum 31. Oktober 2019. (2019, 31. Oktober). Abgerufen am September 2021, von https://www.bvl.bund.de/SharedDocs/Fachmeldungen/04_pflanzenschutzmittel/2019/2019_06_19_Fa_Widerruf_Chlorthalonil.html
[66]
BVL (2024): Personal communication (20241009) on the extension of the approval of Picloram
[67]
BVL (2024b):https://www.bvl.bund.de/SharedDocs/Downloads/04_Pflanzenschutzmittel/01_meldungen_par_64/01_Qualit%C3%A4tsbericht_AbsatzmengenPSM/Qualitaetsbericht_AbsatzmengenPSM_pdf.pdf?__blob=publicationFile&v=4

3.F - Field burning of agricultural residues

Short description

NFR-Code	Method	AD	EF
3.F	NO (*no intentional field burning in Germany*)		

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

Country specifics

Already in 1990, the first year of the emission reporting time series, the burning of crop residues had been banned by law in Germany.

Only in specific, exceptional situations (e. g. infestation by insects) permissions can be issued on municipal level.

Inquiries with several district administration offices revealed that such exceptional permissions mostly do concern forest areas rather than agricultural areas, and that there are no official statistics on those exceptions. Due to the restrictions in legislation and the information gathered from the district administration offices it is assumed that burning of agricultural areas is occurring extremely seldom and that the pertinent emissions can be neglected (NO). For more details see Rösemann et al. (2025) [68)].

[68)]
Rösemann, C., Vos, C., Haenel, H.-D., Dämmgen, U., Döring, U., Wulf, S., Eurich-Menden, B., Freibauer, A., Döhler, H., Schreiner, C., Osterburg, B., Fuß,R. (2025) Calculations of gaseous and particulate emissions from German agriculture 1990 – 2023 : Report on methods and data (RMD) Submission 2025.
https://git-dmz.thuenen.de/vos/emissionsagriculture2025/-/wikis/home

3.I - Agricultural: Other

Short description

Category Code	Name of Category	Method	AD	EF
3.I	Agriculture: other			
consisting of / including source categories:				
3.I	Storage of digestate from energy crops	T2 (NH_3, NO_x)	Q, PS	CS (NH_3, NO_x)

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	**NH_3**	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
-/-	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Country specifics

In 2023, NH_3 emissions from category 3.I (agriculture other) amounted to 0.32 % of total agricultural emissions, which is equal to ~ 1.7 kt NH_3. NO_x emissions from category 3.I contribute 0.09 % (~ 0.09 kt) to the total agricultural emissions. All these emissions originate from the storage of digestate from energy crops (for details on anaerobic digestion of energy crops see Rösemann et al. (2025)[69], Chapter 5.1. The emissions resulting from the application of energy crop digestates as organic fertilizer are dealt with under 3.D.a.2.c.

Activity Data

Time series of activity data have been provided by KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft / Association for Technology and Structures in Agriculture). From these data the amount of N in energy crops fed into anaerobic digestion was calculated.

Table 1: N amount in energy crops fed into anaerobic digestion, in [kt N]

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
0.0	0.6	5.3	45.1	163.0	293.7	292.2	287.4	283.2	283.2	289.3	283.8	304.9	304.9

Table 2: Distribution of gastight storage and storage in open tank of energy crop digestates, in [%]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
gastight	0.0	4.7	9.4	15.8	42.2	65.2	67.1	69.1	71.0	74.9	78.7	82.6	82.0	82.0
non-gastight	100.0	95.3	90.6	84.2	57.8	34.8	32.9	30.9	29.0	25.1	21.3	17.4	18.0	18.0

Methodology

The calculation of emissions from storage of digestate from energy crops considers two different types of storage, i.e. gastight storage and open tank. The frequencies of these storage types are also provided by KTBL (see Table 2). There are no emissions of NH_3 and NO from gastight storage of digestate. Hence the total emissions from the storage of digestate are calculated by multiplying the amount of N in the digestate leaving the fermenter with the relative frequency of open tanks and the emission factor for open tank. The amount of N in the digestate leaving the fermenter is identical to the N amount in energy crops fed into anaerobic digestion (see Table 1) because N losses from pre-storage are negligible and there are no N losses from fermenter (see Rösemann et al. 2025, Chapter 5.1).

Emission factors

As no specific emission factor is known for the storage of digestion residues in open tanks, the NH_3 emission factor for storage of cattle slurry with crust in open tanks was adopted (0.045 kg NH_3 -N per kg TAN). This choice of emission factor is based on the fact that energy crops are, in general, co-fermented with animal manures (i. e. mostly slurry) and that a natural crust forms on the liquid digestates due to the relatively high dry matter content of the energy crops.

The TAN content after the digestion process is 0.56 kg TAN per kg N. The NO emission factor for storage of digestion residues in open tanks was set to 0.0005 kg NO-N per kg N.

The following table shows the resulting implied emission factors for NH_3 -N and NO-N. NO_x emissions are related to NO-N emissions by the ratio of 46/14. This relationship also holds for NO-N and NO_x emission factors.

Table 3: IEF for NH_3 -N and NO-N emissions from storage of digested energy crops

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
IEF in kg NH_3-N per kg N in digested energy crops													
0.0252	0.0240	0.0228	0.0212	0.0146	0.0087	0.0082	0.0078	0.0073	0.0063	0.0054	0.0044	0.0045	0.0045
IEF in kg NO-N per kg N in digested energy crops													
0.00050	0.00048	0.00045	0.00042	0.00029	0.00017	0.00016	0.00015	0.00014	0.00013	0.00011	0.00009	0.00009	0.00009

Trend discussion for Key Sources

NH_3 and NO_x from storage of anaerobically digested energy crops are no key source.

Recalculations

All time series of the emission inventory have completely been recalculated since 1990.

The following table shows the effects of recalculations on NH_3 and NO_x emissions from storage of anaerobically digested

energy crops.

Differences to last year's submission occur in all years since 2013 and are due to the update of activity data (see main page of the agricultural sector, Chapter 5 - NFR 3 - Agriculture (OVERVIEW), **recalculation No. 17**). For further details on recalculations see Rösemann et al. (2025), Chapter 1.3.

Table 4: Comparison of NH_3 and NO_x emissions [kt] with previous submission

	Submission	1990	1995	2000	2005	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Ammonia	**current**	0.0015	0.0180	0.1482	1.1624	2.8842	3.1074	2.9181	2.7131	2.5068	2.1785	1.8901	1.5115	1.5115	1.5115
	previous	0.0015	0.0180	0.1482	1.1624	2.8842	3.2124	3.0579	2.8835	2.7108	2.5822	2.5074	2.3137	2.3137	
	absolute change	0.00	0.00	0.00	0.00	0.00	-0.11	-0.14	-0.17	-0.20	-0.40	-0.62	-0.80	-0.80	
	relative change [%]	0.00	0.00	0.00	0.00	0.00	-3.27	-4.57	-5.91	-7.52	-15.63	-24.62	-34.67	-34.67	
Nitrogen oxides	**current**	0.0001	0.0010	0.0080	0.0624	0.1548	0.1668	0.1567	0.1457	0.1346	0.1170	0.1015	0.0811	0.0899	0.0899
	previous	0.0001	0.0010	0.0080	0.0624	0.1548	0.1725	0.1642	0.1548	0.1455	0.1386	0.1346	0.1242	0.1242	
	absolute change	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.02	-0.03	-0.04	-0.03	
	relative change [%]	0.00	0.00	0.00	0.00	0.00	-3.27	-4.57	-5.91	-7.52	-15.63	-24.62	-34.67	-27.61	

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

Uncertainty

Details are described in chapter 1.7.

69)

Rösemann, C., Vos, C., Haenel, H.-D., Dämmgen, U., Döring, U., Wulf, S., Eurich-Menden, B., Freibauer, A., Döhler, H., Schreiner, C., Osterburg, B., Fuß,R. (2025) Calculations of gaseous and particulate emissions from German agriculture 1990 – 2023 : Report on methods and data (RMD) Submission 2025. https://git-dmz.thuenen.de/vos/emissionsagriculture2025/-/wikis/home

CHAPTER 6: NFR 5 - Waste (OVERVIEW)



Source category *NFR 5 - Waste* is not a key source. NMVOC and $PM_{2.5}$ emissions from Solid Waste Disposal on Land, NH_3 emissions from Composting and Anaerobic Digestion at biogas facilities, emissions from Cremation as well as NMVOC emissions from Domestic & Commercial and Industrial Wastewater Treatment are reported.

Germany has a large number of waste incineration plants, whose emissions are reported in *NFR 1*, because German legislation requires energy recovery. Therefore, waste is also part of the German Energy Statistic as well as the National Energy Balance.

In addition to the “classical” municipal waste incineration, there are also various types of combustion installations, like co-incineration of “replacement fuels” in conventional power plants or industrial plants. The increasing number of co-incineration plants is mainly due to the landfill ban of untreated waste in 2005 and the introduction of the emission trading scheme (ETS). Further information about the methodology of municipal waste incineration, co-incineration in public power plants and emissions from waste wood combustion is available in chapter: 1.A.1.a -Public electricity and heat production. Municipal waste incineration does also include clinical waste, which is not incinerated separately.

Emissions from hazardous waste incineration plants are reported in source category 1.A.2.g. viii - Stationary Combustion in Manufacturing Industries and Construction: Other Production as well as co-incineration in industrial plants, whereas emissions from sewage sludge incineration are reported in source category 1.A.1.c - Manufacture of solid fuels and other energy industries , following the structure of the National Statistics.

In Germany, “Other Waste Incineration” *(NFR 5.C.1.b vi)* is prohibited by law, therefore, “NO” is used as notation key.

Furthermore, it should be mentioned that all emissions originating from biogas recovery are reported in source category 1.A.1.a , following the structure of the National Energy Balance. That covers emissions from sewage gas as well as landfill gas and biogas from biological waste treatment.

NFR 5 consists of the following sub-categories:

NFR Code	Name of Category	State of Reporting
5.A & 5.B - Biological Treatment of Waste		
5.A	Biological Treatment of Waste: Solid Waste Disposal on Land	
5.B.1	Biological Treatment of Waste: Composting	
5.B.2	Biological Treatment of Waste: Anaerobic digestion at biogas facilities	
5.C - Thermal Treatment of Waste		
5.C.1.a	Municipal Waste Incineration	considered in *1.A.1.a*
5.C.1.b i	Industrial Waste Incineration	considered in *1.A.1.a* & 1.A.2.g viii
5.C.1.b ii	Hazardous Waste Incineration	considered in *1.A.2.g viii*
5.C.1.b iii	Clinical Waste Incineration	considered in *1.A.1.a*
5.C.1.b iv	Sewage Sludge incineration	considered in *1.A.1.c*
5.C.1.b v	Cremation	
5.C.1.b vi	Other waste incineration (please specify in the IIR)	NO
5.C.2	Open Burning of Waste	
5.D - Wastewater handling		
5.D.1	Domestic & Commercial Wastewater Handling	
5.D.2	Industrial Wastewater Handling	
5.D.3	Other Wastewater Handling	NO
5.E - Other Waste (please specify in IIR)		
5.E.1	Other Waste: Mechanical-biological Treatment of Waste	GHG emissions only
5.E.2	Other Waste: Building and Car Fires	

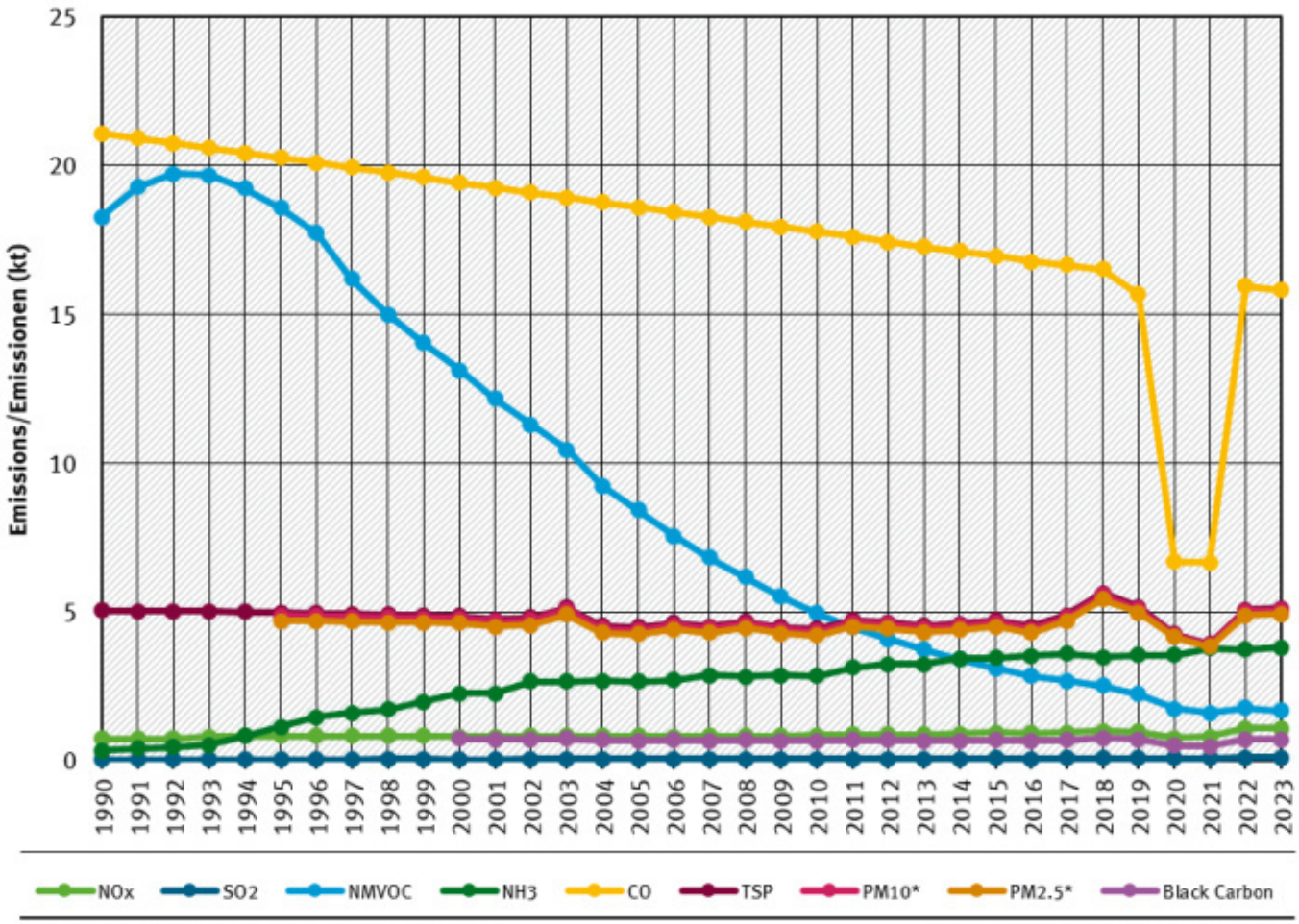
NOTE: Within category *5.C - Waste incineration*, Germany only reports emissions from *NFR 5.C.1.b v - Cremation* and *NFR 5.C.2 bonfires etc.*. For all other sub-categories of NFR 5.C, as all waste incineration in Germany is carried out with energy recovery and in order to avoid double counting, resulting emissions are reported as *not occuring (NO)* under NFR 5.C but are included in energy sector NFR 1.

Visual overview

Emission trends for main pollutants in *NFR 5 - Waste*:

Waste/Abfall (NFR 5)

Emissions by pollutant / Emissionen nach Schadstoff

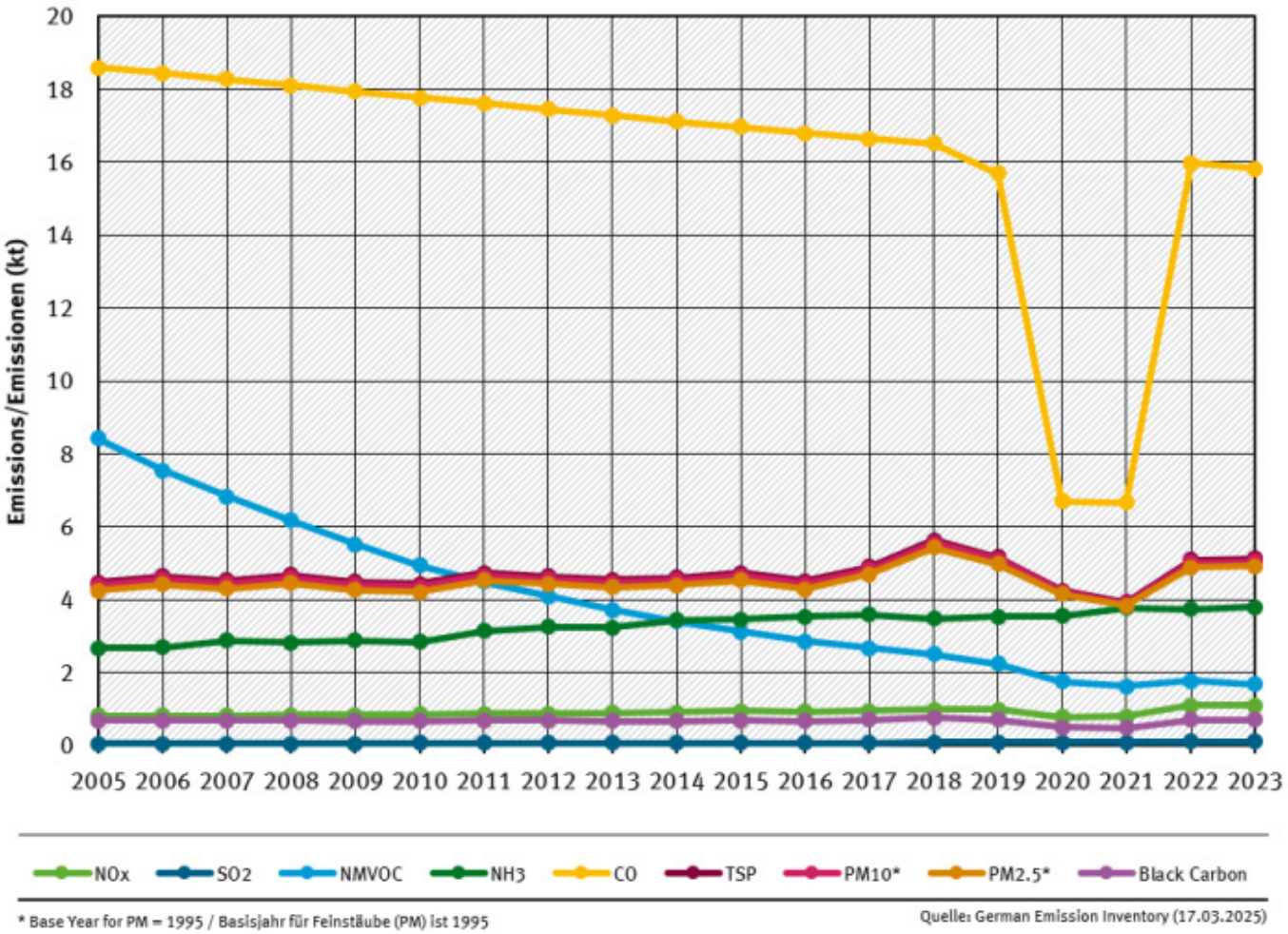


* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Emission Inventory (17.03.2025)

Waste/Abfall (NFR 5)

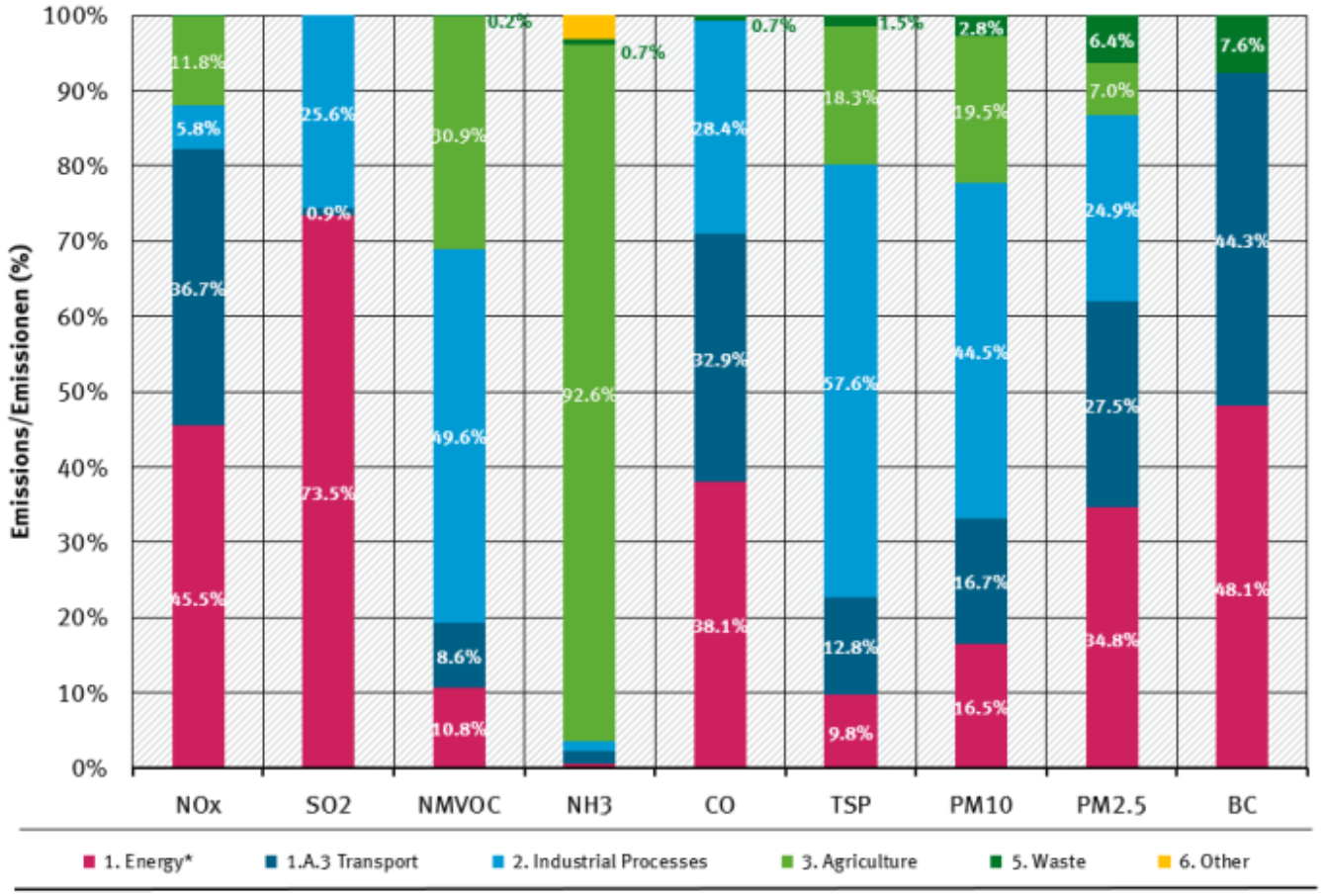
Emissions by pollutant / Emissionen nach Schadstoff



[Contribution of NFRs 1 to 6 to the National Totals, for 2021]

Contribution of NFR categories to the emissions

percentages per air pollutant, 2023



* w/o Transport / ohne Verkehr (1.A.3)

Quelle: German Emission Inventory (17.03.2025)

5.A - Biological Treatment of Waste: Solid Waste Disposal on Land

Short description

Category Code	Method	AD	EF
5.A	T1	NS	D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	SO_2	NH_3	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	CO	Heavy Metals	POPs
NA	-/-	NA	NA	-/-	-/-	-/-	-/-	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

In category **5.A**, NMVOC and $PM_{2.5}$ emissions from managed disposal in landfills are reported in accordance with review recommendation DE-5A-2017-0001. In addition to that, for the sake of completeness, PM_{10} and TSP emissions were also reported.

In the period since 1990 (and previously, to some extent), a number of legal provisions have been issued pertaining to Germany's waste-management sector, and a number of relevant measures have been initiated. These moves have had a strong impact on trends in emissions from waste-landfilling. Relevant developments have included intensified collection of biodegradable waste from households and the commercial sector, intensified collection of other recyclable materials, such as glass, paper/cardboard, metals and plastics; separate collection of packaging and recycling of packaging. In addition, incineration of municipal waste has been expanded, and mechanical biological treatment of residual waste has been introduced. As a result, the amounts of landfilled municipal waste decreased very sharply from 1990 to 2006, and stabilised

at a low level since 2006. Today over half of municipal waste produced in Germany is collected separately and gleaned for recyclable materials (separate collection of recyclable materials and biodegradable waste). National statistical data are used (see sub-chapter “activity- data”).

In 2004, about 2.000 landfills of relevance for this category were in operation in the Federal Republic of Germany.
In June 2005, in keeping with new, stricter requirements under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements (Abfallablagerungsverordnung) and the Landfill Ordinance (Deponieverordnung), nearly half of those landfills were closed. As a result, in 2017 less than 1100 landfills, divided into 5 deposition classes are still in operation.
Also, pursuant to regulations in force since June 2005, landfilling of biodegradable waste is no longer permitted - for conformance with pertinent requirements, municipal waste and other biodegradable waste must be pre-treated via thermal or mechanical-biological processes. All these measures have had strong impact on the formation of NMVOC, $PM_{2.5}$, PM_{10} and TSP so that their emissions decreased signifficantly since 1990.

Methodology

For the estimation of NMVOC, Germany decided against the proposed EF of the EMEP/EEA Guidebook 2019, but instead for the Tier1 approach of the US-EPA which is also reproduced there (Part B, 5.A, chap. 3.2.2, p. 5; [1)].

According to national experts in the field, the approach of the US-EPA is more likely to produce better data, because the ratio between NMVOC (1.3 %) and CH_4 (98.7 %) in VOC from landfill gas is scientifically sound and assumed to be the very same in Germany. Also, already existing and published data for methane emissions from landfills, derived from the IPCC-FOD Waste Model (see NIR of Germany), can be used. However, with the NIR 2023 some of the emission parameters used to estimate methane emissions have been modified (DOC for food waste, DOC_f for wood/straw, half-life time for paper and wood/straw) according to the results of research projects initiated for the improvement of the German inventory reporting (Stegmann et al, 2018; pages 172-173, table 36) [2)]. As a result, the methane emissions have changed considerably and thus the related NMVOC-emissions that are reported here.

Emissions for $PM_{2.5}$, PM_{10} and TSP, reported under this category, are calculated using the Tier1 approach of the EMEP/EEA Guidebook 2019, where the emission factors are 0.033, 0.219 and 0.463 [g/t] [3)].

The EFs are multiplied with the total amount of solid waste (AD) treated in managed above-ground landfills, following the standard equation:

EM = AD * EF

Activity data

From 1990 until 2017, official statistical data provided by the Federal Statisticl Office are applied [4)].

Data for 1991 and 1992 as well as 1994 and 1995 are not available and have been interpolated. From 2018 until today data are made available by the National Statistical Agency by means of a direct data provision on a yearly basis. These data comprise the total amount of solid waste deposited above-ground, meaning, that all mineral wastes (mineral/construction/demolition) are also included. Remaining fractions of these wastes (mineral/construction/demolition) go to underground landfills and therefore do not play a part in dust emissions.

The data are published on a yearly basis with an exception for the actual year of reporting. The activity data for the actual year of reporting are obtained, initially, by carrying the relevant data from the previous year forward, in unchanged form. In the following year, when the actual activity data for the given year becomes available, they replace the data that were carried forward. With regard to emissions from landfills, this procedure has only a very small impact on the total emissions in the relevant current report year.

Emission factors

See “Methodology”.

Uncertainties

The AD from Statistisches Bundesamt usually have an uncertainty of ±3% whereas the uncertainties for the PMs and TSP emission factors, according to the EMEP/EEA Guidebook (Part B, 5.A, chap. 3.2.2, Table 3-1, p. 5), were estimated as:

Table 1: Uncertainty estimates of PM emission factors

$PM_{2.5}$	-99% / +385%
PM_{10}	-99% / +379%
TSP	-99% / +377%

Due to the fact that for the ratio of NMVOC and CH_4 in VOC from landfill gas no range is given in the EMEP-Guidebook, the overall uncertainty for the emission estimation of NMVOC is estimated by expert judgement to be ± 50%.

Recalculations

Regular back-calculations are required annually for the previous year, since the waste statistics of the Federal Statistical Office are published with a one-year delay for the data on the quantities and compositions of waste deposited, so that the current reporting year must therefore be estimated. The estimate is replaced in the following year with the then current data. Since the recalculation required as a result is overall very small in each year, it usually is not reported additionally here.

However, in this year's reporting the need for correction of NMVOC-emissions arises and thus will be reported. Reason for this is that National Statistics have published the recovered gas volumes from the storage and decommissioning phase for 2022, leading to a change of estimated methane emissions under UNFCCC for 2021 + 2022. Due to the fact that the method for the estimation of NMVOC emissions is directly linked to the CH4 amounts estimated by using the IPCCs FOD-Model, the NMVOC-emissions are also affected and recalculated as shown in the following table. In the same course a recalculation of PM and TSP for 2022 is reported additionally (see last table).

Table 1: Revised NMVOC-emissions [kt]

	2021	**2022**
current submission	1,263	1,144
previous submission	1,211	1,117

Table 2: Revised 2022 PM and TSP emissions, in [t]

	TSP	**PM_{10}**	**$PM_{2.5}$**
current submission	18,1347	8,5777	1,2925
previous submission	18,3484	8,6788	1,3078

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1), 3)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, Part B, 5.A, chapter 3.2.2, Table 3-1, page 5;

https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/5-waste/5-a-biological-treatment-of/@@download/file; Copenhagen, 2019.

[2)] Stegmann et al. (2018): Stegmann, R., Heyer, K.-U., Hupe, K. (IFAS - Ingenieurbüro für Abfallwirtschaft, Hamburg) with Rettenberger, G., Schneider, R. (Ingenieurgruppe RUK GmbH, Stuttgar): Überprüfung der methodischen Grundlagen zur Bestimmung der Methanbildung in Deponien, ISSN 1862-4804; https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/139_2023_texte_methanbildung_in_deponien.pdf, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2018.

[4)] Destatis (2024): Federal Statistical Office (Statistisches Bundesamt - Destatis), Fachserie 19, Reihe 1: Abfallentsorgung (Waste management), Table 2.1; https://www.destatis.de/DE/Publikationen/Thematisch/UmweltstatistischeErhebungen/Abfallwirtschaft/Abfallentsorgung.html, Wiesbaden, 2024.

5.B.1 - Biological Treatment of Waste: Composting

Short description

Within NFR category **5.B.1**, ammonia (NH_3) emissions from composting of organic wastes are reported.

NFR Code	Method	AD	EF
5.B.1	CS	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	**NH_3**	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NA	NA	NA	**-/-**	NA	NA	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Separately collected organic waste (biowaste) from e.g. households, public garden and park service, food industry, restaurants, canteens and from agriculture can be treated either (i) aerobically (= composting) or (ii) anaerobically (= biogas production).

The aim of the treatment reported under this category is the production of compost, leading to the recycling of nutrients and organic matter.

The produced compost is used as fertilizer or soil improver in agriculture or horticulture and also in private gardening.

In Germany about 50% of the organic waste is treated in composting plants and ammonia (NH_3) is an important emission to air.

Method

Emissions from composting are not a key source and of minor priority.

Activity Data

Official statistical data (Statistisches Bundesamt, GENESIS, Table Nr. 32111-0003 - Erhebung der Abfallentsorgung; [1)]) are used for the estimation.

The data are published annualy with an exception for the current year of reporting. Therefore, activity data for the current year of reporting are obtained, initially, by extrapolating the trend of the last 3 years. In the following year, when the actual activity data for the given year becomes available, they replace the extrapolated data. This procedure has only a very small impact on the total emissions in the relevant current report year.

Emission factors

The emission factor used for calculating NH_3 emissions is based on emission data from a research project [2)]. The NH_3-EF is 222 g/t and used for the whole time series. The use of abatement technologies (such as biofilters) are taken into account.

Uncertainties

The AD from Statistisches Bundesamt have an uncertainty of ±2% whereas the uncertainty for the EF is -59/+130% (ibid.).

Recalculations

When preparing the current inventory data, statistical data are only available for the previous reporting year. The current reporting year must therefore be extrapolated on the basis of the previous year. The result of this approach is revised by the correct data in the following year. For this reason, annual recalculations are required for the previous year.

Table 1: Revised biowaste activity data, in [kt]

	2022
current submission	8,174
previous submission	9,092

Table 2: Accordingly revised NH_3 emissions, in [t]

	2022
current submission	1,815
previous submission	2,018

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] Statistisches Bundesamt, GENESIS, Table Nr. 32111-0003 - Erhebung der Abfallentsorgung; Wiesbaden; https://www-genesis.destatis.de/genesis//online?operation=table&code=32111-0003&bypass=true&levelindex=0&levelid=1630573034654#abreadcrumb

[2)] Carsten Cuhls, Birte Mähl, Joachim Clemens; gewitra Ingenieurgesellschaft für Wissenstransfer mbH: Ermittlung der Emissionssituation bei der Verwertung von Bioabfällen; https://www.umweltbundesamt.de/publikationen/ermittlung-der-emissionssituation-bei-der; im Auftrag des Umweltbundesamtes, April 2015

5.B.2 - Biological Treatment of Waste: Anaerobic Digestion at Biogas Facilities

Short description

Within NFR category **5.B.2**, ammonia (NH_3) emissions from the anaerobic digestion of organic waste at biogas facilities are reported.

Category Code	Method	AD	EF
5.B.2	CS	NS	CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	**NH_3**	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NA	NA	NA	**-/-**	NA	NA	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Separately collected organic waste (biowaste) from e.g. households, public garden and park service, food industry, restaurants, canteens and from agriculture can be treated in two different ways:
aerobically (composting) and anaerobically (biogas production).

The aim of the treatment reported under this category is the production of digestate, leading to the recycling of nutrients and organic matter.

The produced digestate is used as fertilizer or soil improver in agriculture or horticulture and also in private gardening. In Germany, about 50% of the organic waste is treated in anaerobic digestion plants and ammonia (NH_3) is an important emission to air.

Method

Emissions from anaerobic digestion at biogas facilities are not a key source and of minor priority.

Activity data

Official statistical data (Statistisches Bundesamt, GENESIS, TableNr. 32111-0003 - Erhebung der Abfallentsorgung [1)]) and a Statistical Report on waste disposal [2)] are used for the estimation. The data are published on a yearly basis with an exception for the current year of reporting. The activity data for the current year of reporting are obtained, initially, by extrapolating the trend of the last 3 years into the future. In the following year, when the actual activity data for the given year becomes available, they replace the data that were extrapolated. This procedure has only a very small impact on the total emissions in the relevant current report year.

Emission factors

The emission factor used for calculating NH_3 emissions is based on emission data from a research project [3)]. The NH_3-EF is 274 g/t and used for the whole time series (which is starting in 1998).

Uncertainties

The AD from Statistisches Bundesamt have an uncertainty of ±2% whereas the uncertainty for the EF is -18/+920% (ibid.).

Recalculations

When preparing the current inventory data, statistical data are only available for the previous reporting year. The current reporting year must therefore be extrapolated on the basis of the previous year. The result of this approach is revised by the correct data in the following year. For this reason, annual recalculations are required for the previous year.

Table 1: Revised biowaste activity data, in [kt]

	2022
current submission	7,000
previous submission	6,811

Table 2: Accordingly revised NH_3 emissions, in [t]

	2022
current submission	1,918
previous submission	1,866



For **pollutant-specific information on recalculated emission estimates** for Base Year and 2022, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements



At the moment, no category-specific improvements are planned.

[1)] Statistisches Bundesamt, GENESIS, TableNr. 32111-0003 - Erhebung der Abfallentsorgung; Wiesbaden; https://www-genesis.destatis.de/genesis//online?operation=table&code=32111-0003&bypass=true&levelindex=0&levelid=1630573034654#abreadcrumb

[2)] Statistisches Bundesamt, Statistischer Bericht Abfallentsorgung, TableNr. 32111-12; Wiesbaden; https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Abfallwirtschaft/_inhalt.html#sprg238672

[3)] Carsten Cuhls, Birte Mähl, Joachim Clemens; gewitra Ingenieurgesellschaft für Wissenstransfer mbH: Ermittlung der Emissionssituation bei der Verwertung von Bioabfällen; https://www.umweltbundesamt.de/publikationen/ermittlung-der-emissionssituation-bei-der; im Auftrag des Umweltbundesamtes, April 2015

5.C.1.b v - Cremation

Category Code	Method	AD	EF
5.C.1.b.v	CS	AS	D, CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	-/-	NA	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	NE	NE	NE	NE	NE	NE	-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Method

Emissions from cremation are not a key source and of minor priority. Since March 1997, a national legal ordinance for cremation plants nationwide is in force (27. BImSchV).

Activity data

Activity data for this category are based on data from the statistics of the “Bundesverband Deutscher Bestatter e.V.”[1)]. For purposes of GHG reporting we specify cremations as masses, too. The cremation is a growing trend in funerals.

Table 1: Annual amount of cremated human bodies, in [kt]

1990	1995	2000	2005	2010	2015	2020	2023
13.55	25.32	26.24	29.22	34.18	45.88	56.77	62.51

Source: own calculation, conversion is not described in more detail here for reasons of piety, but is done in a manner comparable to other publications.

Emission factors

Emission factors used are default values from the EMEP/EEA air pollutant emission inventory guidebook 2023 [2)] as well as national data for POPs from the research project “POP- und Hg-Emissionen aus abfallwirtschaftlichen Anlagen” - Teilvorhaben zum Globalvorhaben „Überprüfung des Standes der Technik der Emissionen prioritärer Schadstoffe für einzelne Industriebranchen (Kleinfeuerungsanlagen und abfallwirtschaftliche Anlagen)“ [3)] .

In 2018 the TERT noted that the German Hg EF is 100 times smaller than the default value proposed in the 2016 EMEP/EEA Guidebook and the Cd and Pb EF are 1000 times smaller than the default values proposed in the 2016 EMEP/EEA Guidebook. However, the EF for Pb and Cd are based on national expert judgement: assumption that a) the emissions behave similarly to dust and b) the dust limit value of the air pollution control specification (27th BImSchV) is complied with (to be confirmed on the basis of the new measurement data from 5 crematoria with different exhaust gas cleaning systems). The first national Hg EF was calculated on the basis of the German report on “OSPAR Recommendation 2003/4 on controlling the dispersal of mercury from crematoria“, but is under evaluation.

After the finalization of a research Project [4)] the Hg EF is revised. As part of the project, emission measurements were carried out at six cremation routes. According to OSPAR reporting 2010/2014, approx. 90% of the plants have effective Hg mitigation technology, whereas approx. 10% are not equipped with effective Hg mitigation technology. This ratio is roughly reflected in the 2020 project report, too.

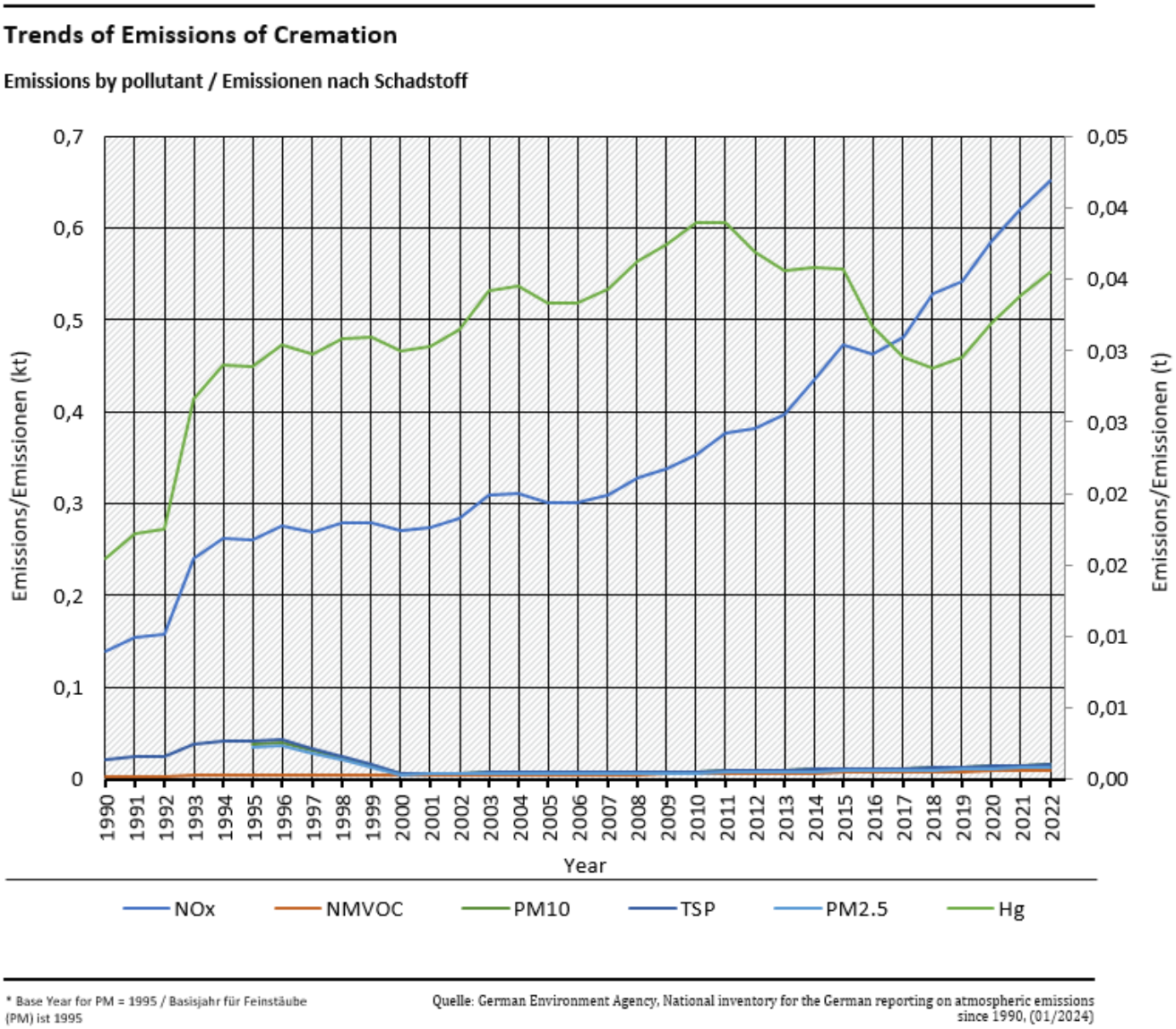
Since the cremation duration is approximately one hour, the mean value per hour corresponds to the Hg load per cremation and is used accordingly in the inventory calculation.

As developement of state of the art values are interpolated between the two endpoints 2010 and 2018 (from 0,0913 g/No. to 0,0449 g/No). This time span represents a real retrofit of the crematoria.

EF for TSP, PM_{10}, and $PM_{2.5}$ derive from the research study “Studie zur Korngrößenverteilung (PM_{10} und $PM_{2.5}$) von Staubemissionen” [5)].

Trends in emissions

Most emission trends are the result of the increasing trend of AD, partly with decreasing EF at the same time. As result even the trend for Hg emissions is decreasing for a temporary period.



Emission trends in NFR 5.C.1.b.v

note: small changes for 2023

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] annual personal message from Stephan Neuser (contact URL: https://www.bestatter.de/verband/allgemeines-ueber-den-bdb/)
[2)] EMEP/EEA air pollutant emission inventory guidebook 2023, Copenhagen, 2023,

https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023

[3)] Stöcklein; Gass; Suritsch: “POP- und Hg-Emissionen aus abfallwirtschaftlichen Anlagen”, Teilvorhaben zum Globalvorhaben „Überprüfung des Standes der Technik der Emissionen prioritärer Schadstoffe für einzelne Industriebranchen (Kleinfeuerungsanlagen und abfallwirtschaftliche Anlagen)“; URL: https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/texte_38_2016_pop-und_hg-emissionen_aus_abfallwirtschaftlichen_anlagen.pdf; UBA-Texte 38/2016; im Auftrag des Umweltbundesamtes, April 2016

[4)] FKZ 3716 53 3021 „Umweltrelevanz und Stand der Technik bei Einäscherungsanlagen“ (Environmental relevance and state of the art for cremation plants); URL: https://www.umweltbundesamt.de/publikationen/umweltrelevanz-stand-technik-einaescherungsanlagen

[5)] Dreiseidler, A.; Baumbach, G.; Pregger, T.; Obermeier, A. (1999): Studie zur Korngrößenverteilung (< PM_{10} und < $PM_{2.5}$) von Staubemissionen. UBA-Forschungsbericht 297 44 853, Umweltbundesamt Berlin (Study on particle size distribution (< PM_{10} and < $PM_{2.5}$) of dust emissions)

5.C.2 - Open Burning of Waste

Category Code	Method	AD	EF
5.C.2	CS	Q	D, CS

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/F	B(a)P	B(b)F	B(k)F	I(x)P	PAH1-4	HCB	PCBs
-/-	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE	NE	NE	NE	NE	NE	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Within NFR sub-category 5.C.2 - Open Burning of Waste, the German emissions inventory provides only emissions from allowed bonfires and from other wooden materials burnt outdoors. Emissions from bonfires are key source for $PM_{2.5}$ and PM_{10}, but in principle of minor priority due to discontinuous appearance.

Please see chapter regarding farming/plantation waste: 3.F - Field burning of agricultural residues - this is banned by law in Germany. So there is no gap of reporting.

Emissions from open burning of wood and green waste for traditional purposes, so-called bonfires such as Easter fires, are reported model-based. In addition to biogenic carbon dioxide, emissions of NO_x, SO_2, CO, NMVOC, particulate matter ($PM_{2.5}$, PM_{10} and TSP), Polycyclic Aromatic Hydrocarbons (PAHs) and Heavy Metals are covered so far.

Method

For developing of a estimation frame a survey regarding the number of such bonfires was carried out by an expert work [1)]. As the result, questionnaires from municipalities and statistical projections for Germany for the year 2016 were checked. The

project has shown a declining trend since 1990. On the basis of expert judgement, a further reduction of emissions in the future is expected.

As discussed on Review 2020 regarding all relevant sources: A comparison shows that the volume of bonfires is significantly higher than the volume of campfires. In terms of number, however, the two types of fires are similar. Due to the large fluctuations of the minimum/maximum values, the median was proposed in study. In our view the estimation of bonfires emissions is conservative and completly.

Activity data

Activity data for this category are based on data from a step by step calculation: After the evaluation of the questionaires an extrapolation of the volume and the number of bonfires was made for Germany. For the years since 2019, it became visible that, in addition to the model-based continuous decrease in activities, special aspects must be taken into account: Because of the restrictions on public activities during the pandemic, modeling of less traditional events was searched for.

Two types of fires were already classified in the expert project: camp fires in the more private sector and, most importantly, Easter Fires in the more public sector. The calculations are now considered separately and the camp fires are modeled with a continued steady decline.

Here, Easter fires follow an approach about general percentage decreases and additionally in 2019 five percentage points decrease corresponding to various cancels due to forest fire risk. In 2020 and 2021, an additional 70 percent decrease was modeled due to cancellations for pandemic response (but no complete cancellation in Germany because there were exceptions and follow-up events). For 2022 no restrictions were modelled, only the known slight decreasing trend. The following values are the result of evaluation:

Table 1: Total annual mass of bonfires, in metric tonnes [t]

1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
431,394	414,276	397,157	380,038	362,919	345,800	135,170	134,297	324,915	322,005

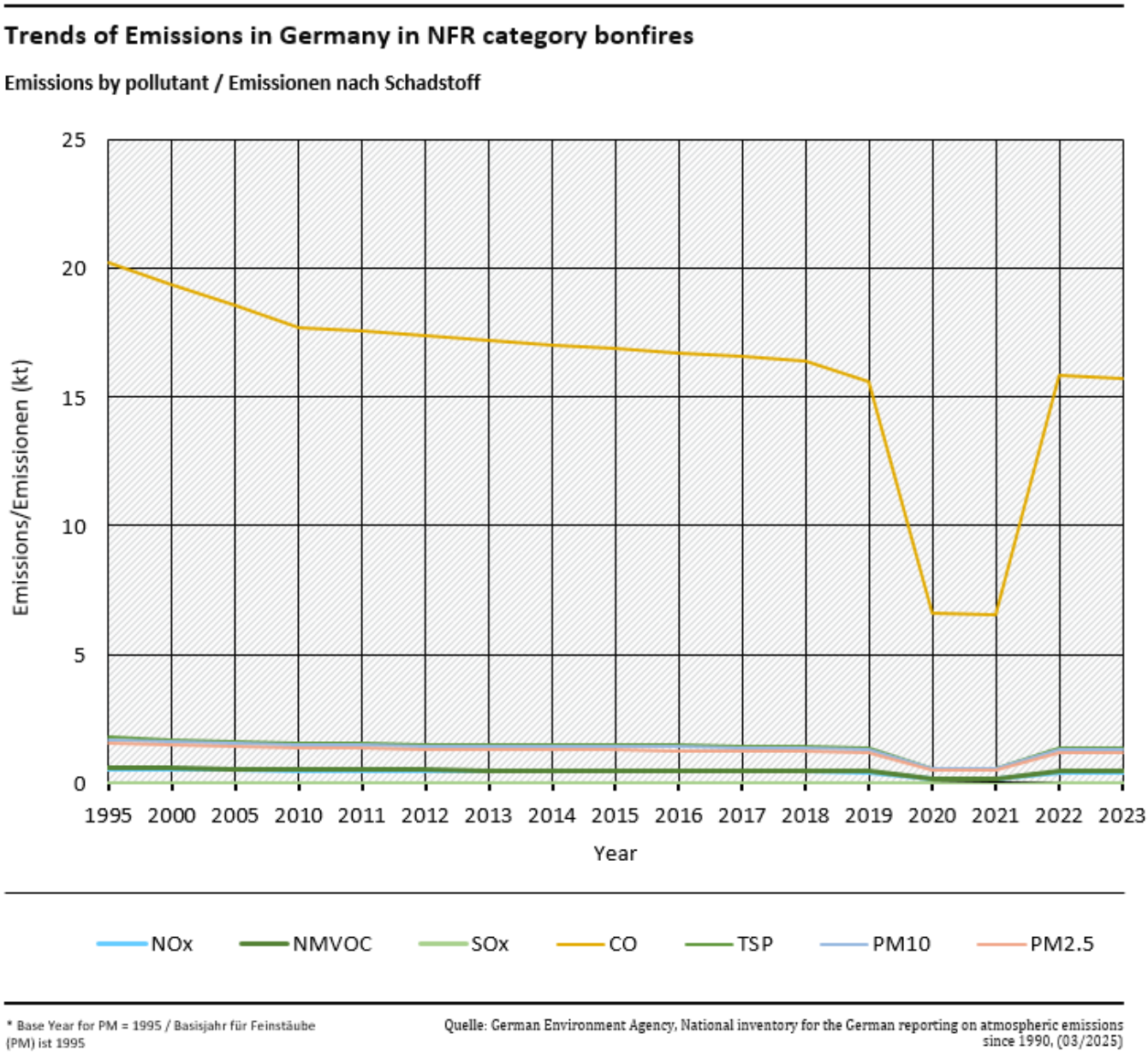
Emission factors

As discussed on Review 2020 regarding EF used and referenced: We use different EF from different references suitable for the burning of wooden wastes. We consider both fresh wood (garden and park waste) and dry wood (without coatings etc.). We have tried to find relevant parallels, for example because of the burning of fresh wood with regard to forest fires. But the most EF are from GB 2023 for 5.C.2, evaluated and corrected in use, as shown in the following table:

	value	unit	Current reference
CO	48.8	kg/ t	GB 2023 5.C.2, table 3-2
NO_x	1.38	kg/ t	GB 2023 5.C.2, table 3-2
SO_2	0.03	kg/ t	GB 2023 5.C.2, table 3-2
NMVOC	1.47	kg/ t	GB 2023 5.C.2, table 3-2
TSP	4.31	kg/ t	GB 2023 5.C.2, table 3-2
PM_{10}	4.13	kg/ t	GB 2023 5.C.2, table 3-2
$PM_{2.5}$	3.76	kg/ t	GB 2023 5.C.2, table 3-2
BC	1,05	kg/ t	GB 2023 5.C.2, table 3-2 (28% of PM2.5)
PCDD/F	10.0	µg/ t	GB 2023 5.C.2, table 3-1
PAH	3.39	g/ t	sum of single compounts
B[a]P	1.3	g/ t	IIR Ireland [2)]
B[b]F	1.5	g/ t	IIR Ireland [3)]
B[k]F	0.5	g/ t	IIR Ireland [4)]
I[...]P	0.09	g/ t	IIR Ireland [5)]
Pb	0.32	g/ t	GB 2023 5.C.2, table 3-2
Cd	0.13	g/ t	GB 2023 5.C.2, table 3-2

Trends in emissions

All trends in emissions correspond to trends of AD. No emissions reduction measures are identifiable in the long term.



Emission trends of bonfires

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] Wagner & Steinmetzer, 2018: Jörg Wagner, Sonja Steinmetzer, INTECUS GmbH Abfallwirtschaft und umweltintegratives Management: Erhebung der Größen und Zusammensetzung von Brauchtums- und Lagerfeuern durch kommunale Befragungen; URL: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2018-02-19_texte_11-2018_lager-brauchtumsfeuer.pdf; UBA-Texte 11/2018

[2), 3), 4), 5)] (EF is referenced to a former research project called 'Use of charcoal, tobacco etc.'. This was a literature research, which is only available via UBA library in German. The EF is relating wood burning as it was documented in Ireland's IIR

5.D.1 - Domestic & Commercial Wastewater Handling

Short description

Category Code	Method	AD	EF
5.D.1	T1	NS	D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NA	**-/-**	NA	NA	NA	NA	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

In category **5.D.1**, NMVOC emissions from domestic and commercial wastewater handling are reported. The domestic section is covered by wastewaters of municipal origin (large centralised plants; ranging from 1,000 up to >100,000 resident values). The commercial section is covered by industrial and commercial wastewaters, co-treated in municipal wwt-plants.

According to national experts, dry toilets (including latrines) do not play a role in sewage treatment in Germany because they are not in compliance with the legislation and thus do not constitute a procedure of orderly wastewater disposal. Due to that reason NH_3 emissions cannot be estimated and the notation key is set to NA.

§ 55 of the German water resources act (german: Wasserhaushaltsgesetz, WHG) demands the assuring of the general wellbeing in order of the wastewater disposal (german: gemeinwohlverträgliche Abwasserentsorgung). To ensure this requirement the water regarding laws of the several federal states of Germany (e.g. § 46 Abs. 1 WG BW; Art. 34 BayWG) obligate to the transfer of wastewater from the citizen to the public authorities or to assigned companies (german: Überlassungspflicht). The details are described in municipal bylaws which for the most cases obligate to the connection to

the municipal wastewater infrastructure (german: Anschluss- und Benutzungszwang). Exceptions are possible but most likely realised in form of septic tanks or drainless cesspools.

We assume that if there are very little exceptions for dry-toilets on a municipal level, that those are demanded to be separating toilets, as urine and faeces would be collected separately. Because of the necessary contact between urine and faeces to build ammonia from urea (contained in urine) by hydrolysis through urease (enzyme, contained in faeces) and the assumed very little number of exceptions, there are no assessable emissions of ammonia.

The superior federal law (WHG) described above was redesigned and implemented in its current form in the year 2009 following the reform of federalism (german: Föderalismusreform) and to implement requirements from the 2000/60/EC Water Framework Directive. The regulation has been described by the laws of the federal states before this time but latest with the implementation of the requirements of the 91/271/EEC directive concerning urban waste water treatment (e.g. BayROkAbwV).

Method

Emissions reported under this category are calculated using the Tier 1 approach of the EMEP/EEA Guidebook 2019, where the emission factor (EF) is 15 mg/m³ wastewater (Part B, 5.D, chap. 3.2.2, Table 3-1, p. 7 [1)]). This EF is multiplied with the total amount of wastewater (AD) treated in domestic and commercial wwt-plants, following the equation:

Emissions $_{(NMVOC)}$ = AD x EF
(ibid., chap. 3.2.1)

Activity data

Total volumes of treated municipal wastewater are derived by the German statistical agency (Statistisches Bundesamt, Fachserie 19, Reihe 2.1.2 [2)]). The data source is published on a three-year basis with new data only for the respective year of the update. The availability of the data starts in 1991 with an exception for the following update, which was for 1995. Missing data are inter- or extrapolated.

Emisson factors

See method

Uncertainties

The AD from Statistisches Bundesamt have an uncertainty of ±3% (normal distribution) whereas the uncertainty for the EF, due to its range (5/50 mg/m³), is -70 / +210 % and the distribution lognormal.

Recalculations

Recalculations were not necessary.

For **pollutant-specific information on recalculated emission estimates** for Base Year and 2022, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements



At the moment, no category-specific improvements are planned.

[1)] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook 2019, Copenhagen, 2019
[2)] Statistisches Bundesamt, Fachserie 19, Reihe 2.1.2

5.D.2 - Industrial Wastewater Handling

Short description

Category Code	Method	AD	EF
5.D.2	T1	NS	D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

In category **5.D.2**, NMVOC emissions from industrial wastewater handling are reported. The industrial section is covered by wastewaters from industrial processes. Main sectors are chemical industries, iron & steel industries, power generation, Food sector, Paper & Cardboard-production and “Other”-Industrial processes.

Method

Emissions reported under this category are calculated using the Tier 1 approach of the EMEP/EEA Guidebook 2019, where the emission factor (EF) is 15 mg/m³ wastewater (Part B, 5.D, chap. 3.2.2, Table 3-1, p. 7 [1)]). This EF is multiplied with the total amount of wastewater (AD) treated in industrial wwt-plants, following the equation:

Emissions $_{NMVOC}$ = AD x EF
(ibid., chap. 3.2.1)

Activity data

Total volumes of treated industrial wastewater are derived by the German statistical agency (Statistisches Bundesamt, Umweltnutzung und Wirtschaft. Tabellen zu den Umweltökonomischen Gesamtrechnungen. Teil 4: Wassereinsatz, Abwasser. Table 7.7 [2)]). The availability of the data starts in 1991 with new data for every following year, until 2001. Until then the data source is published on a three-year basis with new data only for the respective year of the update. Missing data are interpolated. Since the Wastewaterstatistic has not been updated since 2016, the data for Chemical Industry and Paper&Cardboard has been extrapolated until 2017 on the basis of an expert judgment, assuming for the Chemical Industry a yearly reduction of 1% and for Paper&Cardboard of 1,5%. For the remaining industries expert-judgement concluded that constant values since 2016 are deemed to be most probable.

Emisson factors

See method.
It should be noted that the described default emission factor was collected in Turkey for municipal wastewater treatment plants under specific climatic conditions in developing countries. The wastewater characteristics of the considered industries sometimes differ significantly from municipal wastewater.

Uncertainties

The AD from Statistisches Bundesamt have an uncertainty of ±3% (normal distribution) whereas the uncertainty for the EF, due to its range (5/50 mg/m³), is -70 / +210 % and the distribution lognormal.

Recalculations

Recalculations were not necessary.

For **pollutant-specific information on recalculated emission estimates** for Base Year and 2022, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook 2019, Copenhagen, 2019
[2)] Statistisches Bundesamt, Umweltnutzung und Wirtschaft. Tabellen zu den Umweltökonomischen Gesamtrechnungen. Teil 4: Wassereinsatz, Abwasser. Table 7.7

5.E - Other Waste (please specify in IIR)

Under NFR category **5.E - Other Waste**, Germany so far reports greenhouse gas emissions from the mechanical biological treatment (MBT) of waste as well as air-pollutant emissions from building and car fires.

Category Code	Method	AD	EF
5.E - Other Waste	see sub-category details		
consisting of / including source categories:			
5.E.1 - Mechanical Biological Treatment (MBT)	NA (GHG emissions only)		
5.E.2 - Building and Car Fires	D	NS	D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/F**	**PAHs**	**HCB**	**PCBs**
NE	NE	NE	NE	**L/-**	**L/-**	-/-	-/-	NE	-/-	-/-	-/-	-/-	-/-	-/-	NE	NE	NE	**L/-**	NE	NE	NE

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

5.E.1 - Other Waste: Mechanical-biological Treatment of Waste

Short description

Under NFR category 5.E.1 - Other Waste: Mechanical-biological Treatment of Waste, Germany only reports greenhouse gas emissions from the mechanical biological treatment (MBT) of waste.

NFR Code	Name of Category	Method	AD	EF	Key Category
5.E.1	Other Waste: Mechanical-biological Treatment of Waste	NA	5.E.1	Other Waste: Mechanical-biological Treatment of Waste	NA

5.E.2 - Other Waste: Building and Car Fires

Short description

For key source information please see the Overview-chapter 5.E.

Within NFR 5.E.2 - Other Waste: Building and Car Fires, emissions from building and car fires are reported.

Method

With a method for estimation the AD developed within a research project [1)], and after publication of Tier2-EF within the EEA-Guidebook 2019 [2)], a country-specific method was implemented and further developed so that now a full-scale-approach for all Buildings and the cars as well as an estimation for waste container fires can be conducted.

However, in all cases, only accidental fires are mentioned (including acts of vandalism).

Activity data

Official population statistics for Germany are applied as primary activity data.

From these statistical input data, the number of fires is estimated via the following steps:

- specific values for number of fires per 1,000 inhabitants,
- differentiated according to building,
- vehicle and container fires,
- Determination of the number of relevant fires per year in Germany in total,
- Differentiation of the fires according to building and vehicle fires,
- Differentiation of fires according to fire scale,
- Differentiation of building fires by building category,
- Conversion of different fires per year to full-scale fires per year - see addional description,
- Transfer of the results on the number of fires in the form of number of full-scale fires per year differentiated by fire categories.

In order to apply the emission factors available from the EMEP/EEA Guidebook, the annual number of building fires is differentiated for detached and undetached, appartment and industrial buildings.

Table 1: Estimated shares per building category, for recent years

detached houses	undetached houses	appartement buildings	industrial buildings
53%	13%	13%	20%

Description of Conversion to full-scale fires per year

During Review 2023 TERT asked for to more information of method zu fires' conversion, that is given following:

As other inventory compilers weighting factors were applied for each category in order to determine the number of full-scale fires. The idea is to assume that the default EF stands for complete burning of objects, but in real in most cases fires are extinguished as soon as possible.

Table 2: Percental shares of burnt combustible material per type of fire

type of fire	% of burnt combustible material
Building fire, small a)	5
Building fire, small b)	30
Building fire, medium	75

type of fire	% of burnt combustible material
Building fire, major	100
Car fires, small	5
Car fires, medium	30
Car fires, major	100
Container fires, standard	50

Germany uses the following information on EFs: It can be derived from the given information and references on building fires that EFs are given for full-scale fires [3)]. We have no country specific information, but the other appoaches seem to be suitable for our situation, too.

Table 3: Estimated number of full-scale fires, per category, per 1,000 inhabitants, for recent years

detached houses	undetached houses	appartement buildings	industrial buildings	cars/ vehicles	containers
0.02	0.05	0.05	0.08	0.18	0.15

As results we calculate with with the following range of data:

Table 4: Estimated number of full-scale fires per year, per category, range over time

detached houses	undetached houses	appartement buildings	industrial buildings	cars/ vehicles	containers
15,700 - 17,000	4,100 - 5,300	4,200 - 4,700	6,500 - 6,600	15,000 - 15,400	4,100 - 4,200

Emission Factors

For most pollutants, tier2 default values from the EMEP/EEA air pollutant emission inventory guidebook 2019 (as 2016), Chapter 5.E - Other waste, tables 3-2 to 3-6 are applied [4)] are applied.

Due to lack of emissions factors for black carbon we assume the following analogy: BC = 10% of the defaukt-EF for $PM_{2.5}$ as provided in Table 3-40, Tier 2 emission factor for conventional stoves, wood and similar wood waste.

Regarding containers we use figures from Table 6.22 of the Danish IIR [5)].

In contrast to building fires and in accordance to the emission factor values provided in the EMEP/EEA Guidebook, no additional differentiation e.g. of vehicle categories is implemented.

Verification

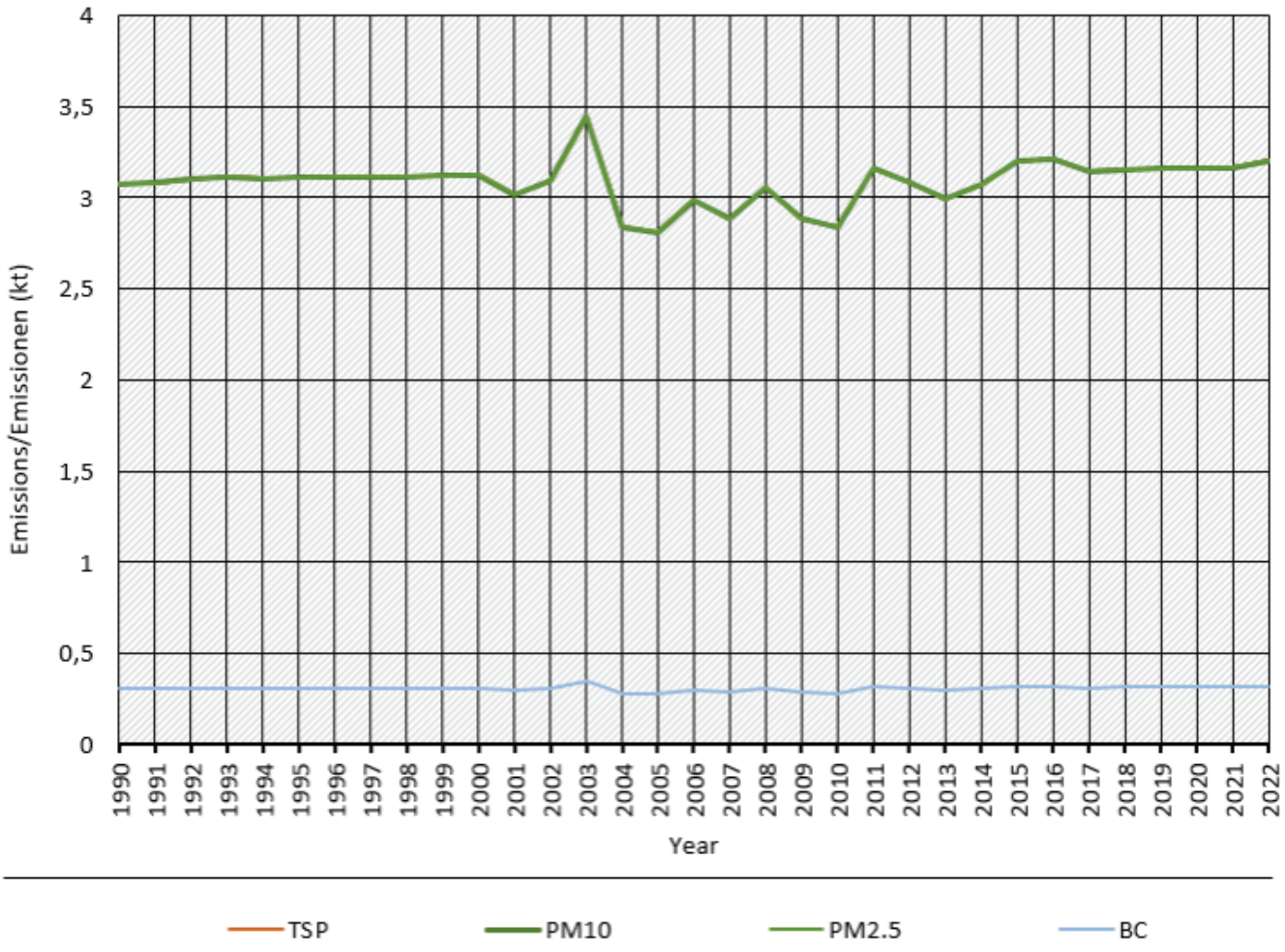
For verification purposes, a consultant has checked the Informative Inventory Reports (IIRs) of other countries. In the IIRs of Denmark and Iceland it is additionally stated that the emission factors refer to so-called “full-scale fires” and therefore the activity data (i.e. the number of fires) must be converted to so-called full-scale equivalent fires.

Trends in emissions

All trends in emissions correspond to trends of AD. No rising trends are to identify, but a jump in 2003 due to many forest fires. Forest fires are part of the total fire AD and affect so the calculation in general, but here figures without forest fires are shown only:

Trends of Emissions of accidental fires

Emissions of particles, three fractions overlapped

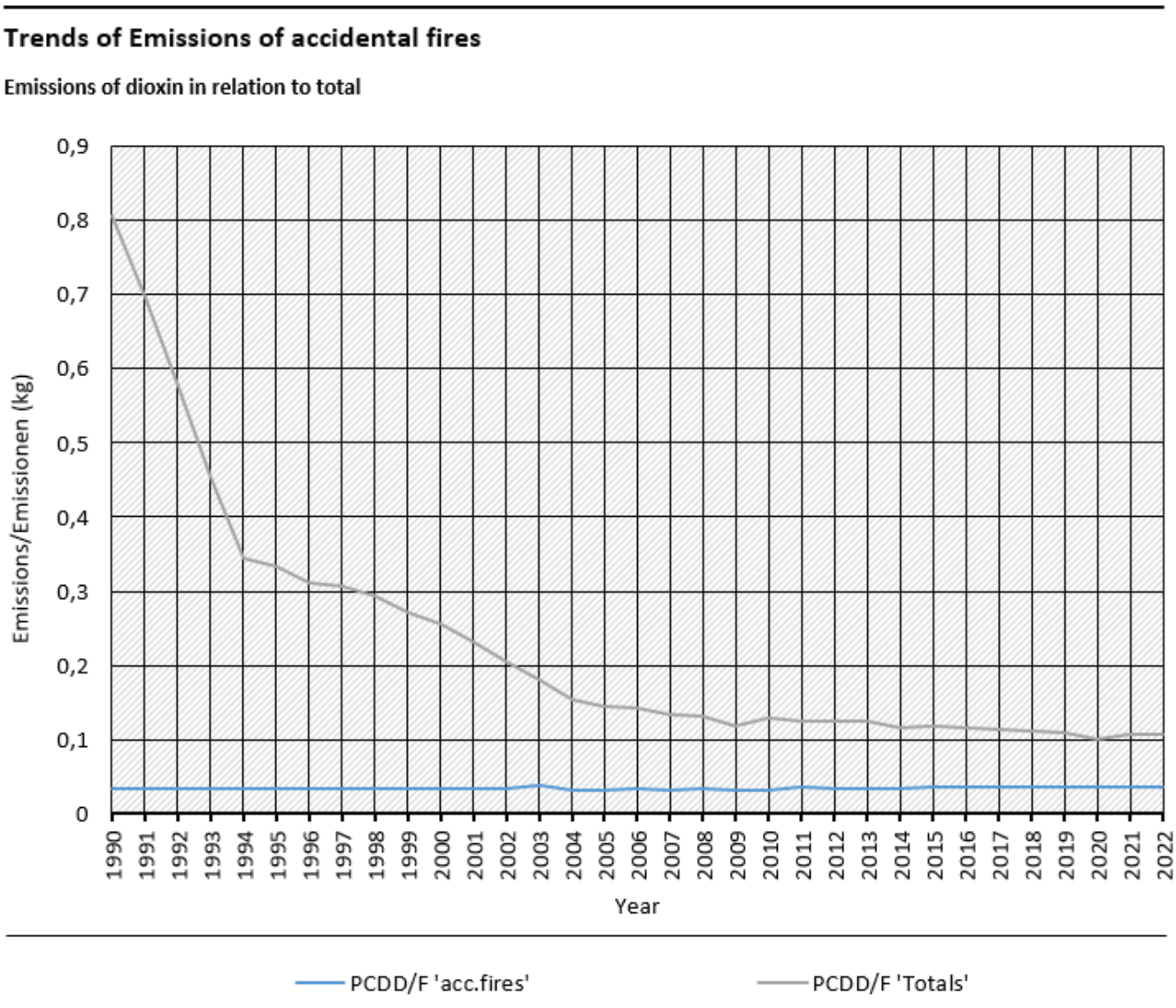


* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (01/2024)

Emission trends in NFR 5.E.2

Due to no sinking trends some pollutants are highlighted in present, so the relation of the PCDD/F is now important:



Emission trends in NFR 5.E.2

note for both graphs: no significant change in 2023

Recalculations

Recalculations were necessary due to change of one figure: Change of data source for fire operations from model-based extrapolation to fire fighter's statistics Germany (DBV), because DFV figures give annual changes [6)].

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the recalculation tables following chapter 9.1 - Recalculations.

Planned improvements

At the moment, no category-specific improvements are planned.

[1)] Project leader Site: https://oekopol.de/en/archiv-en/?doc=EN_720, Publication in prep. as Umweltbundesamt 2021: Research-ID 3717411050, “Wissenschaftlich-methodische Grundlagen der Inventarverbesserung zur Umsetzung der Hinweise aus den Inventarüberprüfungen 2016 und 2017”

[2), 4)] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/5-waste/5-e-other-waste/view

[3)] See IIR of Denmark and of Norway

[5)] https://cdr.eionet.europa.eu/dk/un/clrtap/iir/envxgkjdw/Denmarks_Informative_Inventory_Report_2019.pdf

[6)] https://www.feuerwehrverband.de/app/uploads/2023/11/231128_Statistik-Webseite.pdf

CHAPTER 7: NFR 6 - Other (anthropogenic) emission sources

Category Code	Name of category	Method	AD	EF	Key Category
6	**Other Sources**	*see sub-categories*			
consisting of / including source categories					
6.A.1	Ammonia emissions from human sweating and breathing	T1	NS	D	
6.A.2	Ammonia emissions from pets	T1	NS	D	

6 - Other Sources

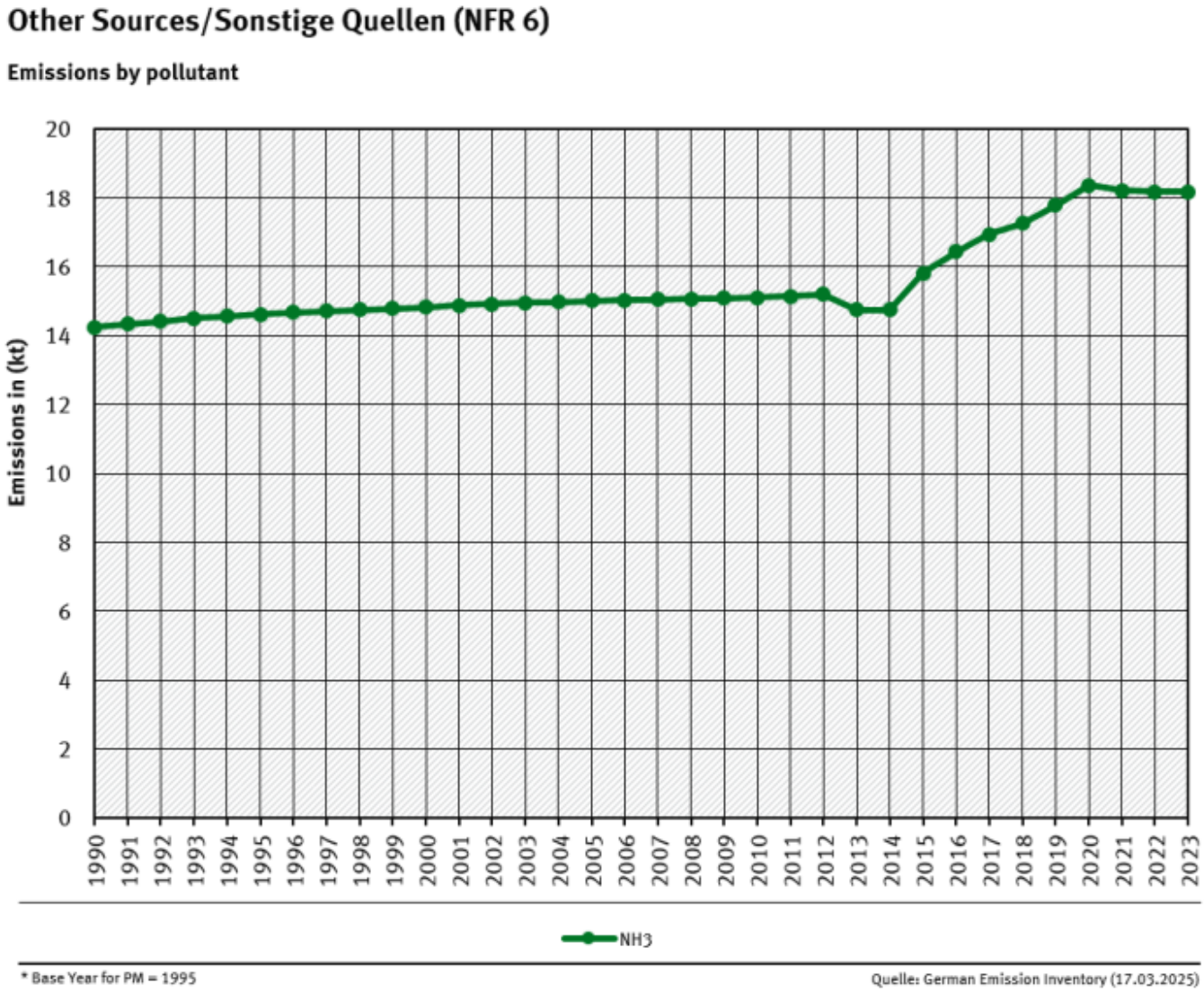
Within **NFR 6 - Other Sources**, activities and resulting emissions are taken into account that cannot be related to any of the other NFR catgeories.

For the time being, the two activities or emission sources taken into account here are human breathing (respiration) and sweating (transpiration) as well as domestic animals (pets).

NFR code	NFR name
6.A.1	Emissions from human re- and transpiration
6.A.2	Ammonia emissions from pets

Overview

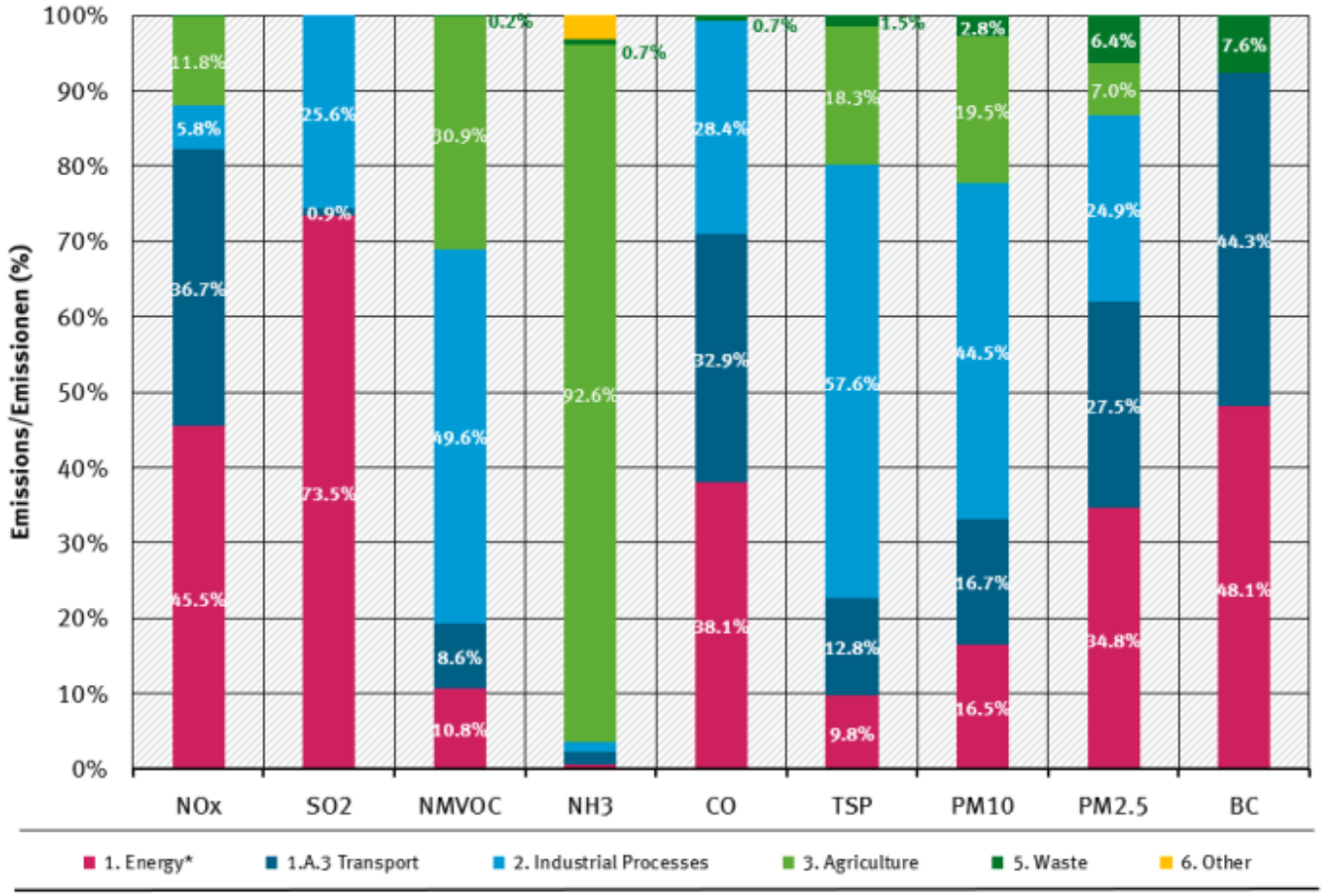
Emission trends for main pollutants in *NFR 6 - Other Sources*:



Contribution of NFRs 1 to 6 to the National Totals, for 2021

Contribution of NFR categories to the emissions

percentages per air pollutant, 2023



* w/o Transport / ohne Verkehr (1.A.3)

Quelle: German Emission Inventory (17.03.2025)

6.A.1 - Ammonia emissions from human respiration and transpiration

Short description

Category Code	Method	AD	EF
6.A.1	T1	NS	D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	**NH_3**	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NA	NA	NA	**-/-**	NA	NA	NA	NR	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

In addition to animal-related excretion, nitrogen (N) is also introduced into the environment through human consumption of food and later disposed of.

Although nitrogen is released into the wastewater system as urine, mainly, physiological processes such as sweating and respiration also release nitrogen as ammonia.

Methodology

The calculation of ammonia emissions in this area is made for the first time and is based on the methodological description of Visschendijk et al. (2022) [70)].

For the complete time series, the emissions are calculated as follows:

$$EM = AD_{(number\ of\ German\ inhabitants)} \times EF_{(kg\ emission\ per\ inhabitant)}$$

Activity data

The number of inhabitants in Germany is derived from the Federal Statistical Office of Germany (DESTATIS) on an annual basis.

The number of people living in Germany by end of June of a specific year is taken as activity data. As of June 2023, 82,7 million people lived in Germany.

The following table shows the population figures over time.

Table 1: Population figures in Germany, as of 1990

1990	**79,753,227**
1995	**81,307,715**
2000	**81,456,617**
2005	**81,336,663**
2010	**80,284,071**
2011	80,274,983
2012	80,523,746
2013	80,767,463
2014	81,197,537
2015	**82,175,684**
2016	82,521,653
2017	82,792,351
2018	83,019,213
2019	83,166,711
2020	**83,155,031**
2021	83,237,124
2022	82,711,282
2023	82,711,282

Emission factor

For the calculation of ammonia emissions in this category, the highest of the emission factors given in Sutton et al. (2000)[71)] are used, resulting in a total emission factor of 0.0826 kg NH_3-N per person per year (according to the assumptions sum of 74.88 (sweating) and 7.7 (breathing) grams NH_3-N per person per year, respectively).

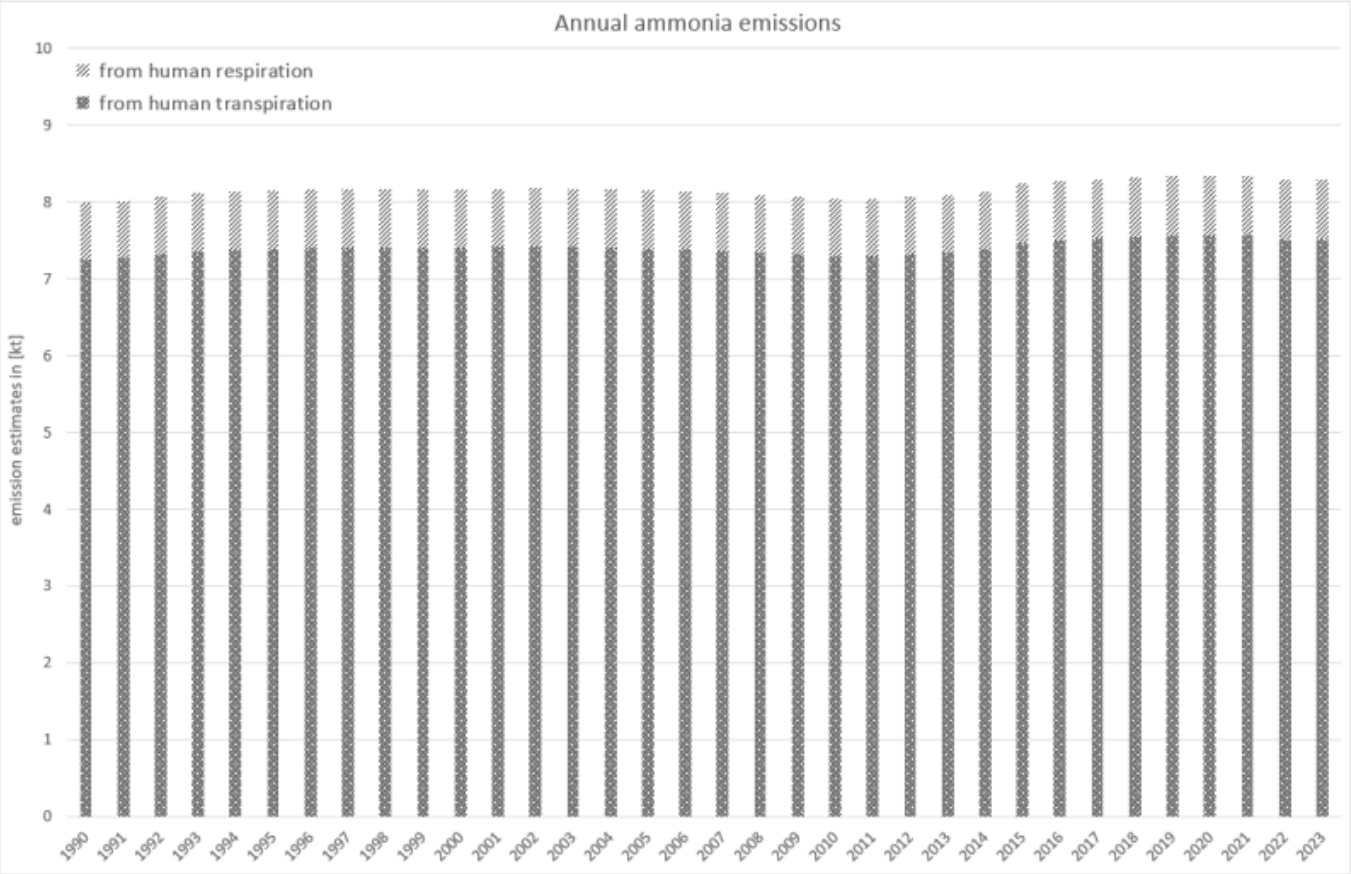
Here, to avoid underestimating of emissions, the higher EFs were applied.

The amount was converted to the amount of ammonia using the stoichiometric factor of 17/14.

Emission Trend

The average value over tha last decade is 8.3 kt NH_3 / year, so this category is not a major source of regional NH_3 emissions.

The following figure shows the emission trend as of 1990:



Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were made compared to the last submission.

Uncertainties

Activity data obtained from the Federal Statistical Office of Germany (DESTATIS) usually have an uncertainty of ±3%.

As emission factors vary between different data sources and the amount of ammonia volatilized is based on an assumption, uncertainties for the emission factors are expected to be relatively high.

Hence the overall uncertainty for the emission estimation of NH_3 is estimated by expert judgement to be ±95%.

Planned Improvement

At the moment, no source-specific improvements are planned.

70)
Visschedijk, A.J.H., J.A.J. Meesters, M.M. Nijkamp, W.W.R. Koch, B.I. Jansen & R. Dröge, 2022. Methods used for the Dutch Emission Inventory. Product usage by consumers, construction and services. RIVM Report 2022-0003. RIVM, Bilthoven., chapter 19 [https://rivm.openrepository.com/bitstream/handle/10029/625730/2022-0003.pdf?sequence=1&isAllowed=y]

71)
Sutton, M.A., U. Dragosits, Y.S. Tang & D. Fowler, 2000. Ammonia emissions from non-agricultural sources in the UK. Atmospheric Environment 34 (2000), 855–869.

6.A.2 - Ammonia emissions from pets

Short description

In addition to non-agricultural sources of ammonia (NH_3), this chapter discusses emissions from domestic animals (pets).

This emission source ist taken into account for the first time with the current submission and with dogs and cats as the only two groups of pets covered so far.

Category Code	Method	AD	EF
6.A.2	T1	NS	D

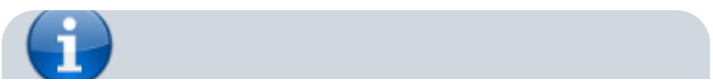
Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
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M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	NMVOC	SO_2	**NH_3**	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
NA	NA	NA	**-/-**	NA	NA	NA	NR	NA	NA	NA

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Ammonia emissions from pets have been calculated for the first time in submission 2024 and are based on the methodological description of Sutton et al. (2000) [72)]and the Guidebook 2023 [73)]. For the complete time series, the emissions are calculated as follows:



$$EM = AD_{(number\ of\ pets)} \times EF_{(kg\ ammonia\ per\ animal\ and\ year)}$$

Activity data

As there are no official statistics on pets in Germany, data from repeated representative surveys of 5.000 to 7.000 households conducted on behalf of the German Pet Food Association (Industrieverband Heimtierbedarf e.V., IVH, and the Zentralverband Zoologischer Fachbetriebe Deutschlands e.V., ZZF)[74)] for the period 2012-2023 are applied.

The latest EMEP EEA Guidebook refers to European statistics. The figures for 2021 and 2022 are consistent with those in the publication mentioned above and according to the 2023 Guidebook only the main categories cats (39% by animal catory) and dogs (27% by animal catory) were considered.

Time series for the main categories of pets are obtained by the numbers of the survey for the years 2012 to 2023. Data for 1990 are estimated retrospectively using the number of households (see also https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Haushalte-Familien/Tabellen/1-3-privathaushalte-neuer-zeitvergleich.html) and the trend between 1991 and 2013 (+13.9%) is accounted for as a baseline for 1990 animal numbers.

The data for 1990 and 2012 are used to gapfill the missing animal numbers by linear interpolation.

The following table shows the estimated pet population over time:

Table 1: Animal numbers in 10^6, as of 1990

	Cats	Dogs
1990	**10.80**	**6.50**
1995	**11.16**	**6.71**
2000	**11.50**	**6.92**
2005	**11.83**	**7.12**
2010	**12.17**	**7.32**
2011	12.23	7.36
2012	12.30	7.40
2013	11.50	6.90
2014	11.80	6.80
2015	**12.90**	**7.90**
2016	13.40	8.60
2017	13.70	9.20
2018	14.80	9.40
2019	14.70	10.10
2020	**15.70**	**10.70**
2021	16.70	10.30
2022	15.20	10.60
2023	15.70	10.50

Emission factors

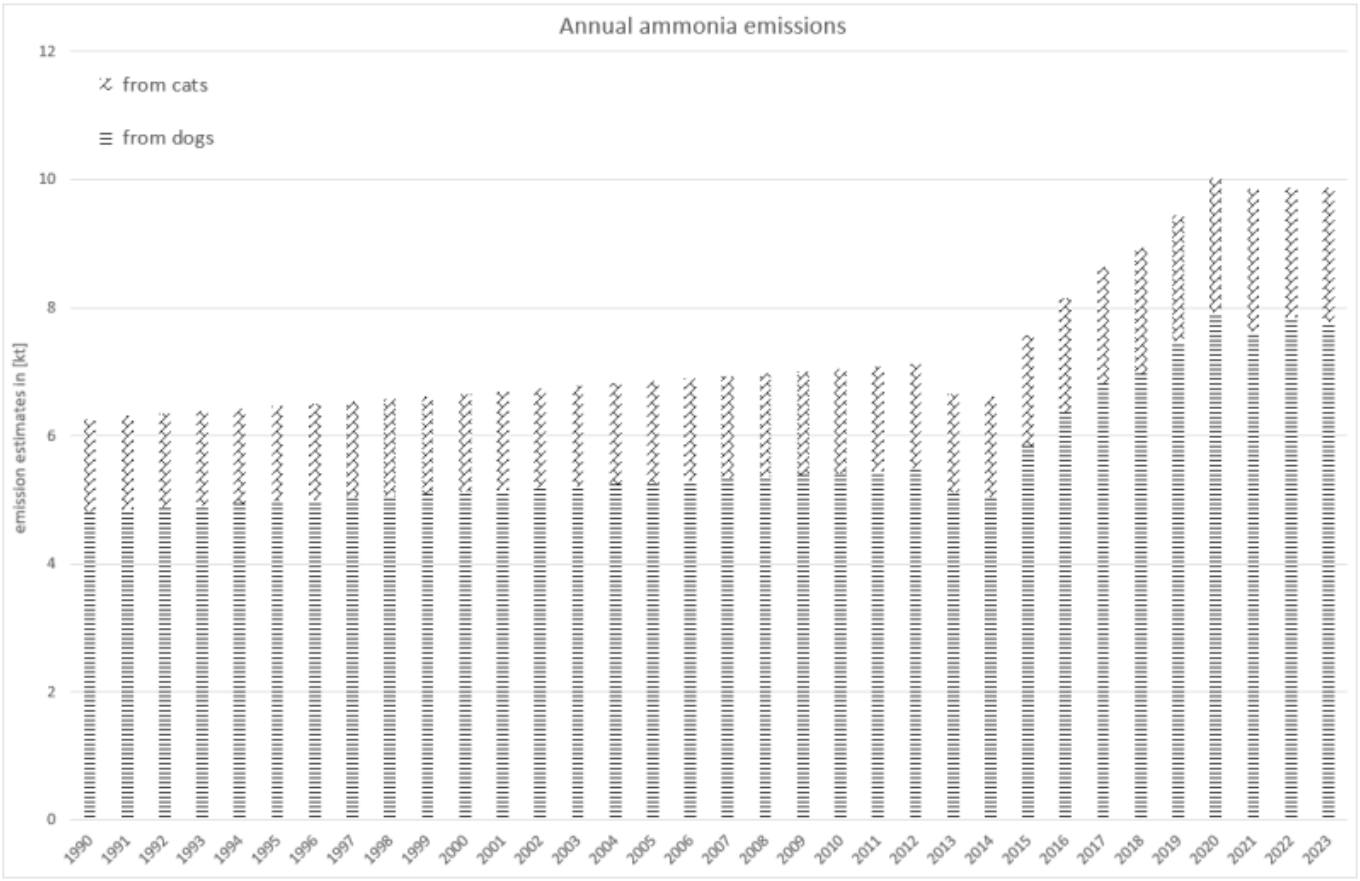
For the calculation of ammonia emissions in this category, the mean (best estimate) of the emission factors given in Sutton et al. (2000) are used:

- EF_{cats}: 0.11 kg NH_3-N $animal^{-1}$ $year^{-1}$
- EF_{dogs}: 0.61 kg NH_3-N $animal^{-1}$ $year^{-1}$

The emission factors were converted to the amount of ammonia using the stoichiometric factor of 17/14.

Emission Trend

The following figure shows the development of emissions for the pet-categories dogs (EM_{dog}) and cats (EM_{cat}) as of 1990:



In recent years, an increasing trend can be observed, resulting in a mean value (between 2020 to 2023) of 9.9 kt NH_3/a or 2 % of total national ammonia emissions reported for 2023. Especially since the Corona year 2020, more people have acquired pets such as dogs.

Recalculations

As these **emissions are reported for the first time**, no recalculations occur against the previous submission.

Uncertainties

For pets the uncertainty of the animal numbers is assumed to be 5% (standard error), and hence 10% for half the 95% confidence interval, with normal distribution.

There is no information on the uncertainty of the emission factors. However, as EF vary between different sources and the amount of ammonia volatilized is based on an assumption, EF uncertainties are expected to be relatively high. Therefore, an uncertainty of 50% for half the 95-percent confidence-interval (normal distribution) is assumed.

Planned Improvement

At the moment, no source-specific improvements are planned.

72)

Sutton, M.A., U. Dragosits, Y.S. Tang & D. Fowler, 2000. Ammonia emissions from non-agricultural sources in the UK. Atmospheric Environment 34 (2000), 855–869.

[73)]

EMEP/EEA Guidebook 2023, Chapter 6, https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/6-other-sources/6-a-other-2023/view

[74)]

https://web.archive.org/web/20240922112326/https://www.ivh-online.de/der-verband/daten-fakten/anzahl-der-heimtiere-in-deutschland.html, 2024

CHAPTER 8: NFR 11 - Natural emission sources

Category Code	Name of category	Method	AD	EF
11	**Natural Sources**	*see sub-categories*		
consisting of / including source categories				
11.A	Volcanoes	*not occurring in Germany*		
11.B	Forest Fires	CS, T2	CS	D
11.C	Other Natural Sources	*see sub-categories*		

11.B - Forest Fires

Short Description

In Germany’s forests, prescribed burning is not applied. Therefore, all forest fires are categorized as wildfires (including emissions from forest fires occurring naturally or caused by humans).

As NFR 11.B is a memo item category, emissions reported here are not accounted for in the National Totals.

Category Code	Method	AD	EF
11.B	CS, T2, T1	CS	D

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	Heavy Metals	POPs
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	NA	NA
This memo item source category is not included in the key category analysis.										

Methodology

For calculating the emissions of wildfires a country specific Tier2 approach was used. The mass of carbon emitted M(C) was calculated using the adapted equation follows the methodology of Seiler and Crutzen (1980) [75)].



$$M_C = 0.45 \times A \times B \times \beta$$

where:

0.45 = average fraction of carbon in fuel wood;

A = forest area burnt in [m²];

B = mean above-ground biomass of fuel material per unit area in [kg/m²];

β = burning efficiency (fraction burnt) of the above-ground biomass.

The data on forest areas burnt for the period 1990 to 2023 have been taken from the German forest fire statistic (BLE, 2024)[76)] managed by the Federal Agency for Agriculture and Food. The mean above-ground biomass of fuel material was determined from the pools above ground biomass, dead wood and litter. The mean above-ground biomass and dead wood biomass was derived for each year by linear extrapolation and interpolation between the

- German National Forest Inventories of 1987, 2002, 2012, 2022 (Bundeswaldinventuren 1987, 2002, 2012, 2022),
- the inventory study 2008 and,
- the carbon inventory 2017.

Biomass of Litter was derived for each year by linear interpolation between 1990 and 2006 and extrapolation from 2007 based on the both Forest soil inventories (BZE I Wald (1990)[77)] and BZE II Wald (2006)[78)]).

Pursuant to König (2007) [79)], 80% of the forest fires in Germany are surface fires and 20% crown fires. In accordance to the IPCC Good Practice Guidance for LULUCF (2003) a burning efficiency of 0.15 was used for surface fires and an efficiency of 0.45 was used for crown fires.

The emissions for the pollutants were calculated by multiplying the mass of carbon with the respective emission factors from table 3-3 (EMEP/EEA, 2019)[80)].

For the calculation of particulate emissions (TSP, PM_{10} and $PM_{2.5}$) the burnt biomass was multiplied with the respective emission factors from table 3-5 (EMEP/EEA, 2019). Those particulate emission factors have been estimated by averaging the emission factors from the US Environmental Protection Agency (USEPA, 1996) [81)] methodology, since no better information is available. Those emission factors are assumed to be the same for all types of forest.

The Guidebook does not indicate whether EFs have considered the condensable component (with or without).

Activity data

The data on forest areas burnt for the period 1990 to 2023 are based on the German forest fire statistic (BLE, 2024) managed by the Federal Agency for Agriculture and Food.

Table 1: Area of forest burnt from 1990 until the latest reporting year, in [ha]

1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1,606	592	581	183	522	214	269	199	120	526	283	395	2,349	2,711	368	148	3,058	1,240

Emission factors

For the year 2021 the follwing estimated emission factors were applied:

Table 2: Emission factors applied for 2023

	EF_{2023}
NO_x	145.94
CO	5205.11
NMVOC	459.70
SO_x	35.03
NH_3	39.40
TSP	826.98
PM_{10}	535.10
$PM_{2.5}$	437.81
BC	39.40

In addition, a single but large-scale fire which occurred in September 2018, is taken into account here. As an exceptionally large amount of CO_2 was released during this event, a detailed description of the circumstances can be found in the NIR 2020, Chapter 6.8.2.5 [82)] .

The burned area of the drained moor used as a military facility covered 1,221 ha. The fire was extensively investigated and documented by the Federal Office for Infrastructure, Environmental Protection and Services of the German Armed Forces. The emissions are calculated according to IPCC GL (2006), chapter 2, form 2.27 [83)].

The product $M_B \times C_f$ is set to 336 t d.m. ha^{-1} according to Table 2.6 and equation 2.7, 2013 IPCC Wetlands Supplement [84)], i.e. it is assumed that the moor was completely drained during the fire.

- M_B = mass of fuel available for combustion, tonnes ha-1 (i.e. mass of dry organic soil fuel)
- C_f = combustion factor, dimensionless

For calculating CO emissions, the EF according to Table 2.7, 2013 IPCC Wetlands Supplement 207 g $(kg\ dm)^{-1}$, is taken into account, resulting in 85 kt CO.

Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Planned Improvement

At the moment, no source-specific improvements are planned.

75)
Seiler, Wolfgang, and Paul J. Crutzen. “Estimates of gross and net fluxes of carbon between the biosphere and the

atmosphere from biomass burning.” Climatic change 2.3 (1980): 207-247.
76)

BLE (Bundesanstalt für Landwirtschaft und Ernährung), (2023, 12. Juli), 2024: Waldbrandstatistik der Bundesrepublik Deutschland für das Jahr 2023, Bonn: 19 p., https://www.ble.de/DE/BZL/Daten-Berichte/Wald/wald_node.html
77)

WOLFF, B. & RIEK, W. (1997): Deutscher Waldbodenbericht 1996 - Ergebnisse der bundesweiten Bodenzustandserhebung in Wald (BZE) 1987 - 1993. Hrsg.: Bundesministerium für Ernährung, Landwirtschaft und Forsten, Bonn, Bd. 1 u. 2., 144 S.,https://web.archive.org/web/20230308011726/https://www.bmel-statistik.de/fileadmin/daten/FHB-0320205-1996.pdf
78)

WELLBROCK , N., AYDIN, C.-T., BLOCK, J., BUSSIAN, B., DECKERT, M., DIEKMANN, O., EVERS, J., FETZER, K. D., GAUER, J., GEHRMANN, J., KÖLLING, C., KÖNIG, N., LIESEBACH, M., MARIN, J., MEIWES, K. J., MILBERT, G., RABEN, G., RIEK, W., SCHÄFFER, W., SCHWERHOFF, J., ULLRICH, T., UTERMANN, J., VOLZ, H.-A., WEIGEL, A. & WOLFF, B. (2006): Bodenzustandserhebung im Wald (BZE II) Arbeitsanleitung für die Außenaufnahmen. Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Berlin, 413 S.
https://www.bmel.de/DE/themen/wald/wald-in-deutschland/bodenzustandserhebung.html
79)

König, H.-C., 2007. Waldbrandschutz - Kompendium für Forst und Feuerwehr. 1. Fachverlag Matthias Grimm, Berlin, 197 S.
80)

EMEP/EEA, 2019:
https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/11-natural-sources/11-b-forest-fires/view
81)

USEPA, 1996: Compilation of Air Pollutant Emission Factors Vol.1. Stationary, Point and Area Sources. Report AP-42, fifth edition
82)

NIR (2020): National Inventory Report 2020 for the German Greenhouse Gas Inventory 1990-2018. Available in April 2020
83)

IPCC (Intergovernmental Panel on Climate Change) (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use. Eds.: Eggleston S., Buendia L., Miwa K., Ngara T., Tanabe K. (Eds). IEA/OECD, IPCC National Greenhouse Gas Inventories Programme, Technical Support Unit, Hayama, Kanagawa, Japan.
http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html
84)

IPCC (Intergovernmental Panel on Climate Change) (2014b): 2013 Supplement to the IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G.(eds). Published: IPCC, Switzerland http://www.ipcc-nggip.iges.or.jp/public/wetlands/index.html

11.C - Other Natural Sources

Short description

Within **NFR 11.C - Other Natural Sources: Other**, natural activities and resulting emissions other than volcanoes (11.A) and forest fires (11.B) are to be taken into account.

The 2023 EMEP/EEA Guidebook distinguishes the following emission sub-categories of **NFR 11.C - Natural Sources: Other**:

NFR 11.C sub-categories
Other natural sources: Non-managed & managed forests
Other natural sources: Natural grassland and other vegetation
Other natural sources: Wetlands and waters
Other natural sources: Animals
Other natural sources: Geological seepage
Other natural sources: Forest & grassland soils
Other natural sources: Lightning
Other natural sources: Changes in forest and other woody biomass stock
Other natural sources: Forest and grassland conversion
Other natural sources: Abandonment of managed land
Other natural sources: CO_2 from or removal into soil
Other natural sources: Other

However, for the time being, from the natural sources listed above, only emissions from lightning is taken into account in the German emissions inventory.

NOTE: As NFR 11.C is a memo item category, emissions reported here are not accounted for in the National Totals.

Other natural sources: Lightning

For the time being, the only natural emission source reported within NFR 11.C is lightning.

Category Code	Method	AD	EF
11.C	T1	NS	D

Category Code	Method	AD	EF
Method(s) applied			
D	Default		
T1	Tier 1 / Simple Methodology *		
T2	Tier 2*		
T3	Tier 3 / Detailed Methodology *		
C	CORINAIR		
CS	Country Specific		
M	Model		
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.			
(source for) Activity Data			
NS	National Statistics		
RS	Regional Statistics		
IS	International Statistics		
PS	Plant Specific		
As	Associations, business organisations		
Q	specific Questionnaires (or surveys)		
M	Model / Modelled		
C	Confidential		
(source for) Emission Factors			
D	Default (EMEP Guidebook)		
CS	Country Specific		
PS	Plant Specific		
M	Model / Modelled		
C	Confidential		

NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Heavy Metals	POPs
-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
This memo item source category is not included in the key category analysis.										

Lightning (and corona discharge) during thunderstorm events cause atmospheric chemical reactions to take place at high voltages and high temperatures. These reactions cause the production of NO_x in the atmosphere.

Methodology

The calculation of NO_x emissions from lightning uses strike counts from the German weather service and default emission factors from the 2023 EMEP/EEA guidebook [1)].

For the complete time series, the emissions are calculated as follows:

EM = **AD** (number of lightning strikes) * **EF** (kg emission per strike)

Activity data

The number of lightning strikes in Germany is taken from a commercial system called “BLIDS” run by Siemens. The data has been cross-referenced with information from the German weather service. Consistent strike count data is available from 1992 onward and has been back-populated to cover the full time series since 1990. The following table shows the strike figures over time.

Table 1: Annual number of lightning strikes in Germany, as 1990, in [1,000 strikes]

1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
443	394	1,026	802	589	687	656	542	623	550	432	443	446	329	399	512	242	316

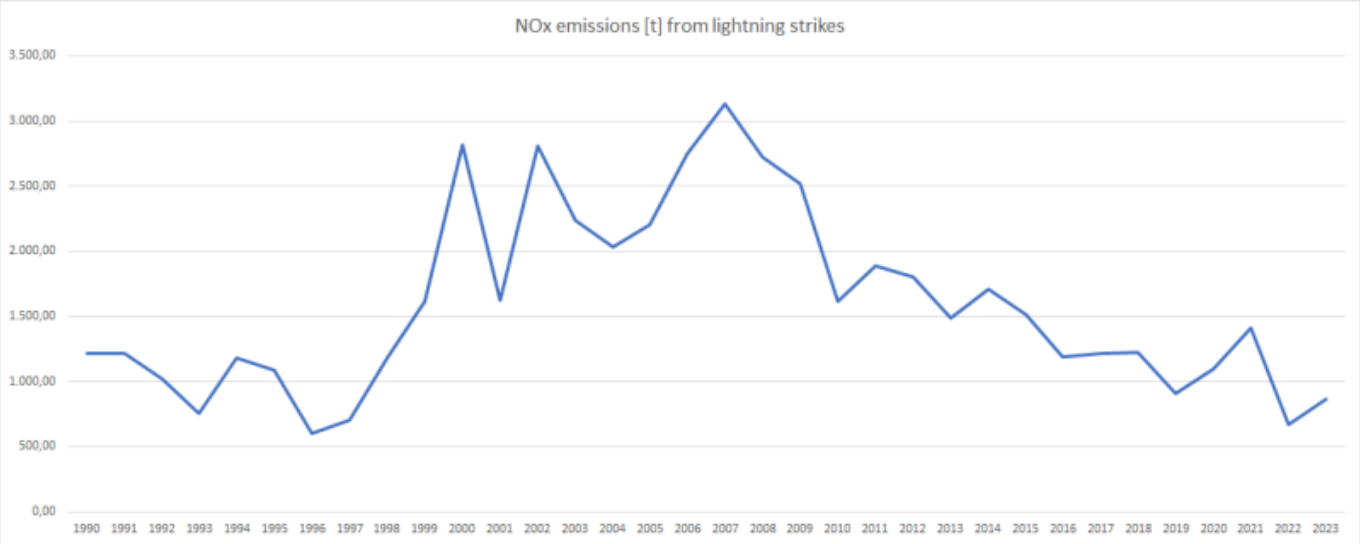
Emission factor(s)

For the calculation of emissions in this category, the Guidebook emission factor of 2.75 kg NO_x per strike is used.

Emission Trend

The emission value is solely dependent on the strike count and varies between 1 to 3 kilotons of NO_x per year.

Figure 1: NFR 11.C, NO_x emissions from lightning



Recalculations

With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

Uncertainties

The AD from BLIDS does have a low uncertainty of ± 3%. The uncertainties for the emission factors are estimated to be relatively high, being a default value. Hence the overall uncertainty for the emission estimation of NO_x from lightning is qualified estimated by expert judgement to be high (>50%).

Planned Improvement

At the moment, no source-specific improvements are planned.

[1)] EMEP/EEA 2023: EMEP/EEA air pollutant emission inventory guidebook 2023, URL: https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/11-natural-sources/11-c-other-natural-sources-6/view, Copenhagen, 2023

CHAPTER 9.1 - Recalculations



Generally, improvement of the emission inventory is an ongoing task and triggers recalculations for all source categories and pollutants frequently.

Further information regarding recalculations (especially due to changes in methods or activity data) can be found in the corresponding chapters of the **National Inventory Document 2025** (NID 2025) [1)].

Possible reasons for Recalculations

Due to the ever ongoing efforts to improve the inventory, more or less broad recalculations become necessary with each new submission.

Possible reasons for recalculations are

- **new** (sub-)**categories** to be included in the inventory or re-allocation of existing sub-categories within the inventory
- **data** (activity data & emission factors) for certain (sub-)categories **available for the first time**
- **change of data sources** (for activity data and emissions)
- use of **new emission factors** (due to: inquest, research projects, expert judgement etc.)
- **improvement of methods** used for calculating emissions
- **outcome of** ongoing **review** activities under both UN FCCC and UN ECE
- etc.

All these changes can effect *specific years* of the inventory as well as the *entire time series*, leading to more or less significant changes within the emission trends.

Declaration of Recalculations

Under UN FCCC reporting, parties have to comment any recalculations in any year leading to differences between latest and current submission for a given year or the time period or series. Thereby, highest attention is given to recalculations within base year and the most current year of the latest submission:

Recalculations in Base Year data

- mostly rather small but of highest importance
- mostly due to changed methods or emission factors used for entire time series
- impact on basis of any evaluation

Recalculations in data of current year of the latest submission

- mostly because of **corrected activity data** (especially in Energy Production) from finalized Energy Balances
- also due to changed methods, emission factors, or data sources used
- impact on the amount of emission reduction reported in latest submission

Under UN ECE, within the IIR, Germany focusses on recalculations in values reported for **1990** for all MAIN POLLUTANTS, HEAVY METALS and POPS, **1995** for $PM_{2.5}$ and PM_{10} and **2000** for BLACK CARBON (BC), and the **last year of the previous submission**, providing the **quantity** (in absolute numbers and in %) of change for any recalculated emission **and the reasons** for the recalculations carried out

Recalculations in current submission

Table 1: Overview of impact of recalculations on the level of National Totals (For more detailed information please mouseclick the pollutant.)

for reporting year:		BASE YEAR[1]				2022			
		prev. subm.	curr. subm.	±	± %	prev. subm.	curr. subm.	±	± %
Main pollutants									
NEC									
Nitrogen Oxides - NO_x (as NO_2)	[kt]	2,842.27	2,846.04	3.77	0.13%	941.99	926.84	-15.15	-1.61%
Non-Methane VOC - NMVOC	[kt]	3,929.35	3,953.69	24.3	0.62%	1,034.51	1,051.46	16.94	1.64%
Sulphur Oxides - SO_x (as SO_2)	[kt]	5,459.96	5,460.81	0.85	0.02%	255.44	246.27	-9.17	-3.59%
Ammonia - NH_3	[kt]	734.36	834.48	100	13.6%	512.22	576.62	64.40	12.6%
Particulate Matter									
Particles <2.5µm - $PM_{2.5}$	[kt]	199.77	197.47	-2.30	-1.15%	84.29	82.31	-1.98	-2.35%
Particles <10µm - PM_{10}	[kt]	337.92	334.41	-3.51	-1.04%	184.56	181.99	-2.57	-1.39%
Total Suspended Particles - TSP	[kt]	2,019.60	2,015.59	-4.01	-0.20%	330.46	327.93	-2.53	-0.77%
Black Carbon - BC	[kt]	39.20	39.20	0.00	0.00%	9.98	10.09	0.11	1.12%
Other									
Carbon Monoxide - CO	[kt]	13,320.20	13,320.53	0.33	0.002%	2,539.17	2,568.11	28.94	1.14%
Heavy Metals									
Priority HM									
Lead - Pb	[t]	1,899.27	1,899.27	0.00	0.00%	151.71	152.45	0.74	0.49%
Cadmium - Cd	[t]	29.10	29.10	0.00	0.00%	10.32	10.62	0.29	2.82%
Mercury - Hg	[t]	35.53	35.53	0.00	0.00%	6.559	6.556	-0.002	-0.03%
Other HM									
Arsenic - As	[t]	85.92	85.92	0.00	0.00%	5.58	5.76	0.18	3.19%
Chrome - Cr	[t]	165.69	165.69	0.00	0.00%	69.96	67.07	-2.89	-4.14%
Copper - Cu	[t]	619.88	619.88	0.00	0.00%	560.30	564.60	4.30	0.77%
Nickel - Ni	[t]	332.75	332.75	0.00	0.00%	143.26	136.14	-7.12	-4.97%
Selenium - Se	[t]	5.73	5.73	0.00	0.00%	2.879	2.931	0.052	1.79%
Zinc - Zn	[t]	474.15	474.15	0.00	0.00%	292.46	296.03	3.58	1.22%
Persistent Organic Pollutants - POPs									
Dioxines & Furanes - PCDD/F	[g]	805.10	805.10	0.00	0.00%	107.67	112.50	4.83	4.48%
Polycyclic Organic Hydrocarbons - PAHs									
Benzo(a)pyrene - B[a]P	[t]	26.99	26.99	0.00	0.00%	17.94	18.81	0.87	4.87%
Benzo(b)fluoranthene - B[b]F	[t]	35.83	35.83	0.00	0.00%	26.02	27.30	1.28	4.92%
Benzo(k)fluoranthene - B[k]F	[t]	16.26	16.26	0.00	0.00%	11.83	12.39	0.57	4.80%
Indeno(1,2,3-c,d)pyrene - I[1,2,3-c,d]P	[t]	23.03	23.03	0.00	0.00%	17.28	18.15	0.86	5.00%
Polycyclic Aromatic Hydrocarbons - PAH 1-4	[t]	115.67	115.67	0.00	0.00%	76.74	80.27	3.53	4.60%
Other POPs									
Hexachlorobenzene - HCB	[kg]	2,900.52	2,900.52	0.00	0.00%	4.63	4.68	0.04	0.94%
Polychlorinated Biphenyls - PCBs	[kg]	1,735.78	1,735.78	0.00	0.00%	213.40	209.46	-3.94	-1.85%

[1]: Base Year of reporting: 1990; excumptions: $PM_{2.5}$ and PM_{10}: 1995 and BC: 2000

Overview of reasons for recalculations against Submission 2024

(main changes only, without claim to completeness)

1. revision of (primary) activity data

- 1.A together with 2.C.1: finalisation of National Energy Balance 2022 [2)]
- 2.A.2 and 2.A.3: small updates of statistical data for most recent years
- 3.B.4.e: Horse numbers were corrected in all years and all districts by a factor of 2.75 to include horses which are kept outside of agricultural holdings and not counted by agricultural census

2. update or revision of entire model

- 1.A.3.a: routine revision of TREMOD Aviation (TREMOD AV) [3)]
- 1.A.3.b: routine revision of TREMOD [4)]
- 1.A.2.g vii, 1.A.4.a ii, 1.A.4.b ii and 1.A.4.c ii: routine revision of TREMOD Mobile Machinery (TREMOD MM) [5)]
- 1.A.3.d: routine revision of E.M.M.A. model maintained at BSH [6)]

3. newly implemented acitivity and/or emission factors

- 3.D.a.1: application of NH_3 emission factors for mineral fertilizers in EMEP (2023)
- 3.D.a.4: calculation of NH_3 from crop residues according to tier2 method from EMEP (2023). Cover crops are another newly reported source of PM emissions from soils.

4. revision of emission factors

- mobile combustion over-all: revision of (implied) country-specific emission factors as part of model revision
- 1.A.3.b i, ii, iv, vi, vii, and 1.A.3.d.i (i): correction of rounding errors in emission factors for B[a]P, B[b]F, B[k]F, I[x]P, and PAH1-4
- 1.A.3.c - abrasive particulate matter: consideration of new (and far lower) emission factors for PM_{10} from the abrasion of wheel on rail from a corresponding measurement campaign as part of a research project [7)]
- 3.B: improved emission factors for cattle and pig housing were introduced based on national research projects
- 3.B: N_2O emission factors were adopted from the IPCC Refinement (2019): N_2O EF for solid manure storage doubles, also affecting the corresponding NO_x and N_2 EFs.

5. re-allocation of activity data and/or emissions

6. as an outcome of the ongoing review activities under both UNFCCC and UNECE

[1)] UBA, 2025: National Inventory Document for the German Greenhouse Gas Inventory 1990-2023 (NID 2025), https://www.umweltbundesamt.de/themen/klima-energie/treibhausgas-emissionen?listpart=1#articlelist, Dessau, April 2025
[2)] AGEB, 2024: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/wp-content/uploads/2024/03/EBD22e.xlsx, (Aufruf: 04.12.2024), Köln & Berlin, 2024
[3)] Allekotte et al. (2024): TREMOD Aviation (TREMOD AV) - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Heidelberg, Berlin: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., Berlin & Heidelberg, 2024.
[4)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2024.
[5)] Knörr et al. (2024b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2024, Heidelberg, 2024.
[6)] Deichnik (2024): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs. from Bundesamts für Seeschifffahrt und Hydrographie (BSH - Federal Maritime and Hydrographic Agency); Hamburg, 2024.
[7)] DZSF (Deutsches Zentrum für Schienenverkehrsforschung / German Centre for Rail Traffic Research) research project on “Size-specific and spatial distribution of traffic-related abrasion and particulate emissions” (Größenspezifische und räumliche

Verteilung von verkehrsbedingten Abrieben und partikulären Emissionen)
https://www.dzsf.bund.de/SharedDocs/Standardartikel/DZSF/Projekte/Projekt_44_Abriebe_Emissionen.html

Recalculations - Nitrogen Oxides

The marginal changes within the **National Total** reported for **1990 (+3.77 kt or +0.13 %)** are dominated by changes in NFRs **1.A.3.d ii**, and **1.A.2.g vii** and **1.A.4.c ii** together with less significant revisions throughout NFRs 1, 2 and 3.

The most significant percental change occurs for **NFR 3.B.4.e with plus 450 %**.

Table 1: Changes of emission estimates 1990

		Submission 2024	Submission 2025		
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**2,842.27**	**2.846.04**	**3.77**	**0.13%**	**sub-category chapters**
NFR 1 - Energy	**2,597.94**	**2.599.34**	**1.40**	**0.05%**	**sub-category chapters**
1.A.2.g vii	35.42	34.65	-0.76	-2.16%	here
1.A.3.d ii	51.59	53.25	1.66	3.22%	here
1.A.4.a ii	10.59	10.44	-0.15	-1.40%	here
1.A.4.c ii	63.59	64.29	0.69	1.09%	here
1.A.4.c iii	0.39	0.38	-0.01	-1.90%	here
1.A.5.b	41.20	41.17	-0.03	-0.08%	here
NFR 2 - IPPU	**100.73**	**100.73**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**142.87**	**145.23**	**2.36**	**1.65%**	**sub-category chapters**
3.B.1.a	0.67	0.89	0.22	33.0%	here
3.B.1.b	0.6896	0.8427	0.15	22.2%	here
3.B.2	0.02	0.04	0.02	100%	here
3.B.3	0.28	0.36	0.08	28.1%	here
3.B.4.d	0.00114	0.00228	0.00114	100%	here
3.B.4.e	0.042	0.232	0.190	450%	here
3.B.4.g ii	0.00562	0.00560	-0.00002	-0.41%	here
3.B.4.g iii	0.00339	0.00343	0.00004	1.23%	here
3.B.4.g iv	0.0025	0.0028	0.0003	13.7%	here
3.B.4.h	0.0038	0.0077	0.0038	100%	here
3.D.a.2.a	44.59	45.94	1.35	3.04%	here
3.D.a.3	8.50	8.84	0.34	4.01%	here
NFR 5 - Waste	**0.74**	**0.74**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The changes within the **National Total** reported for **2022 (-15.2 kt or -1.61 %)** are dominated by revisions in NFRs **1.A.1.a** (-13 kt) and **1.A.2.g viii** (-4.71 kt) together with less significant revisions **throughout NFRs 1, 2 and 3**.

Here, the most significant percental change occurs for **NFR 3.B.4.e with plus 468 %**.

Table 2: Changes of emission estimates 2020

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**941.99**	**926.84**	**-15.15**	**-1.61%**	**sub-category chapters**
NFR 1 - Energy	**785.20**	**767.94**	**-17.26**	**-2.20%**	**sub-category chapters**
1.A.1.a	213.35	200.36	-13.00	-6.09%	here
1.A.1.b	15.62	15.21	-0.41	-2.65%	here
1.A.1.c	12.31	12.09	-0.21	-1.73%	here
1.A.2.a	3.57	3.59	0.03	0.73%	here
1.A.2.b	0.87	0.90	0.04	4.20%	here
1.A.2.e	0.21	0.19	-0.01	-6.98%	here
1.A.2.g vii	6.56	6.11	-0.45	-6.83%	here
1.A.2.g viii	68.53	63.82	-4.71	-6.87%	here
1.A.3.a i(i)	8.30	8.31	0.01	0.14%	here

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**941.99**	**926.84**	**-15.15**	**-1.61%**	**sub-category chapters**
NFR 1 - Energy	**785.20**	**767.94**	**-17.26**	**-2.20%**	**sub-category chapters**
1.A.3.a ii(i)	1.2796	1.2802	0.0006	0.04%	here
1.A.3.b i	178.53	178.82	0.29	0.16%	here
1.A.3.b ii	45.78	45.03	-0.75	-1.64%	here
1.A.3.b iii	70.08	70.78	0.70	1.00%	here
1.A.3.b iv	1.40	1.37	-0.03	-2.41%	here
1.A.3.c	7.84	7.85	0.01	0.07%	here
1.A.3.d ii	20.47	19.25	-1.22	-5.96%	here
1.A.4.a i	17.77	17.69	-0.07	-0.42%	here
1.A.4.a ii	6.38	6.08	-0.29	-4.58%	here
1.A.4.b i	59.79	61.02	1.23	2.06%	here
1.A.4.b ii	0.39	0.41	0.02	5.04%	here
1.A.4.c i	7.58	7.90	0.32	4.21%	here
1.A.4.c ii	32.56	33.58	1.02	3.14%	here
1.A.4.c iii	0.259	0.244	-0.015	-5.63%	here
1.A.5.a	0.259	0.259	0.00	0.00%	here
1.A.5.b	2.61	2.92	0.31	11.88%	here
1.B.1.b	0.28	0.23	-0.05	-18.66%	here
NFR 2 - IPPU	**54.44**	**54.91**	**0.47**	**0.86%**	**sub-category chapters**
2.A.2	3.642	3.715	0.07	1.98%	here
2.A.3	10.99	11.39	0.40	3.61%	here
2.B.3	0.102	0.101	-0.001	-0.87%	here
2.G	0.196	0.196	0.00	0.01%	here
NFR 3 - Agriculture	**101.25**	**102.90**	**1.65**	**1.63%**	**sub-category chapters**
3.B.1.a	0.485	0.544	0.06	12.07%	here
3.B.1.b	0.495	0.561	0.07	13.34%	here
3.B.2	0.01	0.02	0.01	100%	here
3.B.3	0.195	0.224	0.03	14.68%	here
3.B.4.d	0.00206	0.00406	0.00	96.4%	here
3.B.4.e	0.0393	0.2238	0.18	468%	here
3.B.4.g i	0.019	0.017	-0.002	-9.26%	here
3.B.4.g ii	0.0133	0.0126	-0.0007	-5.42%	here
3.B.4.g iii	0.0094	0.0077	-0.0017	-18.40%	here
3.B.4.g iv	0.002022	0.002057	0.000035	1.73%	here
3.B.4.h	0.0006	0.0012	0.0006	98.7%	here
3.D.a.1	45.46	44.29	-1.18	-2.59%	here
3.D.a.2.a	35.22	36.65	1.43	4.06%	here
3.D.a.2.b	0.474	0.476	0.002	0.33%	here
3.D.a.2.c	13.92	14.67	0.75	5.35%	here
3.D.a.3	4.78	5.11	0.33	7.01%	here
3.I	0.12	0.09	-0.03	-27.61%	here
NFR 5 - Waste	**1.10**	**1.10**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

Recalculations - Non-Methane Volatile Organic Compounds

The changes within the **National Total reported for 1990 (+24.35 kt or +0.62 %)** are dominated by revisions in NFR sub-categories **3.B.1.a** (+9.17 kt), **3.B.1.b** (+9 kt) and **3.B.4.e** (+5.7 kt) with the strongest percental change occuring for **3.B.4.e with plus 175 %**.

Table 1: Changes in emission estimates for 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**3,929.35**	**3,953.69**	**24.35**	**0.62%**	**sub-category chapters**
NFR 1 - Energy	**2,220.36**	**2,220.86**	**0.50**	**0.02%**	**sub-category chapters**
1.A.1.a	6.531	6.535	0.003	0.05%	here
1.A.2.g vii	7.28	7.15	-0.13	-1.84%	here
1.A.3.d ii	3.53	3.92	0.39	11.0%	here
1.A.4.a ii	2.10	2.06	-0.04	-1.74%	here
1.A.4.c ii	34.73	34.99	0.25	0.73%	here
1.A.4.c iii	0.016	0.020	0.003	18.4%	here
1.A.5.b	22.97	22.99	0.02	0.10%	here
NFR 2 - IPPU	**1,291.63**	**1,291.63**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**399.07**	**422.91**	**23.8**	**5.98%**	**sub-category chapters**
3.B.1.a	196.60	205.77	9.17	4.66%	here
3.B.1.b	153.85	162.85	9.00	5.85%	here
3.B.4.e	3.25	8.92	5.68	175%	here
NFR 5 - Waste	**18.28**	**18.28**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The changes within the **National Total reported for 2022 (+16.9 kt or +1.64 %)** are dominated by revisions in NFR sub-categories **3.B.1.a** (+7.4 kt), **3.B.1.b** (+3.59 kt) and **3.B.4.e** (+5.65 kt) with the strongest percental change occuring for **3.B.4.e with plus 184 %**.

Table 2: Changes in emission estimates for 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**1,034.51**	**1,051.46**	**16.94**	**1.64%**	**sub-category chapters**
NFR 1 - Energy	**200.72**	**201.48**	**0.75**	**0.38%**	**sub-category chapters**
1.A.1.a	7.32	7.33	0.01	0.12%	here
1.A.1.b	0.85	0.92	0.06	7.53%	here
1.A.1.c	0.37	0.36	-0.01	-2.20%	here
1.A.2.a	0.223	0.225	0.002	0.99%	here
1.A.2.b	0.070	0.073	0.002	3.31%	here
1.A.2.e	0.023	0.024	0.001	5.31%	here
1.A.2.g vii	3.95	4.05	0.10	2.50%	here
1.A.2.g viii	6.52	5.62	-0.90	-13.81%	here
1.A.3.a i(i)	0.4308	0.4315	0.0007	0.15%	here
1.A.3.b i	40.08	40.10	0.02	0.05%	here
1.A.3.b ii	1.46	1.43	-0.03	-2.07%	here
1.A.3.b iii	2.05	2.08	0.03	1.45%	here
1.A.3.b iv	14.00	13.59	-0.41	-2.89%	here
1.A.3.b v	24.21	24.26	0.05	0.19%	here
1.A.3.c	0.394	0.397	0.003	0.72%	here
1.A.3.d ii	1.17	1.47	0.30	25.36%	here

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**1,034.51**	**1,051.46**	**16.94**	**1.64%**	**sub-category chapters**
NFR 1 - Energy	**200.72**	**201.48**	**0.75**	**0.38%**	**sub-category chapters**
1.A.4.a i	3.66	3.57	-0.10	-2.63%	here
1.A.4.a ii	0.679	0.650	-0.03	-4.23%	here
1.A.4.b i	38.37	40.79	2.42	6.31%	here
1.A.4.b ii	7.602	7.791	0.19	2.48%	here
1.A.4.c i	0.850	0.858	0.01	0.86%	here
1.A.4.c ii	15.32	14.27	-1.05	-6.84%	here
1.A.4.c iii	0.010	0.013	0.003	25.24%	here
1.A.5.b	1.43	1.51	0.08	5.77%	here
NFR 2 - IPPU	**544.95**	**546.04**	**1.09**	**0.20%**	**sub-category chapters**
2.A.2	0.237	0.242	0.005	2.13%	here
2.A.3	0.53	0.63	0.10	19.27%	here
2.D.3.a	80.79	80.60	-0.19	-0.23%	here
2.D.3.d	197.54	198.29	0.75	0.38%	here
2.D.3.e	40.36	40.34	-0.02	-0.04%	here
2.D.3.g	47.59	47.67	0.08	0.18%	here
2.D.3.h	38.37	38.38	0.01	0.03%	here
2.D.3.i	65.42	65.38	-0.04	-0.07%	here
2.H.2	15.88	16.27	0.39	2.44%	here
NFR 3 - Agriculture	**287.10**	**302.17**	**15.07**	**5.25%**	**sub-category chapters**
3.B.1.a	153.87	161.27	7.40	4.81%	here
3.B.1.b	81.92	85.52	3.59	4.39%	here
3.B.4.d	0.088	0.087	0.00	-1.79%	here
3.B.4.e	3.06	8.71	5.65	184%	here
3.B.4.g i	9.42	9.14	-0.28	-3.03%	here
3.B.4.g ii	9.99	9.67	-0.31	-3.15%	here
3.B.4.g iii	5.66	4.82	-0.84	-14.86%	here
3.B.4.g iv	2.51	2.39	-0.13	-5.10%	here
3.B.4.h	0.04109	0.04106	-0.00003	-0.07%	here
NFR 5 - Waste	**1.75**	**1.77**	**0.03**	**1.54%**	**sub-category chapters**
5.A	1.117	1.144	0.03	2.40%	here
NFR 6 - Other	**NA**				

Recalculations - Sulphur Oxides

The negligibly small changes in the **National Total** reported for **1990 (+0.85 kt or +0.02 %)** result almost entirely from revised emission estimates in NFR sub-category **2.B.6** together with less significant changes throughout NFR 1.

The strongest percental change, however, occurs for **2.B.6 with plus 49.5 %**.

Table 1: Changes in emission estimates for 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**5,459.96**	**5,460.81**	**0.85**	**0.02%**	**sub-category chapters**
NFR 1 - Energy	**5,284.38**	**5,284.38**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	2.72	2.66	-0.06	-2.15%	here
1.A.4.a ii	0.55	0.53	-0.01	-2.16%	here
1.A.4.c ii	5.69	5.76	0.07	1.24%	here
NFR 2 - IPPU	**175.54**	**176.39**	**0.85**	**0.49%**	**sub-category chapters**
2.B.6	1.73	2.58	0.85	49.5%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.03**	**0.03**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

Changes in the **National Total** reported for **2022 (-9.17 kt or -3.59 %)** result mainly from a variety of revisions throughout NFRs 1, 2 and 5, however dominated by changes in NFR sub-categories **1.A.1.a (-13.78 kt), 1.A.1.b (+ 8.79 kt) and 1.A.2.g viii (-5.16 kt)**.

The most significant percental changes occur for **NFRs 1.A.1.b with plus 25.81% and 1.A.2.g viii with -20.23%**.

Table 2: Changes in emission estimates for 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**255.44**	**246.27**	**-9.17**	**-3.59%**	**sub-category chapters**
NFR 1 - Energy	**194.43**	**184.86**	**-9.57**	**-4.92%**	**sub-category chapters**
1.A.1.a	102.62	88.84	-13.78	-13.43%	here
1.A.1.b	34.07	42.87	8.79	25.81%	here
1.A.1.c	6.20	6.15	-0.05	-0.76%	here
1.A.2.a	4.05	4.31	0.25	6.29%	here
1.A.2.b	0.315	0.287	-0.03	-8.79%	here
1.A.2.e	0.74	0.80	0.06	8.76%	here
1.A.2.g vii	0.012	0.011	0.00	-5.11%	here
1.A.2.g viii	25.49	20.33	-5.16	-20.23%	here
1.A.3.a i(i)	0.447	0.447	0.00	0.16%	here
1.A.3.a ii(i)	0.087	0.087	0.00	0.03%	here
1.A.3.b i	0.4745	0.4750	0.00	0.11%	here
1.A.3.b ii	0.068	0.067	0.00	-1.67%	here
1.A.3.b iii	0.213	0.215	0.00	1.13%	here
1.A.3.b iv	0.0071	0.0069	0.00	-2.57%	here
1.A.3.d ii	0.308	0.308	0.00	-0.04%	here
1.A.3.e i	0.00331	0.00332	0.00	0.29%	here
1.A.4.a i	1.18	1.17	-0.01	-0.89%	here
1.A.4.a ii	0.0037	0.0034	-0.0003	-9.01%	here
1.A.4.b i	9.83	10.20	0.37	3.77%	here
1.A.4.b ii	0.00124	0.00127	0.00003	2.11%	here
1.A.4.c i	1.96	2.04	0.08	3.99%	here
1.A.4.c ii	0.0305	0.0313	0.0008	2.72%	here

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**255.44**	**246.27**	**-9.17**	**-3.59%**	**sub-category chapters**
NFR 1 - Energy	**194.43**	**184.86**	**-9.57**	**-4.92%**	**sub-category chapters**
1.A.4.c iii	0.008	0.008	0.000	0.00%	here
1.A.5.a	0.0148	0.0143	-0.0005	-3.10%	here
1.A.5.b	0.0223	0.0224	0.0001	0.45%	here
1.B.1.b	0.82	0.70	-0.11	-13.84%	here
NFR 2 - IPPU	**60.91**	**61.32**	**0.40**	**0.66%**	**sub-category chapters**
2.A.2	0.7896	0.8043	0.01	1.85%	here
2.A.3	7.82	8.27	0.45	5.71%	here
2.B.6	0.78	0.72	-0.06	-7.76%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.099**	**0.099**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

Recalculations - Ammonia

The important changes within the **National Total** reported for **1990 (+100 kt or +13.6 %)** are dominated by revisions in NR sub-categories **3.B.4.e** (+11.8 kt), **3.D.a.1** (+50.8 kt) and **3.D.a.2.a** (+34.4 kt) together with less significant changes troughout NFRs 1 and 3.

The most significant percental change occurs for NFR **3.B.4.e with plus 175 %**.

Table 1: Changes in emission estimates for 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**734.36**	**834.48**	**100.12**	**13.63%**	**sub-category chapters**
NFR 1 - Energy	**15.8897**	**15.8897**	**0.00003**	**0.002%**	**sub-category chapters**
1.A.2.g vii	0.0056	0.0055	-0.0001	-2.11%	here
1.A.3.d ii	0.01055	0.01059	0.00004	0.36%	here
1.A.4.a ii	0.00164	0.00162	-0.00002	-1.39%	here
1.A.4.c ii	0.0114	0.0115	0.0001	1.16%	here here
NFR 2 - IPPU	**14.68**	**14.68**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**689.20**	**789.32**	**100.12**	**14.5%**	**sub-category chapters**
3.B.1.a	62.10	60.08	-2.02	-3.25%	here
3.B.1.b	81.36	75.09	-6.27	-7.70%	here
3.B.3	120.10	120.20	0.11	0.09%	here
3.B.4.e	6.73	18.52	11.8	175%	here
3.B.4.g ii	5.07	5.06	-0.01	-0.25%	here
3.B.4.g iii	3.99	4.01	0.02	0.46%	here
3.B.4.g iv	2.472	2.849	0.38	15.26%	here
3.D.a.1	78.71	129.55	50.83	64.6%	here
3.D.a.2.a	286.21	320.57	34.37	12.0%	here
3.D.a.2.c	1.55	1.58	0.02	1.57%	here
3.D.a.3	22.37	24.58	2.21	9.86%	here
NFR 5 - Waste	**0.34**	**0.34**	**0.00**	**0.00%**	
NFR 6 - Other	**14.25**	**14.25**	**0.00**	**0.00%**	

The remarkable changes within the **National Total** reported for **2022 (+64.4 kt or +12.6 %)** result mainly from revisions throughout **NFR 3 (+64.5 kt)** together with less significant changes troughout NFRs 1, 2, and 5.

The most significant percental changes occur for NFR sub-categories **3.B.4.e** with plus 184 % **and** 3.D.a.1 with plus 101 %**.

Table 2: Changes in emission estimates for 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**512.22**	**576.62**	**64.40**	**12.57%**	**sub-category chapters**
NFR 1 - Energy	**12.81**	**12.82**	**0.01**	**0.10%**	**sub-category chapters**
1.A.1.a	0.639	0.634	-0.004	-0.67%	here
1.A.1.b	0.584	0.622	0.04	6.60%	here
1.A.1.c	0.0243	0.0240	-0.0003	-1.06%	here
1.A.2.a	0.092	0.093	0.002	2.09%	here
1.A.2.b	0.0073	0.0072	-0.0001	-1.49%	here
1.A.2.e	0.0013	0.0015	0.0002	11.81%	here
1.A.2.f	0.024	0.021	-0.003	-11.84%	here
1.A.2.g vii	0.0049	0.0046	-0.0003	-6.06%	here
1.A.2.g viii	0.392	0.353	-0.04	-10.06%	here
1.A.3.a i(i)	0.0904	0.0905	0.0001	0.16%	here

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**512.22**	**576.62**	**64.40**	**12.57%**	**sub-category chapters**
NFR 1 - Energy	**12.81**	**12.82**	**0.01**	**0.10%**	**sub-category chapters**
1.A.3.a ii(i)	0.01759	0.01759	0.00001	0.03%	here
1.A.3.b i	8.218	8.239	0.02	0.26%	here
1.A.3.b ii	0.278	0.274	-0.004	-1.32%	here
1.A.3.b iii	0.693	0.699	0.01	0.89%	here
1.A.3.b iv	0.022	0.021	-0.001	-2.63%	here
1.A.3.c	0.007341	0.007341	-0.000001	-0.01%	here
1.A.3.d ii	0.0049	0.0048	0.00	-2.55%	here
1.A.4.a i	0.214	0.209	-0.005	-2.15%	here
1.A.4.a ii	0.0018	0.0016	-0.0001	-8.51%	here
1.A.4.b i	1.391	1.390	-0.001	-0.07%	here
1.A.4.b ii	0.00031	0.00032	0.00001	3.01%	here
1.A.4.c i	0.056	0.057	0.001	1.32%	here
1.A.4.c ii	0.0134	0.0138	0.0004	2.92%	here
1.A.5.b	0.023	0.024	0.001	4.58%	here
1.B.1.b	0.002	0.002	0.00	0.00%	here
NFR 2 - IPPU	**7.88**	**8.06**	**0.18**	**2.29%**	**sub-category chapters**
2.A.3	1.01	1.19	0.18	17.83%	here
2.G	0.55344	0.55348	0.00005	0.01%	here
NFR 3 - Agriculture	**469.31**	**533.83**	**64.52**	**13.75%**	**sub-category chapters**
3.B.1.a	53.32	48.11	-5.21	-9.77%	here
3.B.1.b	48.60	43.95	-4.64	-9.56%	here
3.B.3	63.46	62.66	-0.80	-1.27%	here
3.B.4.d	0.264	0.260	-0.005	-1.79%	here
3.B.4.e	6.29	17.88	11.59	184%	here
3.B.4.g i	7.09	6.71	-0.38	-5.42%	here
3.B.4.g ii	8.00	7.57	-0.43	-5.39%	here
3.B.4.g iii	9.04	7.52	-1.52	-16.78%	here
3.B.4.g iv	1.52	1.63	0.11	7.06%	here
3.B.4.h	0.1067	0.1070	0.0003	0.25%	here
3.D.a.1	33.44	67.18	33.73	101%	here
3.D.a.2.a	165.79	185.70	19.91	12.01%	here
3.D.a.2.b	1.61	1.61	0.01	0.33%	here
3.D.a.2.c	54.21	58.24	4.03	7.43%	here
3.D.a.3	12.78	14.93	2.15	16.86%	here
3.I	2.31	1.67	-0.64	-27.61%	here
NFR 5 - Waste	**3.88**	**3.73**	**-0.15**	**-3.91%**	**sub-category chapters**
5.B.1	2.02	1.81	-0.20	-10.10%	here
5.B.2	1.87	1.92	0.05	2.78%	here
NFR 6 - Other	**18.34**	**18.18**	**-0.17**	**-0.90%**	**sub-category chapters**
6.A	18.34	18.18	-0.17	-0.90%	

Recalculations - Particulate Matter <2.5µm

The changes within the **National Total** reported for **1995 (-2.30 kt or -1.15 %)** are dominated by a revision in **NFR 1.A.3.c with -2.51 kt** together with a variety of less significant revisions throughout NFRs 1, 2, 3 and 5.

The most significant percental change occurs for **NFR 3.B.4.e with plus 175 %**.

Table 1: Changes of emission estimates 1995

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**199.77**	**197.47**	**-2.30**	**-1.15%**	**sub-category chapters**
NFR 1 - Energy	**148.18**	**145.68**	**-2.50**	**-1.69%**	**sub-category chapters**
1.A.2.g vii	2.25	2.24	-0.02	-0.69%	here
1.A.3.c	6.37	3.85	-2.51	-39.51%	here
1.A.4.a ii	0.631	0.626	-0.004	-0.70%	here
1.A.4.c ii	14.63	14.67	0.04	0.25%	here
NFR 2 - IPPU	**40.69**	**40.69**	**0.00**	**0.00%**	**sub-category chapters**
NFR 3 - Agriculture	**6.19**	**6.39**	**0.20**	**3.16%**	**sub-category chapters**
3.B.4.e	0.07	0.18	0.11	175%	here
3.D.c	1.70	1.78	0.08	4.84%	here
NFR 5 - Waste	**4.71**	**4.71**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The changes within the **National Total** reported for **2022 (-1.98 kt or -2.35 %)** are dominated by a revision in **NFR 1.A.3.c with -2.87 kt** together with a variety of less significant revisions throughout NFRs 1, 2, 3 and 5.

The most significant percental change occurs for **NFR 3.B.4.e with plus 184 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**84.29**	**82.31**	**-1.98**	**-2.35%**	**sub-category chapters**
NFR 1 - Energy	**53.58**	**51.00**	**-2.58**	**-4.82%**	**sub-category chapters**
1.A.1.a	4.12	3.80	-0.31	-7.63%	here
1.A.1.b	0.53	0.61	0.08	14.62%	here
1.A.1.c	0.2610	0.2614	0.0003	0.12%	here
1.A.2.a	0.064	0.069	0.01	8.23%	here
1.A.2.g vii	0.364	0.340	-0.02	-6.54%	here
1.A.2.g viii	2.43	1.98	-0.45	-18.64%	here
1.A.3.a i(i)	0.0511	0.0512	0.0001	0.19%	here
1.A.3.a ii(i)	0.01410	0.01411	0.00001	0.04%	here
1.A.3.b i	1.81	1.82	0.01	0.30%	here
1.A.3.b ii	1.201	1.187	-0.01	-1.20%	here
1.A.3.b iii	0.99	1.00	0.01	1.25%	here
1.A.3.b iv	1.01	0.98	-0.03	-2.98%	here
1.A.3.c	4.59	1.72	-2.87	-62.59%	here
1.A.3.d ii	0.71	0.70	-0.01	-1.72%	here
1.A.4.a i	2.00	1.93	-0.07	-3.41%	here
1.A.4.a ii	0.149	0.126	-0.02	-15.74%	here
1.A.4.b i	17.34	18.42	1.09	6.26%	here
1.A.4.b ii	0.13	0.11	-0.03	-20.20%	here
1.A.4.c i	0.468	0.471	0.003	0.62%	here
1.A.4.c ii	3.68	3.73	0.05	1.23%	here
1.A.5.b	0.07	0.09	0.02	34.27%	here

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**84.29**	**82.31**	**-1.98**	**-2.35%**	**sub-category chapters**
NFR 1 - Energy	**53.58**	**51.00**	**-2.58**	**-4.82%**	**sub-category chapters**
NFR 2 - IPPU	**21.00**	**20.95**	**-0.05**	**-0.23%**	**sub-category chapters**
2.A.1	0.58	0.58	0.00	0.00%	here
2.A.2	0.125	0.128	0.003	2.16%	here
2.A.3	0.047	0.049	0.003	5.41%	here
2.A.5.a	1.87	1.82	-0.05	-2.43%	here
2.A.5.b	1.12	1.15	0.03	2.97%	here
2.B.5	0.0017	0.0014	-0.0003	-16.29%	here
2.G	3.743	3.757	0.014	0.36%	here
2.L	9.07	9.01	-0.06	-0.61%	here
NFR 3 - Agriculture	**5.27**	**5.48**	**0.21**	**3.92%**	**sub-category chapters**
3.B.3	0.08	0.08	0.00	0.06%	here
3.B.4.d	0.00182	0.00179	-0.00003	-1.79%	here
3.B.4.e	0.05	0.14	0.09	184%	here
3.B.4.g i	0.165	0.160	-0.005	-3.00%	here
3.B.4.g ii	0.182	0.176	-0.006	-3.20%	here
3.B.4.g iii	0.23	0.20	-0.03	-14.86%	here
3.B.4.g iv	0.073	0.069	-0.004	-5.69%	here
3.B.4.h	0.000923	0.000922	-0.000001	-0.11%	here
3.D.c	1.655	1.824	0.17	10.16%	here
NFR 5 - Waste	**4.44**	**4.88**	**0.44**	**9.98%**	**sub-category chapters**
5.A	0.00131	0.00129	-0.00002	-1.16%	here
5.E	3.20	3.65	0.44	13.82%	here
NFR 6 - Other	**NA**				

Recalculations - Particulate Matter <10µm

The changes within the **National Total** reported for **1995 (-3.51 kt or -1.04 %)** are dominated by revisions in NFR sub-categories **1.A.3.c with -5.03 kt** and **3.D.c with +1.32 kt** together with a variety of less significant revisions throughout NFRs 1, 2, 3 and 5.

The most significant percental change occurs for **NFR 3.B.4.e with plus 175 %**.

Table 1: Changes of emission estimates 1995

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**337.92**	**334.41**	**-3.51**	**-1.04%**	**sub-category chapters**
NFR 1 - Energy	**170.76**	**165.74**	**-5.01**	**-2.94%**	**sub-category chapters**
1.A.2.g vii	2.25	2.24	-0.02	-0.69%	here
1.A.3.c	10.69	5.66	-5.03	-47.05%	here
1.A.4.a ii	0.631	0.626	-0.004	-0.70%	here
1.A.4.c ii	14.63	14.67	0.04	0.25%	here
NFR 2 - IPPU	**127.68**	**127.68**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**34.604**	**36.102**	**1.50**	**4.33%**	**sub-category chapters**
3.B.4.e	0.10	0.28	0.18	175%	here
3.D.c	21.67	22.99	1.32	6.09%	here
NFR 5 - Waste	**4.88**	**4.88**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The small changes within the **National Total** reported for **2022 (-2.57 kt or -1.39 %)** are dominated by a revision in NFR sub-categories **1.A.3.c (-5.75 kt)** and **3.D.c (+2.69 kt)** togehter with a variety of revisions throughout NFRs 1, 2, 3 and 5.

However, the most significant percental change occurs for **NFR 3.B.4.e with plus 185 %**

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**184.56**	**181.99**	**-2.57**	**-1.39%**	**sub-category chapters**
NFR 1 - Energy	**71.02**	**65.53**	**-5.49**	**-7.73%**	**sub-category chapters**
1.A.1.a	4.46	4.11	-0.35	-7.86%	here
1.A.1.b	0.60	0.68	0.09	14.66%	here
1.A.1.c	0.2811	0.2814	0.0004	0.13%	here
1.A.2.a	0.064	0.069	0.01	8.20%	here
1.A.2.g vii	0.36	0.34	-0.02	-6.54%	here
1.A.2.g viii	2.73	2.22	-0.51	-18.68%	here
1.A.3.a i(i)	0.0511	0.0512	0.0001	0.19%	here
1.A.3.a ii(i)	0.01410	0.01411	0.00001	0.04%	here
1.A.3.b i	1.81	1.82	0.01	0.30%	here
1.A.3.b ii	1.201	1.187	-0.01	-1.20%	here
1.A.3.b iii	0.99	1.00	0.01	1.25%	here
1.A.3.b iv	1.01	0.98	-0.03	-2.98%	here
1.A.3.c	8.99	3.25	-5.75	-63.92%	here
1.A.3.d ii	0.74	0.73	-0.01	-1.63%	here
1.A.4.a i	2.22	2.14	-0.08	-3.41%	here
1.A.4.a ii	0.149	0.126	-0.02	-15.74%	here
1.A.4.b i	18.24	19.38	1.14	6.26%	here
1.A.4.b ii	0.132	0.105	-0.03	-20.20%	here
1.A.4.c i	0.487	0.490	0.003	0.54%	here
1.A.4.c ii	3.68	3.73	0.05	1.23%	here

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**184.56**	**181.99**	**-2.57**	**-1.39%**	**sub-category chapters**
NFR 1 - Energy	**71.02**	**65.53**	**-5.49**	**-7.73%**	**sub-category chapters**
1.A.5.b	0.07	0.09	0.02	34.13%	here
NFR 2 - IPPU	**75.83**	**75.82**	**-0.01**	**-0.01%**	**sub-category chapters**
2.A.2	0.211	0.216	0.005	2.16%	here
2.A.3	0.080	0.085	0.00	5.67%	here
2.A.5.a	12.48	12.28	-0.20	-1.59%	here
2.A.5.b	11.22	11.55	0.33	2.97%	here
2.B.5	0.0031	0.0026	-0.0005	-16.29%	here
2.G	4.041	4.055	0.01	0.33%	here
2.L	39.67	39.50	-0.17	-0.42%	here
NFR 3 - Agriculture	**33.14**	**35.63**	**2.49**	**7.51%**	**sub-category chapters**
3.B.3	1.77	1.77	0.00	0.06%	here
3.B.4.d	0.0060	0.0059	-0.0001	-1.79%	here
3.B.4.e	0.08	0.21	0.14	185%	here
3.B.4.g i	2.20	2.13	-0.07	-3.00%	here
3.B.4.g ii	1.812	1.754	-0.06	-3.22%	here
3.B.4.g iii	1.27	1.08	-0.19	-14.86%	here
3.B.4.g iv	0.62	0.59	-0.03	-5.20%	here
3.B.4.h	0.004670	0.004665	-0.000005	-0.11%	here
3.D.c	21.02	23.71	2.69	12.82%	here
NFR 5 - Waste	**4.57**	**5.01**	**0.44**	**9.69%**	**sub-category chapters**
5.A	0.0087	0.0086	-0.0001	-1.16%	here
5.E	3.20	3.65	0.44	13.82%	here
NFR 6 - Other	**NA**				

Recalculations - Total Suspended Particles (TSP)

The small changes within the **National Total** reported for **1990 (-4.0 kt or -0.2 %)** are dominated by a revision in NFRs sub-categories **1.A.3.c** (-5.84 kt) and **3.D.c** (+1.43 kt) together with less significant revisions in NFRs 1 and 3.

The strongest percental change occurs for NFR **3.B.4.e with plus 175 %**.

Table 1: Changes in emission estimates for 1990

	Submission 2024	Submission 2025	Difference	Reasoning	
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**2,019.60**	**2,015.59**	**-4.01**	**-0.20%**	**sub-category chapters**
NFR 1 - Energy	**1,397.65**	**1,391.90**	**-5.74**	**-0.41%**	**sub-category chapters**
1.A.2.g vii	5.05	4.94	-0.11	-2.16%	here
1.A.3.c	13.08	7.24	-5.84	-44.64%	here
1.A.4.a ii	1.33	1.30	-0.03	-2.16%	here
1.A.4.c ii	15.65	15.88	0.23	1.48%	here
NFR 2 - IPPU	**543.41**	**543.41**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**73.51**	**75.24**	**1.73**	**2.36%**	**sub-category chapters**
3.B.4.e	0.18	0.48	0.31	175%	here
3.D.c	23.45	24.88	1.43	6.09%	here
NFR 5 - Waste	5.04	5.04	0.00	0.00%	
NFR 6 - Other	**NA**				

The rather small changes within the **National Total** reported for **2022 (-2.52 kt or -0.77 %)** are dominated by a revision in NFRs sub-categories **1.A.3.c** (-5.75 kt) and **3.D.c** (+2.69 kt) together with less significant revisions in NFRs 1 and 3.

The strongest percental change occurs for NFR **3.B.4.e with plus 185 %**.

Table 2: Changes in emission estimates for 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**330.46**	**327.93**	**-2.53**	**-0.77%**	**sub-category chapters**
NFR 1 - Energy	**86.13**	**80.58**	**-5.55**	**-6.45%**	**sub-category chapters**
1.A.1.a	4.77	4.38	-0.39	-8.10%	here
1.A.1.b	0.66	0.76	0.10	14.69%	here
1.A.1.c	0.4090	0.4095	0.0005	0.13%	here
1.A.2.a	0.064	0.069	0.01	8.17%	here
1.A.2.g vii	0.36	0.34	-0.02	-6.54%	here
1.A.2.g viii	3.02	2.45	-0.56	-18.74%	here
1.A.3.a i(i)	0.0511	0.0512	0.0001	0.19%	here
1.A.3.a ii(i)	0.01464	0.01465	0.00001	0.04%	here
1.A.3.b i	1.81	1.82	0.01	0.30%	here
1.A.3.b ii	1.201	1.187	-0.01	-1.20%	here
1.A.3.b iii	0.99	1.00	0.01	1.25%	here
1.A.3.b iv	1.01	0.98	-0.03	-2.98%	here
1.A.3.c	9.00	3.25	-5.75	-63.85%	here
1.A.3.d ii	0.7436	0.7315	-0.01	-1.63%	here
1.A.4.a i	2.31	2.23	-0.08	-3.40%	here
1.A.4.a ii	0.149	0.126	-0.02	-15.74%	here
1.A.4.b i	18.64	19.81	1.17	6.26%	here
1.A.4.b ii	0.13	0.11	-0.03	-20.20%	here
1.A.4.c i	0.499	0.501	0.003	0.50%	here
1.A.4.c ii	3.68	3.73	0.05	1.23%	here
1.A.5.b	0.07	0.09	0.02	34.13%	here

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**330.46**	**327.93**	**-2.53**	**-0.77%**	**sub-category chapters**
NFR 1 - Energy	**86.13**	**80.58**	**-5.55**	**-6.45%**	**sub-category chapters**
NFR 2 - IPPU	**180.62**	**180.85**	**0.22**	**0.12%**	**sub-category chapters**
2.A.2	0.274	0.279	0.006	2.16%	here
2.A.3	0.36	0.46	0.10	27.66%	here
2.A.5.a	37.79	37.29	-0.50	-1.33%	here
2.A.5.b	37.39	38.50	1.11	2.97%	here
2.G	4.04	4.05	0.01	0.33%	here
2.L	88.07	87.57	-0.50	-0.57%	here
NFR 3 - Agriculture	**59.06**	**61.42**	**2.36**	**3.99%**	**sub-category chapters**
3.B.3	12.16	12.17	0.01	0.07%	here
3.B.4.d	0.0149	0.0146	-0.0003	-1.79%	here
3.B.4.e	0.16	0.46	0.30	185%	here
3.B.4.g i	10.45	10.13	-0.31	-3.00%	here
3.B.4.g ii	3.62	3.51	-0.12	-3.22%	here
3.B.4.g iii	1.27	1.08	-0.19	-14.86%	here
3.B.4.g iv	0.86	0.83	-0.03	-3.39%	here
3.B.4.h	0.004754	0.004749	-0.000005	-0.10%	here
3.D.c	21.02	23.71	2.69	12.82%	here
NFR 5 - Waste	**4.64**	**5.08**	**0.44**	**9.54%**	**sub-category chapters**
5.A	0.0183	0.0181	-0.0002	-1.16%	here
5.E	3.20	3.65	0.44	13.82%	here
NFR 6 - Other	**NA**				

Recalculations - Black Carbon (BC)

The changes within the **National Total** reported for **1995 (+1.07 kt or +2.81 %)** result form a **variety of revisions in NFRs 1 and 5** with the **most significant changes in** sub-categories **1.A.2.g vii** (-1.47 kt) and **1.A.4.c ii** (+2.7 kt).

Table 1: Changes of emission estimates 2000

	Submission 2024	Submission 2025	Difference	
NFR Sector	**[kt]**			**relative**
NATIONAL TOTAL	**39.20**	**39.20**	**0.00**	**0.00%**
NFR 1 - Energy	**38.45**	**38.45**	**0.00**	**0.00%**
NFR 2 - IPPU	**0.02**	**0.02**	**0.00**	**0.00%**
NFR 3 - Agriculture	**NA**			
NFR 5 - Waste	**0.73**	**0.73**	**0.00**	**0.00%**
NFR 6 - Other	**NA**			

The changes within the **National Total** reported for **2022 (+0.11 kt or +1,12 %)** result form a **variety of revisions in NFRs 1 and 5** with the biggest change occuring for NFR sub-category **1.A.4.b i with plus 0.11 kt**.

The most significant percental changes occur for **NFRs 1.A.2.g viii with minus 52 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**9.98**	**10.09**	**0.11**	**1.12%**	**sub-category chapters**
NFR 1 - Energy	**9.31**	**9.38**	**0.07**	**0.73%**	**sub-category chapters**
1.A.1.a	0.03449	0.03442	-0.00007	-0.20%	here
1.A.1.b	0.030	0.035	0.005	15.69%	here
1.A.1.c	0.00038	0.00036	-0.00002	-5.17%	here
1.A.2.g vii	0.25	0.23	-0.02	-7.47%	here
1.A.2.g viii	0.067	0.032	-0.03	-51.71%	here
1.A.3.a i(i)	0.02449	0.02454	0.00005	0.19%	here
1.A.3.a ii(i)	0.006359	0.006362	0.000003	0.04%	here
1.A.3.b i	0.902	0.903	0.001	0.09%	here
1.A.3.b ii	0.681	0.669	-0.01	-1.69%	here
1.A.3.b iii	0.454	0.459	0.005	1.09%	here
1.A.3.b iv	0.179	0.174	-0.005	-2.98%	here
1.A.3.c	0.0861	0.0865	0.0004	0.47%	here
1.A.3.d ii	0.21	0.21	-0.004	-1.82%	here
1.A.4.a i	0.51	0.49	-0.02	-3.70%	here
1.A.4.a ii	0.11	0.10	-0.02	-16.04%	here
1.A.4.b i	1.65	1.76	0.11	6.49%	here
1.A.4.b ii	0.007	0.005	-0.001	-20.20%	here
1.A.4.c i	0.088	0.087	-0.001	-1.35%	here
1.A.4.c ii	2.21	2.26	0.05	2.34%	here
1.A.5.b	0.03	0.04	0.01	39.36%	here
NFR 2 - IPPU	**0.0106297**	**0.0106303**	**0.0000006**	**0.01%**	**sub-category chapters**
2.G	0.0077013	0.0077019	0.0000006	0.01%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.66**	**0.71**	**0.04**	**6.69%**	**sub-category chapters**
5.E	0.32	0.36	0.04	13.82%	here
NFR 6 - Other	**NA**				

Recalculations - Carbon monoxide (CO)

The small changes in the **National Total** reported for **1990 (+0.33 kt or +0.002 %)** result from revisions in NFR sub-categories **1.A.2.g vii, 1.A.4.a ii , and 1.A.4.c ii**.

Table 1: Changes in emission estimates for 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**13,320.20**	**13,320.53**	**0.33**	**0.002%**	**sub-category chapters**
NFR 1 - Energy	**12,050.36**	**12,050.69**	**0.33**	**0.003%**	**sub-category chapters**
1.A.2.g vii	74.39	73.97	-0.43	-0.57%	**here**
1.A.4.a ii	6.17	6.05	-0.13	-2.05%	here
1.A.4.c ii	110.83	111.72	0.88	0.80%	here
NFR 2 - IPPU	**1,248.77**	**1,248.77**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**21.08**	**21.08**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The changes in the **National Total** reported for **2022 (+28.9 kt or +1.14 %)** are dominated by revisions within NFR sub-categories **1.A.2.g vii** (+11.06 kt) and **1.A.4.b i** (+26.8 kt).

In contrast, the most signficant percental changes occur for NFRs **1.A.1.b with minus 23.66 %** and **1.A.2.f with minus 18.25 %**.

Table 2: Changes in emission estimates for 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**2,539.17**	**2,568.11**	**28.94**	**1.14%**	**sub-category chapters**
NFR 1 - Energy	**1,799.87**	**1,828.53**	**28.66**	**1.59%**	**sub-category chapters**
1.A.1.a	94.69	94.23	-0.46	-0.49%	here
1.A.1.b	2.08	1.59	-0.49	-23.66%	here
1.A.1.c	11.51	11.44	-0.07	-0.63%	here
1.A.2.a	32.51	30.84	-1.67	-5.14%	here
1.A.2.b	0.123	0.126	0.003	2.59%	here
1.A.2.e	0.082	0.085	0.003	3.79%	here
1.A.2.f	1.61	1.32	-0.29	-18.25%	here
1.A.2.g vii	177.09	188.15	11.06	6.24%	here
1.A.2.g viii	18.63	16.93	-1.71	-9.16%	here
1.A.3.a i(i)	4.29	4.30	0.01	0.22%	here
1.A.3.a ii(i)	2.26634	2.26647	0.00013	0.01%	here
1.A.3.b i	638.00	639.47	1.47	0.23%	here
1.A.3.b ii	38.73	38.76	0.03	0.08%	here
1.A.3.b iii	28.95	29.33	0.39	1.33%	here
1.A.3.b iv	62.60	61.28	-1.32	-2.11%	here
1.A.3.c	1.142	1.146	0.004	0.34%	here
1.A.3.d ii	6.97	6.91	-0.05	-0.77%	here
1.A.4.a i	48.25	46.86	-1.39	-2.89%	here
1.A.4.a ii	1.54	1.37	-0.18	-11.43%	here
1.A.4.b i	434.82	461.62	26.80	6.16%	here
1.A.4.b ii	80.65	82.75	2.09	2.60%	here
1.A.4.c i	15.60	15.73	0.13	0.84%	here
1.A.4.c ii	84.69	78.76	-5.94	-7.01%	here
1.A.4.c iii	0.02	0.02	0.00	0.00%	here

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kt]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**2,539.17**	**2,568.11**	**28.94**	**1.14%**	**sub-category chapters**
NFR 1 - Energy	**1,799.87**	**1,828.53**	**28.66**	**1.59%**	**sub-category chapters**
1.A.5.a	1.617	1.617	0.00	0.00%	here
1.A.5.b	10.358	10.605	0.25	2.38%	here
NFR 2 - IPPU	**723.34**	**723.61**	**0.27**	**0.04%**	**sub-category chapters**
2.A.2	11.23	11.47	0.24	2.13%	here
2.A.3	0.51	0.55	0.03	6.57%	here
2.G	11.939	11.940	0.001	0.01%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**15.97**	**15.97**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

Recalculations - Lead (Pb)

With no reportable changes in the **National Total** reported for **1990**, the only notable percental change occurs for NFR **1.A.4.a ii with minus 2.16 %** (-0.000002 t).

Table 1: Changes of emission estimates 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**1,899.27**	**1,899.27**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**1,499.08**	**1,499.08**	**0.00**	**0.00%**	**sub-category chapters**
1.A.4.a ii	0.000080	0.000078	-0.000002	-2.16%	here
NFR 2 - IPPU	**400.05**	**400.05**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**0.00**				
NFR 5 - Waste	**0.147**	**0.147**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The small changes within the **National Total** reported for **2022 (+0.82 kt or +0.53 %)** are dominated by a handful of **stonger revisions in NFR 1** with the biggest change occuring for NFR sub-categories **1.A.1.b with +1.18 kt** and **1.A.4.a i with -0.76 kt** together with a variety of less significant revisions throughout NFRs 1, 2, 3 and 5.

The most significant percental change occurs in NFR **1.A.1.b with plus 21.36 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**151.71**	**152.45**	**0.74**	**0.49%**	**sub-category chapters**
NFR 1 - Energy	**84.24**	**84.97**	**0.73**	**0.87%**	**sub-category chapters**
1.A.1.a	7.15	7.13	-0.01	-0.20%	here
1.A.1.b	5.54	6.73	1.18	21.36%	here
1.A.1.c	0.068	0.074	0.006	8.90%	here
1.A.2.g vii	0.00051	0.00050	-0.00001	-1.94%	here
1.A.2.g viii	0.49	0.52	0.03	6.29%	here
1.A.3.b i	0.03162	0.03164	0.00003	0.08%	here
1.A.3.b ii	0.00236	0.00231	-0.00004	-1.73%	here
1.A.3.b iii	0.00667	0.00673	0.00006	0.90%	here
1.A.3.b iv	0.00070	0.00068	-0.00002	-2.57%	here
1.A.3.c	0.08753	0.08755	0.00002	0.03%	here
1.A.3.d ii	0.037	0.036	-0.001	-1.79%	here
1.A.4.a i	20.49	19.73	-0.76	-3.70%	here
1.A.4.a ii	0.00007	0.00006	-0.00001	-16.10%	here
1.A.4.b i	4.71	4.99	0.28	6.01%	here
1.A.4.b ii	0.000135	0.000136	0.000002	1.16%	here
1.A.4.c i	0.061	0.060	-0.001	-1.35%	here
1.A.4.c ii	0.00111	0.00112	0.00001	0.94%	here
1.A.5.b	0.003365	0.003369	0.000004	0.12%	here
NFR 2 - IPPU	**67.36**	**67.37**	**0.00841**	**0.01%**	**sub-category chapters**
2.A.3	0.65	0.66	0.00842	1.29%	here
2.G	0.00146	0.00146	-0.00001	-0.51%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.1133**	**0.1145**	**0.0013**	**1.13%**	**sub-category chapters**
5.E	0.0093	0.0106	0.0013	13.82%	here
NFR 6 - Other	**NA**				

Recalculations - Cadmium (Cd)

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -1.86 %** and **1.A.4.a ii with -2.16 %** with mutually canceling absolute changes.

Table 1: Changes of emission estimates 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**29.10**	**29.10**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**12.76**	**12.76**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.0000461	0.0000452	-0.00000086	-1.86%	here
1.A.4.a ii	0.0000080	0.0000078	-0.00000017	-2.16%	here
1.A.4.c ii	0.0065744	0.0065754	0.00000103	0.02%	here
NFR 2 - IPPU	**16.27**	**16.27**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.07**	**0.07**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The changes within the **National Total** reported for **2022 (+0.29 t or +2.82 %)** result from a **variety of revisions throughout** NFRs 1, 2 and 5**.**
Here, the most significant absolute and percental change occurs in NFR 1.A.1.b with plus 0.25 t (plus 21.12%)**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**10.32**	**10.62**	**0.29**	**2.82%**	**sub-category chapters**
NFR 1 - Energy	**3.18**	**3.47**	**0.29**	**9.11%**	**sub-category chapters**
1.A.1.a	0.804	0.801	-0.003	-0.34%	here
1.A.1.b	1.20	1.45	0.25	21.12%	here
1.A.1.c	0.0074	0.0080	0.0007	8.97%	here
1.A.2.g vii	0.000056	0.000055	-0.000001	-1.17%	here
1.A.2.g viii	0.093	0.102	0.008	8.87%	here
1.A.3.b i	0.003809	0.003812	0.000003	0.08%	here
1.A.3.b ii	0.000250	0.000245	-0.000004	-1.73%	here
1.A.3.b iii	0.000687	0.000693	0.000006	0.90%	here
1.A.3.b iv	0.000088	0.000086	-0.000002	-2.57%	here
1.A.3.c	0.003738	0.003742	0.000004	0.11%	here
1.A.3.d ii	0.0042	0.0041	-0.0001	-2.99%	here
1.A.4.a i	0.221	0.213	-0.008	-3.70%	here
1.A.4.a ii	0.000007	0.000006	-0.000001	-16.10%	here
1.A.4.b i	0.62	0.66	0.04	6.38%	here
1.A.4.b ii	0.00154	0.00138	-0.00016	-10.24%	here
1.A.4.c i	0.0086	0.0085	-0.0001	-1.35%	here
1.A.4.c ii	0.008	0.007	-0.001	-10.55%	here
1.A.5.b	0.0000405	0.0000409	0.0000005	1.13%	here
NFR 2 - IPPU	**7.0801**	**7.0793**	**-0.0008**	**-0.01%**	**sub-category chapters**
2.A.3	0.0174	0.0176	0.0002	1.30%	here
2.G	0.7682	0.7672	-0.0010	-0.13%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.061**	**0.064**	**0.003**	**4.25%**	**sub-category chapters**
5.E	0.019	0.021	0.003	13.82%	here
NFR 6 - Other	**NA**				

Recalculations - Mercury (Hg)

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -2.03 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 1.16 %** with mutually canceling absolute changes.

Table 1: Changes of emission estimates 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**35.53**	**35.53**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**26.46**	**26.46**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.00448	0.00439	-0.00009	-2.03%	here
1.A.4.a ii	0.00084	0.00083	-0.00002	-2.16%	here
1.A.4.c ii	0.0094	0.0095	0.0001	1.16%	here
NFR 2 - IPPU	**9.03**	**9.03**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.03**	**0.03**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The mariginally small changes within the **National Total** reported for **2022 (-0.002 t or -0.03 %)** result from a **variety of revisions throughout NFRs 1, 2 and 5**.

The most significant percental change occurs in **NFR 1.A.4.a ii with minus 16.10 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**6.559**	**6.556**	**-0.002**	**-0.03%**	**sub-category chapters**
NFR 1 - Energy	**4.81**	**4.81**	**-0.005**	**-0.11%**	**sub-category chapters**
1.A.1.a	3.46	3.45	-0.01	-0.39%	here
1.A.1.b	0.246	0.248	0.002	0.78%	here
1.A.1.c	0.103	0.101	-0.001	-1.24%	here
1.A.2.a	0.001077	0.001084	0.000008	0.71%	here
1.A.2.g vii	0.0043	0.0042	-0.0002	-3.97%	here
1.A.2.g viii	0.285	0.283	-0.002	-0.64%	here
1.A.3.b i	0.208	0.208	0.000	0.08%	here
1.A.3.b ii	0.0234	0.0230	-0.0004	-1.73%	here
1.A.3.b iii	0.0710	0.0716	0.0006	0.90%	here
1.A.3.b iv	0.0038	0.0037	-0.0001	-2.57%	here
1.A.3.c	0.003349	0.003352	0.000002	0.07%	here
1.A.3.d ii	0.00683	0.00676	-0.00007	-0.98%	here
1.A.4.a i	0.0507	0.0500	-0.0007	-1.40%	here
1.A.4.a ii	0.0007	0.0006	-0.0001	-16.10%	here
1.A.4.b i	0.30	0.31	0.01	3.89%	here
1.A.4.b ii	0.000674	0.000688	0.000015	2.17%	here
1.A.4.c i	0.00302	0.00299	-0.00003	-1.03%	here
1.A.4.c ii	0.0105	0.0107	0.0002	2.37%	here
1.A.5.b	0.00054	0.00057	0.00004	6.79%	here
1.B.1.b	0.015	0.013	-0.002	-10.34%	here
NFR 2 - IPPU	**1.6921**	**1.6924**	**0.0003**	**0.02%**	**sub-category chapters**
2.A.2	0.0145	0.0148	0.0003	2.13%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.054**	**0.057**	**0.003**	**4.78%**	**sub-category chapters**

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**6.559**	**6.556**	**-0.002**	**-0.03%**	**sub-category chapters**
NFR 1 - Energy	**4.81**	**4.81**	**-0.005**	**-0.11%**	**sub-category chapters**
5.E	0.019	0.021	0.003	13.82%	here
NFR 6 - Other	**NA**				

Recalculations - Arsenic (As)

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -1.93 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 1.10 %** with mutually canceling absolute changes.

Table 1: Changes of emission estimates for 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**85.92**	**85.92**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**82.37**	**82.37**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.000089	0.000087	-0.000002	-1.93%	here
1.A.4.a ii	0.0000159	0.0000156	-0.0000003	-2.16%	here
1.A.4.c ii	0.000186	0.000188	0.000002	1.10%	here
NFR 2 - IPPU	**3.52**	**3.52**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.03**	**0.03**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The changes within the **National Total** reported for **2022 (+0.18 t or +3.19 %)** are dominated by a revision in NFR sub-category **1.A.1.b with plus 0.18 t** together with a variety of revisions throughout NFRs 1, 2 and 5.

Here, the most significant percental change occurs in **NFR 1.A.1.b with plus 18.6 %**.

Table 2: Changes of emission estimates for 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**5.58**	**5.76**	**0.18**	**3.19%**	**sub-category chapters**
NFR 1 - Energy	**4.53**	**4.71**	**0.17**	**3.80%**	**sub-category chapters**
1.A.1.a	2.17	2.16	-0.01	-0.38%	here
1.A.1.b	0.99	1.17	0.18	18.60%	here
1.A.1.c	0.0053	0.0057	0.0004	8.50%	here
1.A.2.g vii	0.000099	0.000097	-0.000002	-2.15%	here
1.A.2.g viii	0.187	0.192	0.005	2.65%	here
1.A.3.b i	0.006017	0.006022	0.000005	0.08%	here
1.A.3.b ii	0.000464	0.000456	-0.000008	-1.73%	here
1.A.3.b iii	0.00132	0.00134	0.00001	0.90%	here
1.A.3.b iv	0.000132	0.000129	-0.000003	-2.57%	here
1.A.3.d ii	0.011353	0.011351	-0.000001	-0.01%	here
1.A.4.a i	0.47	0.45	-0.02	-3.70%	here
1.A.4.a ii	0.000013	0.000011	-0.000002	-16.10%	here
1.A.4.b i	0.138	0.146	0.008	6.16%	here
1.A.4.b ii	0.000023	0.000024	0.000001	2.17%	here
1.A.4.c i	0.00098	0.00097	-0.00001	-1.35%	here
1.A.4.c ii	0.000209	0.000212	0.000003	1.65%	here
1.A.5.b	0.000137	0.000138	0.000001	0.60%	here
NFR 2 - IPPU	**1.019**	**1.021**	**0.002**	**0.15%**	**sub-category chapters**
2.A.3	0.195	0.197	0.002	0.77%	here
NFR 3 - Agriculture	**NA**				**sub-category chapters**
NFR 5 - Waste	**0.030**	**0.034**	**0.004**	**13.82%**	**sub-category chapters**
5.E	0.030	0.034	0.004	13.82%	here
NFR 6 - Other	**NA**				

Recalculations - Chromium (Cr)

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -2.10 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 0.42 %** with mutually canceling absolute changes.

Table 1: Changes in emission estimates for 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**165.69**	**165.69**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**122.29**	**122.29**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.0070	0.0068	-0.0002	-2.10%	here
1.A.4.a ii	0.00135	0.00132	-0.00003	-2.16%	here
1.A.4.c ii	0.0417	0.0419	0.0002	0.42%	here
NFR 2 - IPPU	**43.38**	**43.38**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.03**	**0.03**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The changes within the **National Total** reported for **2022 (-2.89 t or -4.14 %)** are dominated by a revision in NFR sub-category **1.A.3.c with -3.30 t** together with a variety of revisions throughout NFRs 1, 2 and 5.

However, the most significant percental change occurs in **NFR 1.A.1.b with plus 19.3 %**.

Table 2: Changes of emission estimates for 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**69.96**	**67.07**	**-2.89**	**-4.14%**	**sub-category chapters**
NFR 1 - Energy	**52.88**	**49.99**	**-2.89**	**-5.47%**	**sub-category chapters**
1.A.1.a	4.14	4.13	-0.02	-0.40%	here
1.A.1.b	1.42	1.69	0.27	19.31%	here
1.A.1.c	0.040	0.044	0.004	9.56%	here
1.A.2.g vii	0.0060	0.0056	-0.0003	-5.67%	here
1.A.2.g viii	0.20	0.21	0.01	6.42%	here
1.A.3.b i	0.2151	0.2153	0.0002	0.08%	here
1.A.3.b ii	0.036	0.035	-0.001	-1.73%	here
1.A.3.b iii	0.114	0.115	0.001	0.90%	here
1.A.3.b iv	0.0028	0.0027	-0.0001	-2.57%	here
1.A.3.c	23.31	20.02	-3.30	-14.14%	here
1.A.3.d ii	0.025	0.024	-0.001	-2.55%	here
1.A.4.a i	2.16	2.08	-0.08	-3.70%	here
1.A.4.a ii	0.0011	0.0009	-0.0002	-16.10%	here
1.A.4.b i	3.25	3.46	0.21	6.56%	here
1.A.4.b ii	0.0069	0.0063	-0.0007	-9.48%	here
1.A.4.c i	0.070	0.069	-0.001	-1.35%	here
1.A.4.c ii	0.049	0.046	-0.003	-6.24%	here
1.A.5.b	0.00049	0.00054	0.00005	10.39%	here
NFR 2 - IPPU	**17.050**	**17.047**	**-0.003**	**-0.02%**	**sub-category chapters**
2.A.3	0.100	0.102	0.001	1.32%	here
2.G	0.873	0.869	-0.004	-0.51%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.028**	**0.032**	**0.004**	**13.82%**	**sub-category chapters**

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**69.96**	**67.07**	**-2.89**	**-4.14%**	**sub-category chapters**
NFR 1 - Energy	**52.88**	**49.99**	**-2.89**	**-5.47%**	**sub-category chapters**
5.E	0.028	0.032	0.004	13.82%	here
NFR 6 - Other	**NA**				

Recalculations - Copper (Cu)

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -2.10 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 0.01 %** with mutually canceling absolute changes.

Table 1: Changes in emission estimates for 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**619.88**	**619.88**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**538.01**	**538.01**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.00466	0.00456	-0.00010	-2.10%	here
1.A.4.a ii	0.00091	0.00089	-0.00002	-2.16%	here
1.A.4.c ii	1.11495	1.11506	0.00012	0.01%	here
NFR 2 - IPPU	**81.81**	**81.81**	**0.00**	**0.00%**	**sub-category chapters**
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.06**	**0.06**	**0.00**	**0.00%**	**sub-category chapters**
NFR 6 - Other	**NA**				

The changes within the **National Total** reported for **2022 (+4.3 t or +.77 %)** are dominated by a revision in NFR sub-category **1.A.3.c with +3.76 t** together with a variety of revisions throughout NFRs 1, 2 and 5.

However, the most significant percental change occurs in **NFR 1.A.1.b with plus 18.6 %**.

Table 2: Changes of emission estimates for 2022

	Submission 2023	Submission 2024	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**560.30**	**564.60**	**4.30**	**0.77%**	**sub-category chapters**
NFR 1 - Energy	**491.53**	**495.99**	**4.47**	**0.91%**	**sub-category chapters**
1.A.1.a	7.37	7.34	-0.03	-0.45%	here
1.A.1.b	4.37	5.19	0.81	18.58%	here
1.A.1.c	0.048	0.052	0.004	9.09%	here
1.A.2.g vii	0.0040	0.0038	-0.0002	-5.56%	here
1.A.2.g viii	0.30	0.31	0.01	1.74%	here
1.A.3.b i	0.1485	0.1486	0.0001	0.08%	here
1.A.3.b ii	0.0242	0.0238	-0.0004	-1.73%	here
1.A.3.b iii	0.076	0.077	0.001	0.90%	here
1.A.3.b iv	0.0020	0.0019	-0.0001	-2.57%	here
1.A.3.c	103.66	107.42	3.76	3.63%	here
1.A.3.d ii	0.56	0.54	-0.02	-3.87%	here
1.A.4.a i	1.82	1.75	-0.07	-3.70%	here
1.A.4.a ii	0.00075	0.00063	-0.00012	-16.10%	here
1.A.4.b i	2.69	2.87	0.18	6.58%	here
1.A.4.b ii	0.26	0.23	-0.03	-10.35%	here
1.A.4.c i	0.086	0.085	-0.001	-1.35%	here
1.A.4.c ii	1.34	1.20	-0.14	-10.61%	here
1.A.5.b	0.00292	0.00296	0.00003	1.18%	here
NFR 2 - IPPU	**68.7118**	**68.5308**	**-0.1809**	**-0.26%**	**sub-category chapters**
2.A.3	0.0646	0.0654	0.0008	1.24%	here
2.G	51.7133	51.5316	-0.1817	-0.35%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.07**	**0.08**	**0.01**	**13.82%**	**sub-category chapters**

	Submission 2023	Submission 2024	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**560.30**	**564.60**	**4.30**	**0.77%**	**sub-category chapters**
NFR 1 - Energy	**491.53**	**495.99**	**4.47**	**0.91%**	**sub-category chapters**
5.E	0.07	0.08	0.01	13.82%	here
NFR 6 - Other	**NA**				

Recalculations - Nickel (Ni)

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -1.47 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 0.01 %** with mutually canceling absolute changes.

Table 1: Changes in emission estimates for 1990

	Submission 2023	Submission 2024	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**332.75**	**332.75**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**305.13**	**305.13**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.000233	0.000230	-0.000003	-1.47%	here
1.A.4.a ii	0.0000319	0.0000312	-0.0000007	-2.16%	here
1.A.4.c ii	0.045793	0.045797	0.000004	0.01%	here
NFR 2 - IPPU	**27.61**	**27.61**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**NA**				
NFR 6 - Other	**NA**				

The significant changes within the **National Total** reported for **2022 (-7.12 t or -4.97 %)** are dominated by a revision in NFR sub-category **1.A.3.c with -5.69 t** together with a variety of revisions throughout NFRs 1, 2 and 5.

However, the most significant percental change occurs in **NFR 1.A.1.b with plus 21.8 %**.

Table 2: Changes in emission estimates for 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**143.26**	**136.14**	**-7.12**	**-4.97%**	**sub-category chapters**
NFR 1 - Energy	**136.08**	**128.97**	**-7.11**	**-5.22%**	**sub-category chapters**
1.A.1.a	3.430	3.410	-0.02	-0.58%	here
1.A.1.b	80.18	79.31	-0.87	-1.09%	here
1.A.1.c	0.0262	0.0283	0.00	8.38%	here
1.A.2.g vii	0.00041	0.00042	0.00	2.36%	here
1.A.2.g viii	1.62	1.97	0.35	21.78%	here
1.A.3.b i	0.0384	0.0384	0.00	0.08%	here
1.A.3.b ii	0.00128	0.00126	-0.00002	-1.74%	here
1.A.3.b iii	0.00270	0.00273	0.00002	0.90%	here
1.A.3.b iv	0.00101	0.00099	-0.00003	-2.57%	here
1.A.3.c	46.61	40.02	-6.59	-14.14%	here
1.A.3.d ii	0.387	0.386	-0.001	-0.23%	here
1.A.4.a i	0.046	0.044	-0.002	-3.67%	here
1.A.4.a ii	0.000026	0.000022	-0.000004	-16.10%	here
1.A.4.b i	0.50	0.53	0.03	6.27%	here
1.A.4.b ii	0.011	0.010	-0.001	-10.16%	here
1.A.4.c i	0.00533	0.00526	-0.00007	-1.35%	here
1.A.4.c ii	0.055	0.049	-0.006	-10.62%	here
1.A.5.b	0.003162	0.003165	0.000003	0.10%	here
NFR 2 - IPPU	**7.1795**	**7.1725**	**-0.0070**	**-0.10%**	**sub-category chapters**
2.A.3	0.0413	0.0417	0.0004	1.04%	here
2.G	1.7308	1.7234	-0.0074	-0.43%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**NA**				

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**143.26**	**136.14**	**-7.12**	**-4.97%**	**sub-category chapters**
NFR 1 - Energy	**136.08**	**128.97**	**-7.11**	**-5.22%**	**sub-category chapters**
NFR 6 - Other	**NA**				

Recalculations - Selenium (Se)

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -2.00 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 0.03 %** with mutually canceling absolute changes.

Table 1: Changes in emission estimates for 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**5.73**	**5.73**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**2.03**	**2.03**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.000086	0.000084	-0.000002	-2.00%	here
1.A.4.a ii	0.0000159	0.0000156	-0.0000003	-2.16%	here
1.A.4.c ii	0.006629	0.006631	0.000002	0.03%	here
NFR 2 - IPPU	**3.70**	**3.70**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**NA**				
NFR 6 - Other	**NA**				

The small changes within the **National Total** reported for **2022 (+0.05 t or +1.79 %)** are dominated by revisions in NFR sub-categories **1.A.1.b with +0.03 t** and **2.A.3 with +0.021 t** togehter with avariety of revisions throughout NFRs 1 and 2.

However, the most significant percental change occurs in NFR **1.A.4.a ii with minus 16.1 %**.

Table 2: Changes in emission estimates for 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**2.88**	**2.93**	**0.05**	**1.79%**	**sub-category chapters**
NFR 1 - Energy	**1.36**	**1.39**	**0.03**	**2.32%**	**sub-category chapters**
1.A.1.a	0.0879	0.0870	-0.001	-1.08%	here
1.A.1.b	0.90	0.93	0.03	3.65%	here
1.A.2.g vii	0.000086	0.000083	-0.000003	-3.42%	here
1.A.2.g viii	0.0167	0.0175	0.0008	4.85%	here
1.A.3.b i	0.004468	0.004471	0.000004	0.08%	here
1.A.3.b ii	0.00044	0.00044	-0.00001	-1.73%	here
1.A.3.b iii	0.00132	0.00134	0.00001	0.90%	here
1.A.3.b iv	0.000088	0.000086	-0.000002	-2.57%	here
1.A.3.c	0.002438	0.002442	0.000004	0.17%	here
1.A.3.d ii	0.0219	0.0217	-0.0001	-0.58%	here
1.A.4.a ii	0.000013	0.000011	-0.000002	-16.10%	here
1.A.4.b ii	0.0015	0.0014	-0.0002	-10.24%	here
1.A.4.c ii	0.008	0.007	-0.001	-10.39%	here
1.A.5.b	0.000315	0.000316	0.000001	0.23%	here
NFR 2 - IPPU	**1.520**	**1.540**	**0.020**	**1.32%**	**sub-category chapters**
2.A.3	1.313	1.334	0.021	1.61%	here
2.G	0.206	0.205	-0.001	-0.51%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**NA**				
NFR 6 - Other	**NA**				

Recalculations - Zinc (Zn)

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -2.01 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 0.06 %** with mutually canceling absolute changes.

Table 1: Changes in emission estimates for 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**474.15**	**474.15**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**387.46**	**387.46**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.0153	0.0150	-0.0003	-2.01%	here
1.A.4.a ii	0.00287	0.00281	-0.00006	-2.16%	here
1.A.4.c ii	0.6716	0.6720	0.0004	0.06%	here
NFR 2 - IPPU	**86.69**	**86.69**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**NA**				
NFR 6 - Other	**NA**				

The changes in the **National Total** reported for **2022 (+3.58 t and +1.22 %)** are dominated by a revision in NFR sub-categories **1.A.4.b i with +4.37 kt** and **1.A.4.a i with -1.23 kt** together with a variety of revisions throughout NFRs 1 and 2.

The most significant percental change occurs in NFR **1.A.1.b with plus 19 %**.

Table 2: Changes of emission estimates for 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**292.46**	**296.03**	**3.58**	**1.22%**	**sub-category chapters**
NFR 1 - Energy	**241.17**	**244.85**	**3.68**	**1.53%**	**sub-category chapters**
1.A.1.a	5.50	5.49	-0.02	-0.33%	here
1.A.1.b	3.47	4.13	0.66	19.02%	here
1.A.1.c	0.029	0.032	0.003	11.37%	here
1.A.2.g vii	0.0151	0.0146	-0.0006	-3.67%	here
1.A.2.g viii	0.47	0.49	0.02	4.61%	here
1.A.3.b i	0.7596	0.7602	0.0006	0.08%	here
1.A.3.b ii	0.080	0.079	-0.001	-1.73%	here
1.A.3.b iii	0.241	0.243	0.002	0.90%	here
1.A.3.b iv	0.0145	0.0141	-0.0004	-2.57%	here
1.A.3.c	0.2499	0.2503	0.0004	0.17%	here
1.A.3.d ii	0.456	0.443	-0.013	-2.78%	here
1.A.4.a i	33.24	32.01	-1.23	-3.70%	here
1.A.4.a ii	0.0024	0.0020	-0.0004	-16.10%	here
1.A.4.b i	66.21	70.58	4.37	6.61%	here
1.A.4.b ii	0.153	0.138	-0.016	-10.16%	here
1.A.4.c i	1.35	1.33	-0.02	-1.35%	here
1.A.4.c ii	0.81	0.73	-0.08	-10.14%	here
1.A.5.b	0.00534	0.00547	0.00013	2.38%	here
NFR 2 - IPPU	**51.29**	**51.18**	**-0.11**	**-0.21%**	**sub-category chapters**
2.G	29.93	29.83	-0.11	-0.35%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**NA**				
NFR 6 - Other	**NA**				

Recalculations - Dioxines & Furanes (PCDD/F)

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -2.02 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 0.49 %** with mutually canceling absolute changes.

Table 1: Changes of emission estimates 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[g]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**805.10**	**805.10**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**522.76**	**522.76**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.0590	0.0578	-0.0012	-2.02%	here
1.A.4.a ii	0.0111	0.0108	-0.0002	-2.16%	here
1.A.4.c ii	0.2929	0.2944	0.0014	0.49%	here
NFR 2 - IPPU	**242.10**	**242.10**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**40.25**	**40.25**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The significant changes within the **National Total** reported for **2022 (+4.83 g or +4.48 %)** are dominated by revisions in NFR sub-categories **5.E with +4.99 g**, **1.A.4.b i with +0.85 g** and **1.A.4.a i with -0.74 g** togehter with a variety of small revisions throughout NFR 1.

However, the most significant percental change occurs in NFR **1.A.4.a ii with minus 16.1 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[g]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**107.67**	**112.50**	**4.83**	**4.48%**	**sub-category chapters**
NFR 1 - Energy	**51.93**	**51.77**	**-0.16**	**-0.31%**	**sub-category chapters**
1.A.1.a	4.05	4.00	-0.05	-1.16%	here
1.A.1.b	0.015	0.014	-0.001	-5.16%	here
1.A.1.c	0.059	0.065	0.01	10.21%	here
1.A.2.a	0.0209	0.0214	0.0004	2.10%	here
1.A.2.g vii	0.058	0.055	-0.002	-3.84%	here
1.A.2.g viii	1.15	1.05	-0.10	-8.58%	here
1.A.3.b i	4.827	4.813	-0.014	-0.29%	here
1.A.3.b ii	0.563	0.550	-0.013	-2.36%	here
1.A.3.b iii	0.2128	0.2125	-0.0002	-0.11%	here
1.A.3.b iv	0.295	0.286	-0.009	-3.08%	here
1.A.3.c	0.02369	0.02373	0.00004	0.16%	here
1.A.3.d ii	1.67	1.62	-0.05	-3.03%	here
1.A.4.a i	20.79	20.06	-0.74	-3.55%	here
1.A.4.a ii	0.009	0.008	-0.001	-16.10%	here
1.A.4.b i	15.98	16.83	0.85	5.32%	here
1.A.4.b ii	0.056	0.052	-0.004	-6.70%	here
1.A.4.c i	1.52	1.50	-0.02	-1.30%	here
1.A.4.c ii	0.34	0.32	-0.02	-5.46%	here
1.A.5.b	0.0183	0.0188	0.0005	2.65%	here
NFR 2 - IPPU	**16.32**	**16.32**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**39.42**	**44.41**	**4.99**	**12.65%**	**sub-category chapters**
5.E	36.08	41.07	4.99	13.82%	here

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[g]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**107.67**	**112.50**	**4.83**	**4.48%**	**sub-category chapters**
NFR 1 - Energy	**51.93**	**51.77**	**-0.16**	**-0.31%**	**sub-category chapters**
NFR 6 - Other	**NA**				

Recalculations - Benzo[a]Pyrene

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -2.05 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 1.18 %** with mutually canceling absolute changes.

Table 1: Changes of emission estimates 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**26.99**	**26.99**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**25.47**	**25.47**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.0250	0.0245	-0.0005	-2.05%	here
1.A.4.a ii	0.0048	0.0047	-0.0001	-2.16%	here
1.A.4.c ii	0.0525	0.0531	0.0006	1.18%	here
NFR 2 - IPPU	**0.96**	**0.96**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.56**	**0.56**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The significant changes within the **National Total** reported for **2022 (+0.87 t or +4.87 %)** are dominated by revisions in NFR sub-categories **1.A.4.b i with +0.95 t** and **1.A.4.a ii with -0.07 t** togehter with a variety of small revisions throughout NFRs 1 and 2.

However, the most significant percental change occurs in NFR **1.A.4.a ii with minus 16 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**17.94**	**18.81**	**0.87**	**4.87%**	**sub-category chapters**
NFR 1 - Energy	17.47	18.34	0.87	5.00%	sub-category chapters
1.A.1.a	0.0474	0.0471	-0.0003	-0.62%	here
1.A.1.b	0.0043	0.0042	-0.0001	-2.74%	here
1.A.1.c	0.0009	0.0008	-0.0001	-10.23%	here
1.A.2.a	0.000105	0.000107	0.000002	2.10%	here
1.A.2.g vii	0.023	0.022	-0.001	-4.50%	here
1.A.2.g viii	0.0253	0.0251	-0.0002	-0.71%	here
1.A.3.b i	0.3813	0.3816	0.0003	0.08%	here
1.A.3.b ii	0.065	0.064	-0.001	-1.73%	here
1.A.3.b iii	0.068	0.069	0.001	0.90%	here
1.A.3.b iv	0.0037	0.0036	-0.0001	-2.57%	here
1.A.3.c	0.007933	0.007946	0.000013	0.16%	here
1.A.3.d ii	0.0125	0.0122	-0.0004	-3.03%	here
1.A.4.a i	2.01	1.93	-0.07	-3.70%	here
1.A.4.a ii	0.004	0.003	-0.001	-16.03%	here
1.A.4.b i	14.51	15.46	0.95	6.55%	here
1.A.4.b ii	0.0031	0.0032	0.0001	2.11%	here
1.A.4.c i	0.145	0.143	-0.002	-1.35%	here
1.A.4.c ii	0.059	0.060	0.001	2.53%	here
1.A.5.b	0.0022	0.0024	0.0002	9.13%	here
NFR 2 - IPPU	**0.046503**	**0.046505**	**0.000002**	**0.004%**	**sub-category chapters**
2.G	0.022246	0.022247	0.000002	0.01%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.422**	**0.422**	**0.000**	**0.00%**	

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**17.94**	**18.81**	**0.87**	**4.87%**	**sub-category chapters**
NFR 6 - Other	**NA**				

Recalculations - Benzo[b]Fluoranthene

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -2.09 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 1.20 %** with mutually canceling absolute changes.

Table 1: Changes of emission estimates 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**35.83**	**35.83**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**35.14**	**35.14**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.0409	0.0400	-0.0009	-2.09%	here
1.A.4.a ii	0.0080	0.0078	-0.0002	-2.16%	here
1.A.4.c ii	0.0855	0.0866	0.0010	1.20%	here
NFR 2 - IPPU	**0.04**	**0.04**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.65**	**0.65**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The significant changes within the **National Total** reported for **2022 (+1.28 t or +4.92 %)** are dominated by revisions in NFR sub-categories **1.A.4.b i with +1.39 t** and **1.A.4.a i with -0.11 t** togehter with a variety of small revisions throughout NFR 1.

However, the most significant percental change occurs in NFR **1.A.4.a ii with minus 16 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**26.02**	**27.30**	**1.28**	**4.92%**	**sub-category chapters**
NFR 1 - Energy	**25.51**	**26.79**	**1.28**	**5.01%**	**sub-category chapters**
1.A.2.g vii	0.036	0.034	-0.002	-5.54%	here
1.A.3.b i	0.4322	0.4325	0.0003	0.08%	here
1.A.3.b ii	0.069	0.068	-0.001	-1.73%	here
1.A.3.b iii	0.412	0.416	0.004	0.90%	here
1.A.3.b iv	0.0041	0.0040	-0.0001	-2.57%	here
1.A.3.c	0.01316	0.01318	0.00002	0.16%	here
1.A.3.d ii	0.0209	0.0203	-0.0006	-3.03%	here
1.A.4.a i	2.93	2.82	-0.11	-3.70%	here
1.A.4.a ii	0.007	0.006	-0.001	-16.10%	here
1.A.4.b i	21.15	22.54	1.39	6.56%	here
1.A.4.b ii	0.0031	0.0032	0.0001	2.11%	here
1.A.4.c i	0.212	0.209	-0.003	-1.35%	here
1.A.4.c ii	0.095	0.098	0.003	2.84%	here
1.A.5.b	0.0023	0.0026	0.0003	13.22%	here
NFR 2 - IPPU	**0.027064**	**0.027067**	**0.000002**	**0.01%**	**sub-category chapters**
2.G	0.027064	0.027067	0.000002	0.01%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.49**	**0.49**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

Recalculations - Benzo[k]Fluoranthene

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -2.15 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 1.24 %** with mutually canceling absolute changes.

Table 1: Changes of emission estimates 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**16.26**	**16.26**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**16.00**	**16.00**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.0274	0.0268	-0.0006	-2.15%	here
1.A.4.a ii	0.0055	0.0054	-0.0001	-2.16%	here
1.A.4.c ii	0.0572	0.0579	0.0007	1.24%	here
NFR 2 - IPPU	**0.04**	**0.04**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.22**	**0.22**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The significant changes within the **National Total** reported for **2022 (+0.57 t or +4.80 %)** are dominated by revisions in NFR sub-categories **1.A.4.b i with +0.61 t** and **1.A.4.a i with -0.05 t** togehter with a variety of small revisions throughout NFR 1.

However, the most significant percental change occurs in NFR **1.A.5.b with plus 44 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**11.83**	**12.39**	**0.57**	**4.80%**	**sub-category chapters**
NFR 1 - Energy	**11.64**	**12.21**	**0.57**	**4.87%**	**sub-category chapters**
1.A.2.g vii	0.0215	0.0199	-0.0015	-7.22%	here
1.A.3.b i	0.2237	0.2238	0.0002	0.08%	here
1.A.3.b ii	0.0362	0.0356	-0.0006	-1.73%	here
1.A.3.b iii	0.461	0.465	0.004	0.90%	here
1.A.3.b iv	0.0030	0.0029	-0.0001	-2.57%	here
1.A.3.c	0.009051	0.009065	0.000015	0.16%	
1.A.3.d ii	0.0144	0.0139	-0.0004	-3.03%	
1.A.4.a i	1.30	1.25	-0.05	-3.70%	
1.A.4.a ii	0.005	0.004	-0.001	-16.04%	
1.A.4.b i	9.37	9.98	0.61	6.55%	
1.A.4.b ii	0.00030	0.00031	0.00001	2.11%	
1.A.4.c i	0.094	0.092	-0.001	-1.35%	
1.A.4.c ii	0.064	0.066	0.002	3.27%	
1.A.5.b	0.0004	0.0006	0.0002	44.02%	
NFR 2 - IPPU	**0.027064**	**0.027067**	**0.000002**	**0.01%**	**sub-category chapters**
2.G	0.027064	0.027067	0.000002	0.01%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.16**	**0.16**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

Recalculations - Indeno[1,2,3-c,d]Pyrene

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -2.07 %**, **1.A.4.a ii with -2.14 %** and **1.A.4.c ii with plus 1.19 %** with mutually canceling absolute changes.

Table 1: Changes of emission estimates 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**23.03**	**23.03**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**22.92**	**22.92**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.00654	0.00641	-0.00014	-2.07%	here
1.A.4.a ii	0.00127	0.00124	-0.00003	-2.14%	here
1.A.4.c ii	0.01370	0.01386	0.00016	1.19%	here
NFR 2 - IPPU	**0.07**	**0.07**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.04**	**0.04**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The significant changes within the **National Total** reported for **2022 (+0.86 t or +5 %)** are dominated by revisions in NFR sub-categories **1.A.4.b i with +0.94 t** and **1.A.4.a i with -0.07 t** togehter with a variety of small revisions throughout NFR 1.

However, the most significant percental change occurs in NFR **1.A.4.a ii with minus 15.8 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**17.28**	**18.15**	**0.86**	**5.00%**	**sub-category chapters**
NFR 1 - Energy	**17.21**	**18.08**	**0.86**	**5.02%**	**sub-category chapters**
1.A.2.g vii	0.0059	0.0057	-0.0003	-4.88%	here
1.A.3.b i	0.4311	0.4314	0.0003	0.08%	here
1.A.3.b ii	0.066	0.065	-0.001	-1.73%	here
1.A.3.b iii	0.11	0.11	0.001	0.90%	here
1.A.3.b iv	0.0045	0.0044	-0.0001	-2.57%	here
1.A.3.c	0.002079	0.002082	0.000003	0.16%	here
1.A.3.d ii	0.0033	0.0032	-0.0001	-3.03%	here
1.A.4.a i	1.99	1.91	-0.073	-3.70%	here
1.A.4.a ii	0.0011	0.0009	-0.0002	-15.83%	here
1.A.4.b i	14.39	15.33	0.94	6.53%	here
1.A.4.b ii	0.000692	0.000707	0.000015	2.11%	here
1.A.4.c i	0.14370	0.14176	-0.002	-1.35%	here
1.A.4.c ii	0.0153	0.0157	0.0004	2.65%	here
1.A.5.b	0.00049	0.00054	0.00005	10.31%	here
NFR 2 - IPPU	**0.043546**	**0.043550**	**0.000004**	**0.008%**	**sub-category chapters**
2.G	0.043546	0.043550	0.000004	0.008%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.03**	**0.03**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

Recalculations - Polyaromatic Hydrocarbons 1 to 4

With no reportable changes within the **National Total** reported for **1990**, the only notable percental changes occur for NFRs **1.A.2.g vii with -2.10 %**, **1.A.4.a ii with -2.16 %** and **1.A.4.c ii with plus 1.20 %** with mutually canceling absolute changes.

Table 1: Changes of emission estimates 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**115.67**	**115.67**	**0.00**	**0.00%**	**sub-category chapters**
NFR 1 - Energy	**102.40**	**102.40**	**0.00**	**0.00%**	**sub-category chapters**
1.A.2.g vii	0.0998	0.0977	-0.0021	-2.10%	here
1.A.4.a ii	0.0195	0.0191	-0.0004	-2.16%	here
1.A.4.c ii	0.2088	0.2114	0.0025	1.20%	here
NFR 2 - IPPU	**11.81**	**11.81**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**1.46**	**1.46**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The significant changes within the **National Total** reported for **2022 (+3.53 t or +4.87 %)** are dominated by revisions in NFR sub-categories **1.A.4.b i with +3.89 t** and **1.A.4.a i with -0.30 t** togehter with a variety of small revisions throughout NFR 1.

However, the most significant percental change occurs in NFR **1.A.4.a ii with minus 16 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[t]**			**relative**	**see description and reasoning in:**
NFR 1 - Energy	**72.51**	**76.04**	**3.53**	**4.87%**	**sub-category chapters**
1.A.1.a	**0.0474**	**0.0471**	**-0.0003**	**-0.62%**	**here**
1.A.1.b	0.0043	0.0042	-0.0001	-2.74%	here
1.A.1.c	0.0009	0.0008	-0.0001	-10.23%	here
1.A.2.a	0.00029	0.00030	0.00001	1.97%	here
1.A.2.g vii	0.086	0.081	-0.005	-5.63%	here
1.A.2.g viii	0.70	0.65	-0.05	-7.53%	here
1.A.3.b i	1.468	1.469	0.001	0.08%	here
1.A.3.b ii	0.237	0.233	-0.004	-1.73%	here
1.A.3.b iii	1.05	1.06	0.01	0.90%	here
1.A.3.b iv	0.0153	0.0149	-0.0004	-2.57%	here
1.A.3.c	0.03228	0.03233	0.00005	0.16%	here
1.A.3.d ii	0.051	0.050	-0.002	-3.03%	here
1.A.4.a i	8.23	7.92	-0.30	-3.70%	here
1.A.4.a ii	0.016	0.014	-0.003	-16.05%	here
1.A.4.b i	59.42	63.31	3.89	6.55%	here
1.A.4.b ii	0.0072	0.0074	0.0002	2.11%	here
1.A.4.c i	0.595	0.587	-0.008	-1.35%	here
1.A.4.c ii	0.23	0.24	0.01	2.87%	here
1.A.5.b	0.0054	0.0061	0.0007	13.74%	here
NFR 2 - IPPU	**3.12785**	**3.12786**	**0.00001**	**0.0003%**	**sub-category chapters**
2.G	0.11992	0.11993	0.00001	0.01%	here
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**1.10**	**1.10**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

Recalculations - Hexachlorobenzene (HCB)

Compared to the previous submission, the **National Total** reported for **1990** remains **unaltered**.

Table 1: Changes of emission estimates 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kg]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**2,900.52**	**2,900.52**	**0.00**	**0.00%**	
NFR 1 - Energy	**4.80**	**4.80**	**0.00**	**0.00%**	
NFR 2 - IPPU	**2,786.42**	**2,786.42**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**109.29**	**109.29**	**0.00**	**0.00%**	
NFR 5 - Waste	**0.01**	**0.01**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

The changes within the **National Total** reported for **2022 (+0.04 kg or +0.94 %)** are dominated by revisions in NFR sub-categories **1.A.4.b i with +0.08kg** and **1.A.1.a with -0.04 kg** togehter with a variety of small revisions throughout NFR 1 and with the most significant percental change occuring in NFR **1.A.4.b i with plus 6.6 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kg]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**4.63**	**4.68**	**0.04**	**0.94%**	**sub-category chapters**
NFR 1 - Energy	**2.64**	**2.68**	**0.04**	**1.65%**	**sub-category chapters**
1.A.1.a	1.26	1.22	-0.04	-2.93%	here
1.A.2.g viii	0.019	0.020	0.001	3.83%	here
1.A.3.d ii	0.037	0.035	-0.001	-3.20%	here
1.A.4.a i	0.060	0.058	-0.002	-3.70%	here
1.A.4.b i	1.258	1.341	0.08	6.60%	here
1.A.4.c i	0.00480	0.00474	0.00	-1.35%	here
NFR 2 - IPPU	**1.32**	**1.32**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**0.65**	**0.65**	**0.00**	**0.00%**	
NFR 5 - Waste	**0.03**	**0.03**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

Recalculations - Polychlorinated Biphenyls (PCBs)

Compared to the previous submission, the **National Total** reported for **1990** remains **unaltered**.

Table 1: Changes of emission estimates 1990

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kg]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**1,735.78**	**1,735.78**	**0.00**	**0.00%**	
NFR 1 - Energy	**588.96**	**588.96**	**0.00**	**0.00%**	
NFR 2 - IPPU	**1,146.82**	**1,146.82**	**0.00**	**0.00%**	
NFR 3 - Agriculture	**NA**				
NFR 5 - Waste	**0.0000005**	**0.0000005**	**0.0000000**	**0.00%**	
NFR 6 - Other	**NA**				

The changes within the **National Total** reported for **2022 (-3.94 kg or 1.85 %)** are dominated by changes in NFR sub-categories **1.A.1.a** (-3.94 kg), **1.A.4.b i** (+1.19 kg) and **1.A.2.g viii** (-1.04 kg) togehter with a variety of small revisions throughout NFR 1 and with the most significant percental change occuring for NFR **1.A.2.g viii with minus 6.19 %**.

Table 2: Changes of emission estimates 2022

	Submission 2024	Submission 2025	Difference		Reasoning
NFR Sector	**[kg]**			**relative**	**see description and reasoning in:**
NATIONAL TOTAL	**213.40**	**209.46**	**-3.94**	**-1.85%**	**sub-category chapters**
NFR 1 - Energy	**145.67**	**141.72**	**-3.94**	**-2.71%**	**sub-category chapters**
1.A.1.a	101.87	97.93	-3.94	-3.87%	here
1.A.2.g viii	16.83	15.79	-1.04	-6.19%	here
1.A.3.b i	0.001092	0.001089	-0.000003	-0.29%	here
1.A.3.b ii	0.000120	0.000118	-0.000003	-2.36%	here
1.A.3.b iii	0.00004190	0.00004186	-0.00000005	-0.11%	here
1.A.3.b iv	0.000140	0.000135	-0.000004	-3.05%	here
1.A.3.d ii	0.0818	0.0813	-0.0005	-0.59%	here
1.A.4.a i	3.81	3.66	-0.15	-3.85%	here
1.A.4.b i	22.64	23.83	1.19	5.23%	here
1.A.4.c i	0.343	0.339	-0.003	-0.97%	here
NFR 2 - IPPU	**67.74**	**67.74**	**0.00**	**0.00%**	
NFR 3 - Agriculture					
NFR 5 - Waste	**0.000002**	**0.000002**	**0.00**	**0.00%**	
NFR 6 - Other	**NA**				

CHAPTER 9.2 - Improvements

Improvements since last Submission



The following table provides an overview of the main improvements introduced with the current NFR and IIR submission and their affect on the **TACCC** principles for **T**ransparency, **A**ccuracy, **C**onsistency, **C**ompleteness, and **C**omparability.

		improvement of:					result of review?
What?	**Where?**	**Transparency**	**Accuracy**	**Consistency**	**Completeness**	**Comparability**	
IMPROVEMENTS SPECIFIC TO GERMANY'S EMISSIONS INVENTORY (as provided in the NFR tables)							
newly implemented emission sources (!)	3.D.a.4: NH_3 from crop residues	x			x	x	
	3.D.a.4: particulate matter emissions from cover crops	x			x	x	
re-allocation of activity data and/or emissions	1.A.1.b, 1.A.1.c, 1.A.2.g viii: to assure consistency between data sources and database structure	x	x	x		x	
adoption of EF from:							
(i) the latest EMEP/EEA GB (ongoing)	3.D.a.1: tier2 for NH_3 from mineral fertilizers					x	
(ii) the IPCC Refinement (2019)	3.B: N_2O					x	
(iii) research projects	among others: 1.A.3.c (abrasive PM), 3.B			x		x	
IMPROVEMENTS SPECIFIC TO THE IIR							
(i) fundamental revision of specific chapter	IIR chapter 10 on Projections	x				x	
(ii) new chapter/annex	*no such improvement with current IIR submission*						
(iii) provision of original inventory data	test: for NFR 1.A.3.a, 1.A.3.c (feedback welcome!)	x				x	

Improvements planned for future submissions

Possible improvement issues that have been identified so far and will be checked in the future are given below:

OVER-ALL INVENTORY (all source categories)

- To prioritise improvements on the basis of the results of the uncertainty analysis, it is planned to determine uncertainty analysis at source category level.

stationary fuel combustion:

- 1.A.1.a: evaluation of measurement data on POPs and heavy metal in large combustion plants
- 1.A.1.b: revision of SO_2 emission factors
- further improvements of PAH Emission factors for small combustion plants

mobile fuel combustion:

- 1.A.3.b vi + vii: update of emission factors for abrasive emissions from tyres and brakes (via research project), with special focus on Euro7 standard; possible implementation into TREMOD
- 1.A.3.c: validation and revision of approach for abrasive emissions from railways; possible implementation into TREMOD

industrial processes:

- aluminium production: completeness of PAH reporting
- iron and steel production: assessment of the use of default emission factors to complete PAH emission reporting.
- copper production: completeness of HM reporting

Investigated Review Findings

NECD 2023

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Official Comment for IIR
(lack of) Transparency	2C4	2022	Lack of transparency regarding the use of notation keys does not match IIR description	DE-2-2022-0002;DE-2-2022-0002	Partly	
	2D3	2023	Check Notation keys	DE-2D-2023-0001	No	
	2D3a	2023	Improve discription of domestic solvent use	DE-2D3a-2023-0001	No	
	2D3i	2023	consider allocation of NMVOC from lubricants, concrete additives, and plant protectives to NFR 2.G and provide information for not calculating the emission from use of shoes, and clarification about reporting NMVOC from lubricants and cooling lubricants	DE-2D3i-2023-0001	No	
	3Da2c	2023	harmonise description of conversion of NO_x EFs throughout all Chapters for 3.D Agricultural soils in the IIR	DE-3Da2c-2023-0001	Yes	
	3Dc	2023	correct tier level for 3.D.c provided in the IIR	DE-3Dc-2023-0001	No	tier corrected to T2
	5E	2023	Include the information (weighting factors applied for each type of buildings/car fires in order to derive the number of full□scale fires justification that the default emission factors refer to full-scale burning) and complete the description with detailed activity data split by type of fire (small medium major) and category of buildings including the sources of the data.	DE-5E-2023-0001	Yes	Germany has improved transparency regarding the methodological description. About the conversion of different types of fires to full-scale fires and about the activity data split by type of fire now there is more information in IIR.
	2A5a	2023	Include an explanation for how the share of the emissions from saltmining has been determined	DE-2A5a-2023-0001	Yes	Germany has included an explanation of the determination in IIR and has added an informative graph.
Accuracy	1A3di(i)	2023	check $PM_{2.5}$ implied emission factor	DE-1A3di(i)-2023-0002	No	
	2D3e	2023	investigate the possibility of using surrogate data	DE-2D3e-2023-0001	No	
Completeness	2D3c	2022	For particulate matter Germany did not provide estimates and was using the notation key ‘NA’ (not applicable) in its NFR	DE-2D3c-2022-0001;DE-2D3c-2022-0001	Yes	The research is ongoing now we have changed the notation keys to NE. Germany will report on the progress made implementing this improvement in IIR submissions.
	3B	2022	Other animals not reported	DE-3B4h-2022-0001;DE-3B4h-2022-0001	Yes	Will be implemented in Submission 2024
	5A	2023	estimate PM emissions from all mineral waste handled (including backfilling) or provide a justification in the IIR that the estimate includes all relevant emissions	DE-5A-2023-0001	Yes	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Official Comment for IIR
Consistency	3B4gi	2023	Correct inconsistencies in the timeseries and to include explanations of any fluctuations with clear references to other documents and corresponding statements	Germany-2023-3B-4	No	
	3B4gii	2023	Correct inconsistencies in the timeseries and include explanations of any fluctuations with clear references to other documents and corresponding statements in it the IIR	Germany-2023-3B-5	Yes	Germany will add the link to chimney sweeps statistic in the next IIR submission.

NECD 2022

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
(lack of) Transparency	1A5b	2022	Lack of transparency regarding the NO_x emissions outlier in 2005 compared to 2000-2010 emissions	DE-1A5b-2022-0001	Yes	
	1A5b	2022	Lack of transparency regarding the $PM_{2.5}$ emissions outlier in 2005 compared to 2000-2010 emissions	DE-1A5b-2022-0002	Partly	
	2C4	2022	Lack of transparency regarding the use of notation keys does not match IIR description	DE-2-2022-0002	Partly	
	2G	2022	Lack of transparency regarding the drop in the emissions in 2020 from the previous rather steady trend	DE-2G-2022-0001	Yes	
	2J	2022	Lack of transparency regarding the use of notation keys because the notation keys 'NA' and 'NE' do not match the explanation in the IIR	DE-2J-2022-0001	Yes	
	2K	2022	Lack of transparency on the use of these notation keys and the explanation provided in the IIR	DE-2K-2022-0001	No	
	3D	2022	Lack of transparency regarding activity data reported in the NFR tables for years 1990-2020	DE-3D-2022-0001	Yes	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
Consistency	1A4ciii	2018		DE-1A4ciii-2018-0001	No	As described in the relevant IIR chapter activity dta for maritime navigation including fishing is estimated bottom-up in a country-specific model and based on ship movement data. From that perspective jumps in fuel consumption cannot be explained by errors in statistics but are assumed to represent reality in respect to the amounts of fuels used by fishing vessels opreating from German harbours.
Completeness	2D3c	2022	For particulate matter Germany did not provide estimates and was using the notation key 'NA' (not applicable) in its NFR	DE-2D3c-2022-0001	Yes	The research is ongoing now we have changed the notation keys to NE. Germany will report on the progress made implementing this improvement in IIR submissions.
	2H1	2022	Germany reports 'IE' for all pollutants under NFR 1.A.2.d assuming that the fuel-related emissions are allocated under 2.H.1. However, for BC and CO the notation key 'NE' is used	DE-2H1-2022-0002	Yes	We have improved the IIR documentation of the allocation of all emissions from the pulp and paper industry and included an explanation of the management of process related sulphur and ammonia emissions for pulping processes occurring in Germany.
	3B	2022	Other animals not reported	DE-3B4h-2022-0001	Yes	Will be implemented in Submission 2024
	3Da2a	2022	Use of notation key for NMVOC while emissions are expected	DE-3Da2a-2022-0001	Yes	
	5D1	2022	Lack of transparency regarding dry toilets (including latrines)	DE-5-2022-0001	No	
Accuracy	3Dc	2022	Farm-Level Agricultural Operations should be reported using Tier 2 or higher	DE-3Dc-2022-0001	Yes	

NECD 2021

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
General	LPS	2021	Update to the 2019 dataset	DE-LPS-GEN-2021-0002	No	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
(lack of) Transparency	1A1a\1A2gviii\1A4\1B1	2021	Clearly reference EFs used for HCB and BC	DE-1A1a-2021-0001	Yes	
	1A2b	2021	Update notation key used for BC emission	DE-1A2b-2021-0001	Yes	
	1A2e	2021	Update notation key for BC and check allocation	DE-1A2e-2021-0001	Yes	The notation key for 1.A.2.e is changed and a description of the allocation of the emissions is included in the IIR 2022.
	1A4bii	2021	Update IIR description	DE-1A4bii-2021-0001	Yes	
	1A3ei	2021	Explicitly state why $PM_{2.5}$ is equal to PM_{10}	DE-1A3ei-2021-0001	Yes	
	5	2021	Update to the latest Guidebook where needed	DE-5-2021-0001	Yes	Citation has been updated to the latest GB version - no changes in EF needed. Only for 5C2 some changes in EF is planned.
Consistency	1A4ciii	2018	Large increase in AD from 2015 to 2016	DE-1A4ciii-2018-0001	No	As described in the relevant IIR chapter activity dta for maritime navigation including fishing is estimated bottom-up in a country-specific model and based on ship movement data. From that perspective jumps in fuel consumption cannot be explained by errors in statistics but are assumed to represent reality in respect to the amounts of fuels used by fishing vessels opreating from German harbours.
	1A4cii	2018	Inconsistent AD values NFR vs. IIR	DE-1A4cii-2018-0001	Yes	
	1A1b	2021	Resolve time series issue for BC	DE-1A1b-2021-0001	No	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
Completeness	2D3g	2018	Report PAHs from 2.D.3.g Chemical Products	DE-2D3g-2018-0001	Yes	
	LPS	2020	Add missing pollutants: PAHs, PCBs, $PM_{2.5}$	DE-LPS-GEN-2020-0001	Yes	Since these pollutants are not in the ePRTR dataset Germany cannot report them.
	1A2a	2021	Report BC emissions	DE-1A2a-2021-0002	No	
	1A2a	2021	Include BC emissions	DE-1A2a-2021-0001	Yes	
	1A5a	2021	Include BC emissions	DE-1A5a-2021-0001	Yes	
	2A3	2021	Include BC emissions	DE-2A3-2021-0001	Yes	The notation key for BC is changed from 'NA' to 'NE' and a justification for this notation key is included in the IIR.
	LPS	2021	Include PCDD/F emissions	DE-LPS-GEN-2021-0001	No	
	GRID	2021	Include NOx emissions from shipping	DE-GRID-G-2021-0001	Yes	
Comparability	1B1b	2021	Update PAH reporting	DE-1B1b-2021-0001	Yes	Revised emission factors developed according to suggestions in review.
	2A1	2021	Update PAH reporting	DE-2A1-2021-0001	Yes	Details of the methodology used for BaP and for PAH-1-4 estimation are explained in IIR 2022.
	2C1	2021	Update PAH reporting	DE-2C1-2021-0001	Yes	
	2C3	2021	Update PAH reporting	DE-2C3-2021-0001	partly	
Accuracy	1A2f	2021	Move CO emission calculation to a higher tier	DE-1A2f-2021-0003	Yes	

NECD 2020

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
General	LPS	2020	Improve consistency with the latest ePRTR reporting.	DE-LPS-GEN-2020-0002	Yes	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
(lack of) Transparency	3I	2020	Improve the transparency of the calculations used for NO emissions from storage of digestate from energy crops.	DE-3I-2020-0001	Yes	
	2C7a	2020	Improve Transparency for Cd and Pb emissions from copper production	DE-2C7a-2020-0001	Yes	
	LPS	2020	Reallocate livestock emissions from GNFR L_AgriOther to K_AgriLivestock	DE-LPS-K-2020-0001	Yes	
Consistency	1A4cii	2018	IEF Cd trend since 2007 erratic	DE-1A4cii-2018-0001	Partly	As described in the relevant IIR chapter activity dta for maritime navigation including fishing is estimated bottom-up in a country-specific model and based on ship movement data. From that perspective jumps in fuel consumption cannot be explained by errors in statistics but are assumed to represent reality in respect to the amounts of fuels used by fishing vessels opreating from German harbours.
	1A4ciii	2018	Large increase in AD from 2015 to 2016	DE-1A4ciii-2018-0001	No	Metal and PCDD/F emissions are not considered as fugitive. If IE would be used nevertheless one can assume there are such fugitives. Germany suggest to keep the notation key NA.

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
Completeness	2B6	2017	Include the NOx emissions in the next submission.	DE-2B6-2017-0001;DE-2B6-2018-0001	Yes	
	2D3g	2018	Report PAHs from 2D3g Chemical Products	DE-2D3g-2018-0001	Yes	
	2C1	2018	Potential under-estimate of emissions of HCB	DE-2C1-2018-0001	Yes	Implemented in submission 2021 using the default emission factor from the 2019 EMEP/EEA Guidebook.
	5D2	2019	NMVOC emissions missing although default EFs exist	DE-5D2-2019-0001	Yes	Industrial wastewater NMVOC emissions were implemented and are part of the 2021 reporting.
	2D3a	2019	Emissions of Hg not estimated	DE-2D3a-2019-0001	Yes	
	LPS	2020	Add missing pollutants PAHs PCBs PM2.5	DE-LPS-GEN-2020-0001	Yes	Since these pollutants are not in the ePRTR dataset Germany cannot report them.
	GRID	2020	Add gridded emissions of Cd Pb Hg PCDD/F PAHs HCB PCBs to reporting	DE-GRID-GEN-2020-0001	Yes	
Accuracy	2D3a	2018	Rationale for not estimating emissions in category 2D3a and notation key selection	DE-2D3a-2018-0001	Yes	Germany is in the process of evaluating data to calculate emissions of Hg from the use of fluorescent tubes.
	LPS	2020	Check emission data for facility “Heyne & Penke Verpackungen GmbH”	DE-LPS-E-2020-0001	Yes	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
QA/QC	LPS	2020	Improve coordinates given check for collisions	DE-LPS-GEN-2020-0004	No	
	LPS	2020	Make sure each point source reported has unique key build from attributes	DE-LPS-GEN-2020-0003	No	Germany checked this issue and does not see any reason to change the data. It is unclear why LPS name GNFR and stack height should function as a key alternative in particular because the table already provides the ePRTR ID as an unique and valid key.

NECD 2019

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
(lack of) Transparency	1A1	2017	Presents its NH3 EF for stationary combustion in the next submission of its IIR justify the use of these and compare these against the values in 2016 EMEP/EEA Guidebook.	DE-1A1-2017-0001;DE-1A1-2018-0001	Yes	A comparison with default values is not possible.
Consistency	1A4cii	2018	IEF Cd trend since 2007 erratic	DE-1A4cii-2018-0001	Partly	As the National Energy Balances 2003 to 2020 have been revised by the Working Group on Energy Balances (AGEB) in advance of the 2024 submission this erratic trend has been resolved.
	1A4ciii	2018	Large increase in AD from 2015 to 2016	DE-1A4ciii-2018-0001	No	As described in the relevant IIR chapter activity dta for maritime navigation including fishing is estimated bottom-up in a country-specific model and based on ship movement data. From that perspective jumps in fuel consumption cannot be explained by errors in statistics but are assumed to represent reality in respect to the amounts of fuels used by fishing vessels opreating from German harbours.
	1A4bii	2019	Significant fluctuations in fuel consumption over the time series	DE-1A4bii-2019-0001	Yes	As the National Energy Balances 2003 to 2020 have been revised by the Working Group on Energy Balances (AGEB) in advance of the 2024 submission this erratic trend has been resolved.

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
Completeness	2B3	2017	Include the NOx emissions in the next submission preferably using a country specific method to account for the specific technologies and abatement equipment applied.	DE-2B3-2017-0001;DE-2B3-2018-0001	Yes	
	2B6	2017	Include the NOx emissions in the next submission.	DE-2B6-2017-0001;DE-2B6-2018-0001	Yes	
	5A	2017	Include NMVOC and PM2.5 emissions from 5A in its next submission.	DE-5A-2017-0001;DE-5A-2018-0001	Yes	Implemented in 2020 reporting. Although only the reporting of NMVOC and PM2.5 emissions was requested Germany decided to additionally report PM10 and TSP.
	2D3g	2018	Report PAHs from 2D3g Chemical Products	DE-2D3g-2018-0001	Yes	
	2C1	2018	Potential under-estimate of emissions of HCB	DE-2C1-2018-0001	Yes	Implemented in submission 2021 using the default emission factor from the 2019 EMEP/EEA Guidebook.
	5D2	2019	NMVOC emissions missing although default EFs exist	DE-5D2-2019-0001	Yes	Industrial wastewater NMVOC emissions were implemented and are part of the 2021 reporting.
	1A2a	2019	NE reported for Cadmium although a default EF is available	DE-1A2a-2019-0001	Yes	
	1A2b	2019	NE reported for some pollutants although default EFs are available	DE-1A2b-2019-0002	Yes	
	1A2b	2019	NA is reported for HCB 1990	DE-1A2b-2019-0001	Yes	Germany carefully checked all possible aditional sources for HCB in this sector. This includes the BREF documents as well as other literature. There was no indication for any missing emission found. The emission factors in the Guidebook are only applicable to processes not occuring in Germany.
	1A3b	2019	PCB emissions missing for all years although default emission factors are available	DE-1A3b-2019-0001	Yes	Emissions calculated based on default EF
	1A3c	2019	Update notation key from NE to NA	DE-1A3c-2019-0001	Yes	
	2D3a	2019	Emissions of Hg not estimated	DE-2D3a-2019-0001	Yes	
	5C2	2019	Emission are not estimated for PCDD/F Pb and Cd although default EFs are available	DE-5C2-2019-0001	Yes	Default-EF used emissions reported.
Comparability	1A4ai	2019	Implied EFs PAHs and PCDD/F are outliers compared to other member states	DE-1A4ai-2019-0001	No	
Accuracy	1A1a	2017	Include the revised estimate of activity data and emissions for biogas in its next submission.	DE-1A1a-2017-0003;DE-1A1a-2018-0001	Partly	Implemented in 2020 submission
	2D3a	2018	Rationale for not estimating emissions in category 2D3a and notation key selection	DE-2D3a-2018-0001	Yes	Germany is in the process of evaluating data to calculate emissions of Hg from the use of fluorescent tubes.
	3B	2019	Tier 1 method used for key category	DE-3B-2019-0001	Yes	Implemented in 2020 reporting

NECD 2018

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
(lack of) Transparency	1A1	2017	Presents its NH3 EF for stationary combustion in the next submission of its IIR justify the use of these and compare these against the values in 2016 EMEP/EEA Guidebook.	DE-1A1-2017-0001;DE-1A1-2018-0001	Yes	A comparison with default values is not possible.
	1A1b	2014	Include the country specific EFs for combustion in refineries in the relating chapter of its IIR to improve transparency.	§ 55 (CLRTAP 2014);DE-1A1b-2017-0001;DE-1A1b-2018-0001	Yes	The emission factors continue to be under revision. New emission factors will be included in the IIR following the use of results of a finished project.
	2D3d	2017	Include explanation on recalculation to 1994 in the next submission.	DE-2D3d-2017-0001;DE-2D3d-2018-0001	Yes	Was reported with the submission 2019.
	1A3bi	2018	Incorrect notation keys for activity data	DE-1A3bi-2018-0002	Yes	notation keys replaced by activity data values
	1A3bv	2018	Incorrect notation keys for HCB and PCB emissions	DE-1A3bv-2018-0001	Yes	'NE' replaced by 'NA' as suggested by the TERT
Consistency	1A4cii	2018	IEF Cd trend since 2007 erratic	DE-1A4cii-2018-0001	Partly	As the National Energy Balances 2003 to 2020 have been revised by the Working Group on Energy Balances (AGEB) in advance of the 2024 submission this erratic trend has been resolved.
	1A4ciii	2018	Large increase in AD from 2015 to 2016	DE-1A4ciii-2018-0001	No	As described in the relevant IIR chapter activity dta for maritime navigation including fishing is estimated bottom-up in a country-specific model and based on ship movement data. From that perspective jumps in fuel consumption cannot be explained by errors in statistics but are assumed to represent reality in respect to the amounts of fuels used by fishing vessels opreating from German harbours.
	1A4cii	2018	Inconsistent AD values NFR vs. IIR	DE-1A4cii-2018-0001	Yes	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
Completeness	2B3	2017	Include the NOx emissions in the next submission preferably using a country specific method to account for the specific technologies and abatement equipment applied.	DE-2B3-2017-0001;DE-2B3-2018-0001	Yes	
	2B6	2017	Include the NOx emissions in the next submission.	DE-2B6-2017-0001;DE-2B6-2018-0001	Yes	
	2C3	2017	Include NOx from aluminium production in the next submission to improve completeness and comparability.	DE-2C3-2017-0001;DE-2C3-2018-0002	Yes	Germany carefully assessed the situation regarding this issue and concluded that no substantial NOx emission are to be expected from this source. But in order to avoid an underestimation Germany implemented the default EF of the emission guidebook 2019.
	5A	2017	Include NMVOC and PM2.5 emissions from 5A in its next submission.	DE-5A-2017-0001;DE-5A-2018-0001	Yes	Implemented in 2020 reporting. Although only the reporting of NMVOC and PM2.5 emissions was requested Germany decided to additionally report PM10 and TSP.
	5D	2017	Include the estimation of NMVOC emissions from wastewater treatment plant in its next submission.	DE-5D-2017-0001;DE-5D-2018-0001	Yes	
	2D3g	2018	Report PAHs from 2D3g Chemical Products	DE-2D3g-2018-0001	Yes	
	1B2aiv	2018	Potential under-estimate of emissions of Hg Cd PCDD/F	DE-1B2aiv-2018-0001	Yes	Metal and PCDD/F emissions are not considered as fugitive. If IE would be used nevertheless one can assume there are such fugitives. Germany suggest to keep the notation key NA.
	2C1	2018	Potential under-estimate of emissions of HCB	DE-2C1-2018-0001	Yes	Data acquisition for the resolution of this issue will be implemented in the framework of a research project updating several emission factors. The effort is scheduled to start in 2021 and will take about 3 years. Until then the default emission factor from the EMEP/EEA Guidebook is used.
	2C3	2018	Potential under-estimate of emissions of HCB	DE-2C3-2018-0001	Yes	Implemented in submission 2019 using the default emission factor of the 2016 EMEP/EEA Guidebook
Comparability	5C	2018	Hg EF is 100 times smaller than the default value proposed in the 2016 EMEP/EEA Guidebook and the Cd and Pb EF are 1000 times smaller than the default values proposed in the 2016 EMEP/EEA Guidebook	DE-5-2018-0001	No	References to research Projects of CS-EF added
Accuracy	1A1a	2017	Include the revised estimate of activity data and emissions for biogas in its next submission.	DE-1A1a-2017-0003;DE-1A1a-2018-0001	Partly	Implemented in 2020 submission
	2D3a	2018	Rationale for not estimating emissions in category 2D3a and notation key selection	DE-2D3a-2018-0001	Yes	Germany is in the process of evaluating data to calculate emissions of Hg from the use of fluorescent tubes.

NECD 2017

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
(lack of) Transparency	1A1	2017	Presents its NH3 EF for stationary combustion in the next submission of its IIR justify the use of these and compare these against the values in 2016 EMEP/EEA Guidebook.	DE-1A1-2017-0001;DE-1A1-2018-0001	Yes	A comparison with default values is not possible.
	1A1a	2017	Improves the transparency of its IIR regarding PM2.5 shares used for each fuel (solid fuels (coal and lignite) and gaseous fuels but also biomass if relevant).	DE-1A1a-2017-0001	No	
	1A1b	2014	Include the country specific EFs for combustion in refineries in the relating chapter of its IIR to improve transparency.	§ 55 (CLRTAP 2014);DE-1A1b-2017-0001;DE-1A1b-2018-0001	Yes	The emission factors continue to be under revision. New emission factors will be included in the IIR following the use of results of a finished project.
	1A2gviii	2017	Improve the transparency of the IIR to explain its assumptions on the PM2.5 fraction used for each fuel and particularly for liquid fuels biomass and other fuels.	DE-1A2gviii-2017-0001	Yes	
	2A1	2017	Include the explanation and rationale for using two sets of activity data to be included in the IIR for the next submission.	DE-2A1-2017-0001	Yes	
	2C	2017	Update the SO2 emission factors for 2C5 2C6 and 2C7a for the next submission to reflect the individual production activities and to include more transparent information on primary vs. secondary production of lead zinc and copper in the IIR.	DE-2C-2017-0001	Yes	
	2D3d	2017	Include explanation on recalculation to 1994 in the next submission.	DE-2D3d-2017-0001;DE-2D3d-2018-0001	Yes	Was reported with the submission 2019.
	3B	2017	Include the information for the proportional of NO-N and N2 and the reference in the IIR to improve transparency.	DE-3B-2017-0002	Yes	
	3B2	2017	Mention that NFR 3B2 includes lambs and also explain the lower EF NMVOC used for lambs. Furthermore the TERT recommend that Germany in IIR mentioned that pullets are included in NFR 3B4giv other poultry.	DE-3B2-2017-0004	Yes	
	3F	2017	Include more information in the IIR for the next submission referring to the specific law and clarifying from which year the ban came into force. Furthermore it is recommended to inform whether there are derogations for field burning under certain circumstances or for certain crop types.	DE-3F-2017-0001	Yes	
Consistency	1A2	2017	Use the right notation keys in the NFR tables for its next submissions. (1A2 Stationary Combustion in Manufacturing Industries and Construction PM2.5 2005-2015)	DE-1A2-2017-0001	Yes	
Completeness	5E	2010	Although the Guidebook has methods for car and house fires in Chapter 6 it may be more transparent to include these in Chapter 7 as Chapter 6D is more focused on compost and sludge. The ERT encourages Germany to consider including some of these emissions in the next submissions.	§ 116 (CLRTAP 2010);§139 (CLRTAP 2014);DE-5A-2017-0003	Partly	
	2B10a	2017	Investigate whether flaring occurs in relation to carbide production e.g. by contacting the single producer of carbide.	DE-2B10a-2017-0002	Yes	Flaring is a common destruction technic in chemical industry. But no information exists to assign flaring quantities to a single installation.
	2B3	2017	Include the NOx emissions in the next submission preferably using a country specific method to account for the specific technologies and abatement equipment applied.	DE-2B3-2017-0001;DE-2B3-2018-0001	Yes	
	2B6	2017	Include the NOx emissions in the next submission.	DE-2B6-2017-0001;DE-2B6-2018-0001	Yes	
	2C3	2017	Include NOx from aluminium production in the next submission to improve completeness and comparability.	DE-2C3-2017-0001;DE-2C3-2018-0002	Yes	Germany carefully assessed the situation regarding this issue and concluded that no substantial NOx emission are to be expected from this source. But in order to avoid an underestimation Germany implemented the default EF of the emission guidebook 2019.
	3D1bii	2017	Include the emission from sewage sludge applied to agricultural soils in the next submission.	DE-3Da2b-2017-0001	Yes	
	5A	2017	Include NMVOC and PM2.5 emissions from 5A in its next submission.	DE-5A-2017-0001;DE-5A-2018-0001	Yes	Implemented in 2020 reporting. Although only the reporting of NMVOC and PM2.5 emissions was requested Germany decided to additionally report PM10 and TSP.
	5D	2017	Include the estimation of NMVOC emissions from wastewater treatment plant in its next submission.	DE-5D-2017-0001;DE-5D-2018-0001	Yes	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
Comparability	3D1a	2017	Use the updated emission factors available in the 2016 EMEP/EEA Guidebook (Table 3.2) for the next submission.	DE-3Da1-2017-0001	Yes	
Accuracy	1A1a	2017	Include the revised estimate of activity data and emissions for biogas in its next submission.	DE-1A1a-2017-0003;DE-1A1a-2018-0001	Partly	Implemented in 2020 submission

CLRTAP 2023

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
(lack of) Transparency	3F	2023	Include information and the correct reference to Roseman et al. (2023) in the IIR	Germany-2023-3F-1	No	Updated Publication is now correctly referenced as Vos et al. 2024
	KCA	2023	Includes information on available the linked background files on the quantitative KCA level and trend assessment in its IIR	Germany-2023-0-1	Yes	
	3B2\3B4d\3B4e	2023	Add in the improvement plan a year in which the CLRTAP recommendation was implemented to include a clear reference to the chapters of the NIR and other documents and to link the previous IIRs in the relevant chapters	Germany-2023-3B-2	No	
	3b1a\3B3\3B4gi	2023	include the provided justifications of fluctuations in emissions and changes in the calculations in its IIR and to add in the improvement plan the year in which the recommendation was implemented	Germany-2023-3B-3	No	
Consistency	3B4gi	2023	correct inconsistencies in the timeseries and to include explanations of any fluctuations with clear references to other documents and corresponding statements	Germany-2023-3B-4	No	
	3B4gii	2023	Correct inconsistencies in the timeseries and include explanations of any fluctuations with clear references to other documents and corresponding statements in it the IIR	Germany-2023-3B-5	Yes	
Completeness	3B4h	2023	Continue the effort in calculating emissions from the category Other animals and include more detailed information on the manner of the gathering activity data for this category	Germany 2023-3B-1	No	Emissions from other animals (deer ostrich rabbits fur-bearing animals) included.

CLRTAP 2022

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
(lack of) Transparency	1A4bi	2022	Document the description of the activity date in more detail including information from the chimney sweeps statistic in the next IIR submission.	§ 10 (CLRTAP 2022)	No	Germany will add the link to chimney sweeps statistic in the next IIR submission.
	1A4bi	2022	Provide a complete and clear documentation on the splitting of appliance types are in the next IIR submission.	§ 12 (CLRTAP 2022)	Partly	Germany will check possible further information and report the results in future IIR submission.
	1A4bi	2022	Include information on the measurement standards and equipment used to determine the emission factors.	§ 14 (CLRTAP 2022)	No	Germany will check possible further information and report the results in future IIR submission. Nevertheless information about the status is already included in IIR.
	1A4bi	2022	Include the information provided during the review on the approach to the so-called user impact	§ 17 (CLRTAP 2022)	No	Germany will look at the development of the Guidebook and then will consider changes.
	1A4bi	2022	Include further information on the age distribution of the vehicle fleet and more information about the traffic condition.	§ 25 (CLRTAP 2022)		
Completeness	1A4bi	2022	Further investigate for each biomass and coal PM emission factor whether or not condensables are included.	§ 18 (CLRTAP 2022)	No	Germany will look at the development of the Guidebook and then will consider changes.

CLRTAP 2014

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
General		2010	Provide a PDF version of the IIR for offline use and to better facilitate the review process	§ 6 9 11 28 (CLRTAP 2010);§ 17 (CLRTAP 2014)	Yes	The German IIR is basically created in the form and structure of a wiki and is published as such. A parallel publication in the form of a continuous text document is currently not planned. However the inventory compiler routinely creates a PDF copy of the finished report particularly for documentation purposes - which can be made available upon request and if necessary for example during a review.
		2014	Use the results of the KCA to prioritise improvements in the inventory	§ 14 (CLRTAP 2014)	Yes	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
(lack of) Transparency	3B	2014	Explain the variation in activity data for goats in the IIR.	§ 120 (CLRTAP 2014)	Yes	
	2D3	2014	The methodology described in the IIR for solvent and other product use is found to be not transparent. Provide detail on all 37 subcategories including activity data and emission factors.	§ 18 96 97 98 (CLRTAP 2014)	Yes	The transparency for the solvents used and products used sector in the IIR was much improved in the submission 2016.
		2010	Inaccuracies were found in the use of notation keys and it is recommended to justify the use of notation keys in the IIR for each particular sector.	§ 38 (CLRTAP 2010);§ 19 (CLRTAP 2014)	Yes	Information tables for NE & IE were added to the completeness chapter of the current IIR.
		2014	Provide more detailed to explain emission trends e.g. annual fluctuations and discontinuities of emissions.	§ 21 78 (CLRTAP 2014)	Yes	
		2014	Extend the use of a bibliography for some subsectors to all sectors in the IIR.	§ 77 (CLRTAP 2014)	No	The amount of recurring references is very small within most source categories. And the total number of references per page is usually quite low. So directly linking to the documents seems like a good way to make sources available to the readers.
	1A1b	2014	Include the country specific EFs for combustion in refineries in the relating chapter of its IIR to improve transparency.	§ 55 (CLRTAP 2014);DE-1A1b-2017-0001;DE-1A1b-2018-0001	Yes	The emission factors continue to be under revision. New emission factors will be included in the IIR following the use of results of a finished project.
	1A3b	2010	Explain in more detail the emission calculation for road transport not only by saying that HBEFA and TREMOD are used but giving more information including an overview of emission factors in the next versions of the IIR.	§ 65 (CLRTAP 2010);§ 72 (CLRTAP 2014)	Yes	
	1B2d	2014	Report in the IIR on what basis emissions from geothermal energy extraction are considered negligible.	§ 59 (CLRTAP 2014)	Yes	
	3B	2014	Provide additional information in the IIR especially related to: TAN contents distributions of housing and storage facilities (e.g. for the first and last reporting year) slurry storage systems and the spreading systems applied corresponding EFs.	§ 117 (CLRTAP 2014)	Yes	
	5A\5B\5C	2010	Since all incineration is reported under energy add information about the methodology used for different types of waste incineration under NFR 1. In NFR 6C use the notation key “IE” instead of “NO” and to explain the use of the notation key in the IIR.	§ 103 110 111 112 (CLRTAP 2010);§ 136 (CLRTAP 2014)	Yes	Information on methods used for estimation of energy-related is reported in NFR 1. Germany considers NO to be correct and explains the situation in its IIR. Cremation estimation is explained now.
Consistency	2	2014	Ensure time series consistency of TSP emissions between 1990 and later years and clearly explain in the IIR where and why consistent reporting is not possible.	§ 80 (CLRTAP 2014)	Yes	
	1A1\1A2	2010	In the IIR in the “Short description” for 1A1 and 1A2 Germany presents a tier 2 or 3 approach. However during the review Germany indicated that only the tier 2 approach was used. This needs correction in the IIR (was agreed by Germany to do this)	§ 47 (CLRTAP 2010);§ 54 (CLRTAP 2014)	Yes	
	2A1\2A2	2014	A time series inconsistency is found which relates to a different reporting structure before 2000. It is recommended to explore the feasibility of harmonizing the methodology.	§ 93 (CLRTAP 2014)	Yes	
	2D3	2014	Provide emissions for 1990-2005 at a disaggregated level similar to later years if possible. If not explain why for the earlier period emissions have been estimated at a more aggregated level. Also clearly document in the case of IE where emissions have been allocated.	§ 100 101 (CLRTAP 2014)	Yes	The manufacturing industry was the most important branch of the GDR economy. The transformation of the markets and the disappearance of large state-owned enterprises in the course of the German unity led to a dramatic change in the eastern part of Germany
	3B	2014	The ERT encourages Germany to further improve the consistency of the time series of NH3 for manure management. In chapter 4 of the EMEP/EEA Guidebook 2013 specific methods are provided.	§ 110 (CLRTAP 2014)	Yes	
	3B	2014	Sheep animal numbers show a step change due to a different reporting time. This should be corrected for and described in the IIR as appropriate.	§ 119 (CLRTAP 2014)	Yes	
	3B	2014	Check and explain the variation in activity data for horses in the IIR.	§ 121 (CLRTAP 2014)	Yes	
	3B	2014	Explain how the change in farm practices or the implementation of mitigation measures has affected the time series in the IIR in order to facilitate the assessment of emission trends.	§ 111 (CLRTAP 2014)	Yes	
	3B	2014	Explain in the IIR why the NH3 EF for dairy cattle decreased from 2011 to 2012.	§ 122 (CLRTAP 2014)	Yes	
	3B	2014	Explain in the IIR why the NH3 EF for swine decreased from 1993 to 1994.	§ 123 (CLRTAP 2014)	Yes	
	3B	2014	Explain in the IIR why the NH3 EF significant changes for different poultry subsectors in the 2000s.	§ 124 (CLRTAP 2014)	No	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
Completeness		2010	Emissions prior to 1990 are not reported.	§ 27 (CLRTAP 2010);§ 24 (CLRTAP 2014)	Yes	Little information is available due to the split of Germany into two nations. Some overview data has been added to the IIR.
		2014	LPS data were not reported.	§ 10 (CLRTAP 2014)	Yes	
		2014	A key category analysis (KCA) was missing for the base years (1990 or 2000 for PM) of the pollutants.	§ 13 (CLRTAP 2014)	Yes	
	5E	2010	Although the Guidebook has methods for car and house fires in Chapter 6 it may be more transparent to include these in Chapter 7 as Chapter 6D is more focused on compost and sludge. The ERT encourages Germany to consider including some of these emissions in the next submissions.	§ 116 (CLRTAP 2010);§139 (CLRTAP 2014);DE-5A-2017-0003	Partly	
	1A4ai\1A4ci\1A5a	2014	HM and POP currently not reported since no consistent dataset is available (partly country specific partly Guidebook). The recommendation is to describe the issue in the IIR and until it is solved use the Guidebook emission factors despite their recognized uncertainty rather than reporting NE.	§ 57 (CLRTAP 2014)	Yes	Implemented for 1A4ai and 1A4ci
	1A3ai(i)\1A3aii(i)	2014	Heavy metal emissions are currently not estimated. The ERT recommends that the Party estimates these emissions using the methodology in the EMEP/EEA Guidebook.	§ 62 (CLRTAP 2014)	Yes	
	1A3biv\1A4bii	2014	PM10 and PM2.5 emissions are reported as “NE”. The ERT recommends that Germany completes the inventory by estimating these emissions.	§ 63 (CLRTAP 2014)	Yes	
	1A3bv	2014	Evaporative emissions from running losses (i.e. vapour generated in the fuel tank during vehicle operation) were missing because not considered in the TREMOD model. The ERT recommends to include these in the inventory.	§ 73 (CLRTAP 2014)	Yes	This issue has not yet been looked into as other model revisions especially regarding a follow-up of 'diesel gate' appear much more relevant tying up all resources.
	1A3dii	2014	Pb and Hg emissions are currently not estimated. The ERT recommends that the Party considers the emission factors available in the Guidebook.	§ 64 (CLRTAP 2014)	Yes	
	5A\5D	2014	Improves the completeness of the inventory by estimating emissions from solid waste disposal and wastewater handling.	§ 127 (CLRTAP 2014)	Yes	Solid waste emissions implemented since 2020 reporting. Domestic wastewater emissions implemented since 2018 reporting. Industrial wastewater emissions implemented since 2021 reporting.
	5A\5C\5D	2010	The inventory regarding Waste is currently not complete with missing estimates for several source categories.	§ 102 (CLRTAP 2010);§ 134 135 (CLRTAP 2014)	Yes	Industrial wastewater emissions implemented since 2021 reporting. Solid waste emissions implemented since 2020 reporting. Domestic wastewater emissions implemented since 2018 reporting. 5.C completed
Comparability	1A4bii\1A4cii	2014	Implied NOx emission factors are at the high end of the range when compared with a selected group of countries (AT BE DK ES FI FR GB IE IT NL NO). The ERT recommends that the Party reviews the emission factors for these two sources and includes an explanation for this issue in the IIR.	§ 66 (CLRTAP 2014)	Yes	This minor issue has not yet been checked. The inventory compiler will look into this as soon as resources allow.
	1A2a\1A4ai\1A4ci\1A5a	2014	Notation key NE is used for (many) heavy metals despite the availability of EFs in the EMEP/EEA Guidebook. If all HM emissions from iron & steel are reported in 2C1 the notation key should be IE.	§ 56 (CLRTAP 2014)	Yes	Implemented for 1A4ai and 1A4ci

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
Accuracy		2010	Implement a (qualitative and quantitative) uncertainty analysis and use the results to prioritize improvements to the inventory	§ 20 24 (CLRTAP 2010);§ 32 44e 85 (CLRTAP 2014)	Partly	
		2014	Include a chapter in the IIR with for each source category the foreseen improvements for the inventory	§ 34 (CLRTAP 2014)	Partly	Included for most categories
	1A3bvi	2014	This source is a key category for Pb and the ERT has noted that the emission factor for brake wear used by Germany was higher than the maximum range quoted by the 2013 Guidebook. Germany is recommended to review the EF explain where it is coming from in the IIR and potentially revise to bring in line with the Guidebook.	§ 74 (CLRTAP 2014)	Yes	
	1A3dii\1A5b	2014	Review the methodology for national navigation by distinguishing between coastal and inland shipping based on an ongoing research project as well as explicitly include emissions from military activities.	§ 75 76 (CLRTAP 2014)	Yes	
	2A1	2010	Cement production is a key source for Hg HCB and for NOx PM10 and PAH but Tier 1 is used. The ERT encourages Germany to use plant-specific data collected as part of the LCPD IPPC and E-PRTR to develop a tier 2 or 3 methodology in the near future and to document these in its IIR.	§ 79 (CLRTAP 2010);§ 88 (CLRTAP 2014)	Yes	plant-specific data approach is not planned
	2D3	2014	Increase the use of information from individual installations that make a high contribution to the key categories such as car assembly sites and big printing installations.	§ 104 (CLRTAP 2014)	Yes	Emissions caused by the use of solvents and solvent-based products are reported in the relevant source groups. In our methodology we also include the application of solvent-based products in large installations such as those used in automotive series production or large printing systems. The emission data of defined individual plants are thus included in the calculation but cannot be shown and published individually for reasons of confidentiality and data protection.
	3B	2014	Describe the efforts taken to verify / validate the emission model in the IIR.	§ 118 (CLRTAP 2014)	No	
QA/QC		2010	Fully implement the QA/QC system for the air pollutant emission inventory. If possible implement a unified QA/QC system for reporting to CLRTAP and UNFCCC.	§ 21 24 62 74 88 105 (CLRTAP 2010);§ 37 44f (CLRTAP 2014)	No	Ongoing discussion
		2010	Widen the use of the existing QA/QC system used for the set of activity data as well as the methods and emission factors for GHGs for the needs of CLRTAP/NECD inventories and providing further details on its implementation in the IIR (general and sectoral descriptions).	§ 33 40 (CLRTAP 2010);§ 16 69 84 87 103 105 (CLRTAP 2014)	No	Ongoing discussion
		2014	Include information on verification and validation of the inventory in the IIR.	§ 38 (CLRTAP 2014)	Yes	Ongoing discussion

CLRTAP 2010

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
General		2010	Provide a PDF version of the IIR for offline use and to better facilitate the review process	§ 6 9 11 28 (CLRTAP 2010);§ 17 (CLRTAP2014)	Yes	The German IIR is basically created in the form and structure of a wiki and is published as such. A parallel publication in the form of a continuous text document is currently not planned. However the inventory compiler routinely creates a PDF copy of the finished report particularly for documentation purposes - which can be made available upon request and if necessary for example during a review.

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
(lack of) Transparency		2010	Inaccuracies were found in the use of notation keys and it is recommended to justify the use of notation keys in the IIR for each particular sector.	§ 38 (CLRTAP 2010);§ 19 (CLRTAP 2014)	Yes	Information tables for NE & IE were added to the completeness chapter of the current IIR.
		2010	Provide more detailed information on the rationale for recalculations at a sectoral level to compliment the information already provided in the recalculation tables per pollutant.	§ 30 43 90 107 (CLRTAP 2010)	Partly	
	1A2a\1A2b\2C	2010	For iron & steel there is a mix of reporting under 1A2a (PM & CO) 2C1 (NOx SOx VOC NH3) and “NE” (HMs and POPs). For non ferrous metals similar issues are observed. The recommendation is to explain the rationale for reporting in different source categories as well the rationale for NEs. NE reporting should be avoided as much as possible e.g. by applying Guidebook Tier 1 EFs.	§ 48 49 (CLRTAP 2010)	Yes	The reporting in the different source categories is explained in the IIR.
	1A2gviii	2010	The ERT recommends that Germany include details of the units of AD used in its estimations as this was not always the case.	§ 51 (CLRTAP 2010)	Yes	
	1A3b	2010	Explain in more detail the emission calculation for road transport not only by saying that HBEFA and TREMOD are used but giving more information including an overview of emission factors in the next versions of the IIR.	§ 65 (CLRTAP 2010);§ 72 (CLRTAP 2014)	Yes	
	1A4	2010	Provide more detail on the emission factors used including their applicability for the different years and sub-categories of the time series. Find EFs to estimate emissions for heavy metals (for example: using tier 1 in the EMEP Guidebook inventories in other countries).	§ 52 (CLRTAP 2010)	Yes	
	3B	2010	The ERT recommends including in the IIR information on the complete time series of the activity data description of emission drivers recalculations and improvements for the agriculture sector.	§ 86 94 (CLRTAP 2010)	Yes	
	5A\5B\5C	2010	Since all incineration is reported under energy add information about the methodology used for different types of waste incineration under NFR 1. In NFR 6C use the notation key “IE” instead of “NO” and to explain the use of the notation key in the IIR.	§ 103 110 111 112 (CLRTAP 2010);§ 136 (CLRTAP 2014)	Yes	Information on methods used for estimation of energy-related is reported in NFR 1. Germany considers NO to be correct and explains the situation in its IIR. Cremation estimation is explained now.
Consistency	1A1\1A2	2010	In the IIR in the “Short description” for 1A1 and 1A2 Germany presents a tier 2 or 3 approach. However during the review Germany indicated that only the tier 2 approach was used. This needs correction in the IIR (was agreed by Germany to do this)	§ 47 (CLRTAP 2010);§ 54 (CLRTAP 2014)	Yes	
	1A5	2010	The IIR says Tier 1 method is used for 1A5 but it is actually Tier 2/3. This should be corrected in the IIR.	§ 53 (CLRTAP 2010)	Yes	
	3B	2010	The activity data (animal numbers) is coming from various sources and some corrections are being done. It is recommended that Germany includes a table in the IIR showing the livestock numbers from different sources and the type of elaboration/correction that has been done.	§ 94 (CLRTAP 2010)	Yes	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
Completeness		2010	Emissions prior to 1990 are not reported.	§ 27 (CLRTAP 2010);§ 24 (CLRTAP 2014)	Yes	Little information is available due to the split of Germany into two nations. Some overview data has been added to the IIR.
	1A2a\1A2b\1A4\1B1a	2010	Some emissions are not estimated for some pollutants: heavy metals and POPs for 1A2a particulates heavy metals and POPs for 1A2b heavy metals for 1A4 and NMVOC for 1B1a. The ERT recommends Germany to use the Guidebook default EFs if no other method is available.	§ 36 (CLRTAP 2010)	Yes	
	5E	2010	Although the Guidebook has methods for car and house fires in Chapter 6 it may be more transparent to include these in Chapter 7 as Chapter 6D is more focused on compost and sludge. The ERT encourages Germany to consider including some of these emissions in the next submissions.	§ 116 (CLRTAP 2010);§139 (CLRTAP 2014);DE-5A-2017-0003	Partly	
	6	2010	Consider currently missing sources: NH3 emissions from Cats and Dogs from Zoo animals and human ammonia emissions etc.	§ 116 (CLRTAP 2010)	Partly	Car and house fires have been included for quite a while now (5E). Human NH3 emissions are considered in 6A. Pets will be considered in sub2024.
	1A3a	2010	NH3 reported as NE. Recommendation to investigate the emissions or report as NO if emissions do not occur.	§ 68 (CLRTAP 2010)	Yes	The notation key 'NE' is used only for ammonia from aviation gasoline (as recommended in the 2016 EMEP Guidebook). For jet kerosene emissions are estimated.
	1B1a	2010	In 2010 “NE” is indicated for particulates and “NA” for NMVOC but the Guidebook has EFs. It is recommended that Germany identifies the type of coal mining using the EFs from the EMEP Guidebook or other references to estimate emissions for this sector. In 2014 NMVOC was reported as NE and the ERT recommends Germany to describe why NE is reported (emissions assumed negligible).	§ 54 (CLRTAP 2010)	Yes	
	2C1	2010	Include emissions for dioxins and heavy metals based on new research project.	§ 80 81 (CLRTAP 2010)	Yes	
	3D	2010	The ERT encourages Germany to estimate PM10 and PM2.5 emissions for 3D in future submissions following the EMEP/EEA Guidebook recommendations.	§ 98 (CLRTAP 2010)	Yes	
	5A\5C\5D	2010	The inventory regarding Waste is currently not complete with missing estimates for several source categories.	§ 102 (CLRTAP 2010);§ 134 135 (CLRTAP 2014)	Yes	Industrial wastewater emissions implemented since 2021 reporting. Solid waste emissions implemented since 2020 reporting. Domestic wastewater emissions implemented since 2018 reporting. 5.C completed
Comparability	1A4aii	2010	Emissions for main pollutants were reported as IE. The ERT encourages the Party to investigate further statistical resources for missing estimates in this sector and include a progress report within the next IIR.	§ 67 (CLRTAP 2010)	Yes	
	1A2\2	2010	Germany reports emissions from sugar production in source category 2D2. It is recommended to report these emissions under 1A2e and include a more detailed description of the sub-categories the methodology used the source of activity data the source of EFs and consistency across the time series (1990-2008).	§ 50 (CLRTAP 2010)	Yes	Reporting of NMVOC and PM emissions from sugar production in 2H2 (used to be 2D2) is correct according to the Inventory Guidebook 2016.
	1A3di(ii)\1A4ciii	2010	Emissions reported as IE. The ERT encourages Germany to make separate emission estimates for these sectors in future IIR reports and in the meantime a separate summary table of all categories (fully or partially reported as IE) and where they have been moved would be beneficial.	§ 69 (CLRTAP 2010)	Yes	

Aspect	Sector	First identified in	Finding summary	Observation	Implemented?	Comment
Accuracy		2010	Implement a (qualitative and quantitative) uncertainty analysis and use the results to prioritize improvements to the inventory	§ 20 24 (CLRTAP 2010);§ 32 44e 85 (CLRTAP 2014)	Partly	
	1A1b\1A1c\2	2010	Improvement from Tier 2 to Tier 3 using plant-specific data for some industrial processes including cement production as well as for large combustion plants (e.g. 1A1b 1A1c)	§ 19 41 45 46 (CLRTAP 2010)	Yes	Included for large combustion plants no plant-specific data for cement production
	2A1	2010	Cement production is a key source for Hg HCB and for NOx PM10 and PAH but Tier 1 is used. The ERT encourages Germany to use plant-specific data collected as part of the LCPD IPPC and E-PRTR to develop a tier 2 or 3 methodology in the near future and to document these in its IIR.	§ 79 (CLRTAP 2010);§ 88 (CLRTAP 2014)	Yes	plant-specific data approach is not planned
	2L	2010	Include results of ongoing research project to improve from Tier 1 to higher Tier methodology.	§ 82 83 (CLRTAP 2010)	Yes	
	3B	2010	There were errors in the calculation of N excretion rates it is recommended that Germany corrects this.	§ 97 (CLRTAP 2010)	Yes	
QA/QC		2010	Fully implement the QA/QC system for the air pollutant emission inventory. If possible implement a unified QA/QC system for reporting to CLRTAP and UNFCCC.	§ 21 24 62 74 88 105 (CLRTAP 2010);§ 37 44f (CLRTAP 2014)	No	Ongoing discussion
		2010	Widen the use of the existing QA/QC system used for the set of activity data as well as the methods and emission factors for GHGs for the needs of CLRTAP/NECD inventories and providing further details on its implementation in the IIR (general and sectoral descriptions).	§ 33 40 (CLRTAP 2010);§ 16 69 84 87 103 105 (CLRTAP 2014)	No	Ongoing discussion

CHAPTER 10: Reported Projections 2025 - Overview

In May 2019, Germany published its first National Air Pollution Control Programme (NAPCP 2019) under the revised NEC directive (EU) 2016/2284. According to Article 6 (3) of the Directive, the NAPCP must be reported in an updated version at least every four years. In this context, Germany published a draft NAPCP on June 7th, 2023. Corresponding emission projections were reported to the central data repository of the European Environment Agency (EEA) on May 2nd, 2023 under the CLRTAP and the NEC directive, presenting both the “with measures” (WM) and the “with additional measures” (WAM) preliminary scenarios as defined in the draft NAPCP 2023 mentioned above. The second German National Air Pollution Control Programme (NAPCP 2023) was passed by the federal government and published in May 2024, consistent with the previously reported projections. According to Article 8 (6) of the EU Directive 2016/2284, these projections must be updated and reported every two years. Emission projections under the CLRTAP are fully aligned with the reporting presented in the context of the NEC directive.

Updated emission projections were reported on March 14th, 2025 under the (CLRTAP) and the (NEC directive), presenting both the “with measures” (WM) and the “with additional measures” (WAM) scenarios. The IIR 2025 projections chapter describes all assumptions and methodology of those emission projections.

Projections reported in 2025 are based on emission inventory submission 2024 (see Table 1). In addition, because of relevant recalculations in ammonia emissions of the agricultural sector (NFR 3) within emission inventory submission 2025 (see Chapter 8.1 - Recalculations), a second dataset was submitted containing only ammonia emission projections in the “with measures” (WM) scenario based on emission inventory submission 2025 under otherwise identical assumptions (see Table 2).

Based on the NEC & CLRTAP Inventory Submission 2024, the results can be summarized as follows:

Table 1: Overview results of projections 2025 (based on NEC & CLRTAP Inventory Submission 2024)

	NO_x	**SO_2**	**NMVOC**	**NH_3**	**$PM_{2.5}$**
NATIONAL TOTAL 2005 (Submission 2024)	1,478 kt	472 kt	1,167 kt	627 kt	133 kt
NATIONAL TOTAL 2022 (Submission 2024)	841 kt	255 kt	747 kt	512 kt	84 kt
Reduction Commitment 2020	-39 %	-21 %	-13 %	-5 %	-26 %
Reduction Reported 2022	-43 %	-46 %	-36 %	-18 %	-37 %
NEC-Compliance	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Reduction Commitment 2030	-65 %	-58 %	-28 %	-29 %	-43 %
Reduction Commitment 2030	517 kt	198 kt	840 kt	445 kt	76 kt
Projected Emissions 2030 WM	-66 %	-71 %	-35 %	-31 %	-43 %
NEC-Compliance WM	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Projected Emissions 2030 WAM	-66 %	-71 %	-35 %	-31 %	-44 %
NEC-Compliance WAM	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Notes: This table does not include NO_x and NMVOC emissions from agriculture (NFR 3.B and 3.D) as they are excluded for compliance checking according to Article 4 (3) of the NEC directive. Projected emissions and historic data are based on submission 2024. All values have been rounded to integer numbers. The calculation for determining the reduction commitment took place with the exact values in 2005. The rounding can lead to slight deviations.

Based on the NEC & CLRTAP Inventory Submission 2025, the recalculated results for ammonia can be summarized as follows:

Table 2: Recalculated projections 2025 for NH_3 (ammonia), (based on NEC & CLRTAP Inventory Submission 2025)

	NH_3
NATIONAL TOTAL 2005 (Submission 2025)	714 kt
NATIONAL TOTAL 2023 (Submission 2025)	569 kt
Reduction Commitment 2020	-5%
Reduction Reported 2023	-20%
NEC-Compliance	**Yes**
Reduction Commitment 2030	-29%
Reduction Commitment 2030	507 kt
Projected Emissions 2030 WM	-33%

	NH_3
NEC-Compliance WM	**Yes**

Introduction

Context

Reliable data on historic emissions are key to the political process and to decisions on abatement technology promotion. However, future emission paths also do have the power to shed a new light on these discussions. Therefore, greenhouse gases (GHG) and air pollutants are inventoried and projected in the same database system using the same structure of detailed time series.

For the National Air Pollution Control Programme, a new database within this system was created in 2018 that is basically a copy of the German inventory database. In addition, multiple scenarios are taken into account, sketching development of activity data and emission factors up to 2040 and beyond. The system features integrated assessment for both greenhouse gases (GHG) and air pollutants. In particular, existing projections for GHG can be applied to air pollution contexts. The database used also allow for the flexible combination of distinct scenarios for specific sectors and source categories to add up to a complete projection of the inventory. Furthermore, reduction potentials of mitigation measures can be modelled in detail and quantified directly in the database. The projection database is fully operational and used as the common basis for reporting on emission projections under NEC directive and CLRTAP reporting obligations

Policies

For the past years, climate change and greenhouse gas (GHG) emissions have been an important issue in society and politics. GHG emission inventories have seen a lot of attention as a consequence. However, there have also been a couple of air pollution related headlines, including “diesel gate” and particulate matter concentrations caused by residential wood burning. In Germany, these discussions have led to a number of legislative projects and new regulations which have the power to significantly change emission levels. Thus, projections generally show a further decline in emissions. Some main policy drivers are listed and contextualized below:

- Energy
  - Phase-out of coal use for energy production until 2038 with significant reductions before 2030 (last modified for lignite burning power plants on December 2nd, 2023, see (KVBG, Annex 2))
  - increasing prices in the Emissions Trading System (EU-ETS1)
  - transfer of the national Emissions Trading System (n-ETS) into the Emissions Trading System for buildings, Transport and other sectors (EU-ETS 2)
  - the EU Carbon Border Adjustment Mechanism (CBAM)
  - increasing capacity and production of renewable energy (e. g. modified Renewable Energy Sources Act from 2023 (EEG 2023))
  - new regulations with stricter emission limit values for some installation types (e. g. modified 13th BImSchV from 2021, modified 17th BImSchV from 2024, LCP BREF 2021, WGC BREF 2023)
- Transport
  - new vehicle regulations (e. g. Emission Performance Regulation (EU) 2019/631 [1)] , Euro 7 Regulation (EU) 2024/1257 [2)]
  - increasing share of electric vehicles, increasing shift to public transport
- Agriculture
  - Amendments of the “Düngeverordnung” (fertiliser ordinance) in 2017 and 2020 as well as other legislative and incentive measures to reduce fertiliser use, increase the nitrogen use efficiency and increase the share of low emission application techniques.

[1)] (EU) 2019/631: Regulation (EU) 2019/631 of the European Parliament and of the Council of 17 April 2019 setting CO2 emission performance standards for new passenger cars and for new light commercial vehicles, and repealing Regulations (EC) No 443/2009 and (EU) No 510/2011 (recast); http://data.europa.eu/eli/reg/2019/631/oj

[2)] (EU) 2024/1257: Regulation (EU) 2024/1257 of the European Parliament and of the Council of 24 April 2024 on type-approval of motor vehicles and engines and of systems, components and separate technical units intended for such vehicles, with respect to their emissions and battery durability (Euro 7), amending Regulation (EU) 2018/858 of the European Parliament and of the Council and repealing Regulations (EC) No 715/2007 and (EC) No 595/2009 of the European Parliament and of the Council, Commission Regulation (EU) No 582/2011, Commission Regulation (EU) 2017/1151, Commission Regulation (EU) 2017/2400 and Commission Implementing Regulation (EU) 2022/1362; http://data.europa.eu/eli/reg/2024/1257/oj

Results - Overview

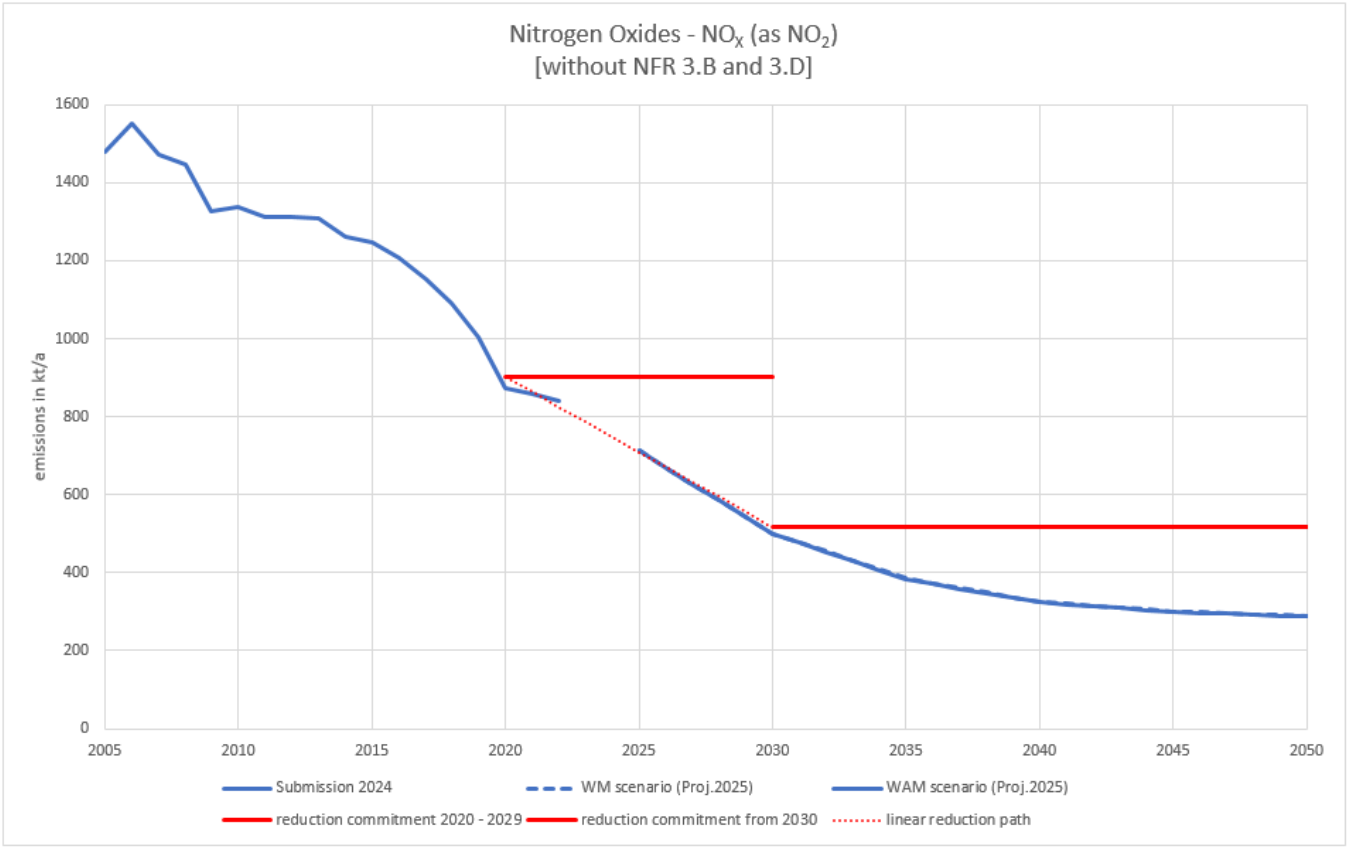
Modelling different scenarios in our database, we finally calculated the following numbers for Germany's emissions in 2030:

Table 3: Overview of projected 2030 emissions

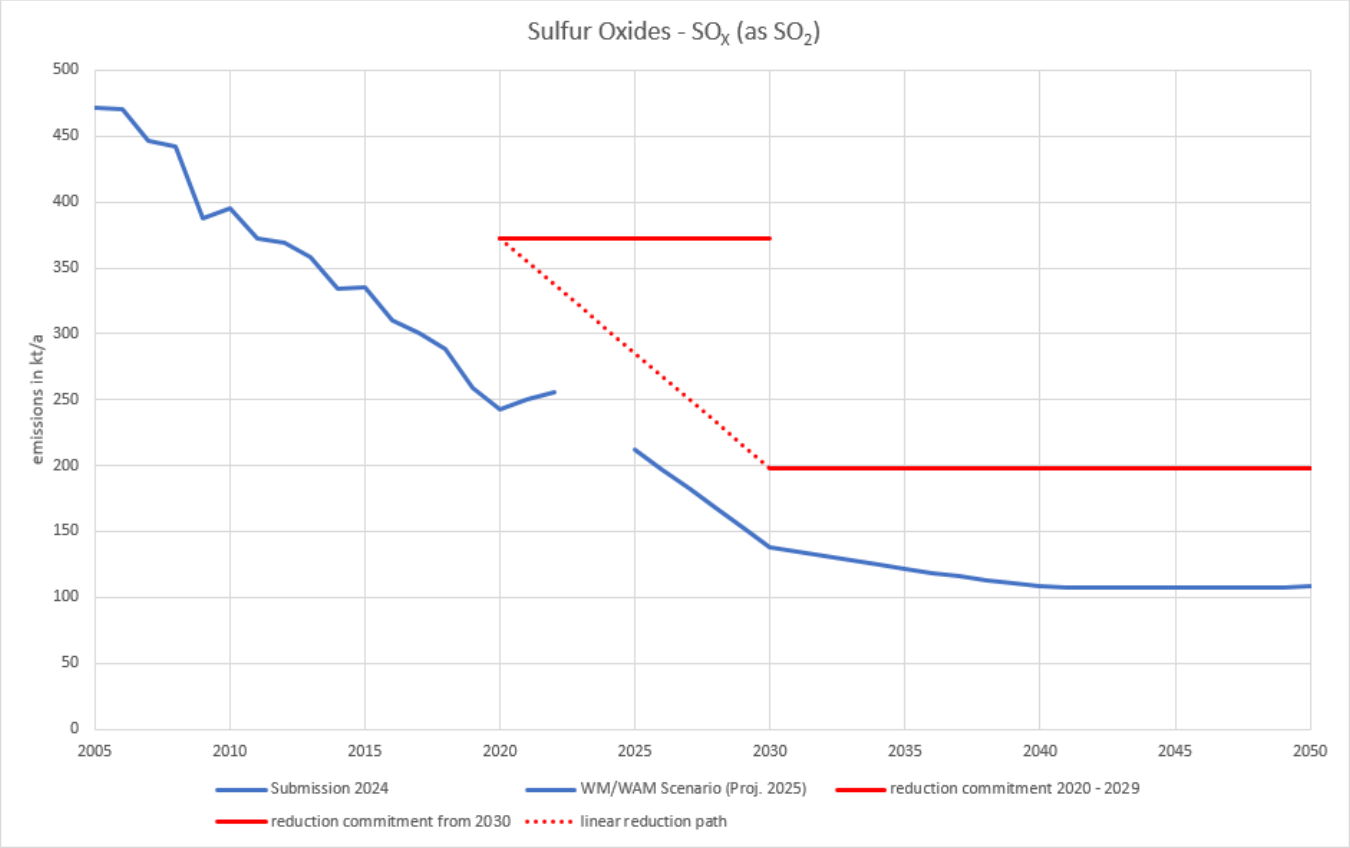
Projections for the year 2030	**NO_x**	**SO_2**	**NMVOC**	**NH_3**	**$PM_{2.5}$**
With measures	**500.9 kt**	**138.4 kt**	**763.8 kt**	**434.2 kt**	**75.4 kt**
Amendment of the emission limits of the Ecodesign Regulations (EU) 2015/1185 [1)] and (EU) 2015/1189 [2)]					-0.8 kt
[optional] Amendment of 13th BImSchV [3)]					
With additional measures	**500.9 kt**	**138.4 kt**	**763.8 kt**	**434.2 kt**	**74.6 kt**

With these numbers, Germany will meet its reduction commitments for all pollutants in 2030 in both scenarios.

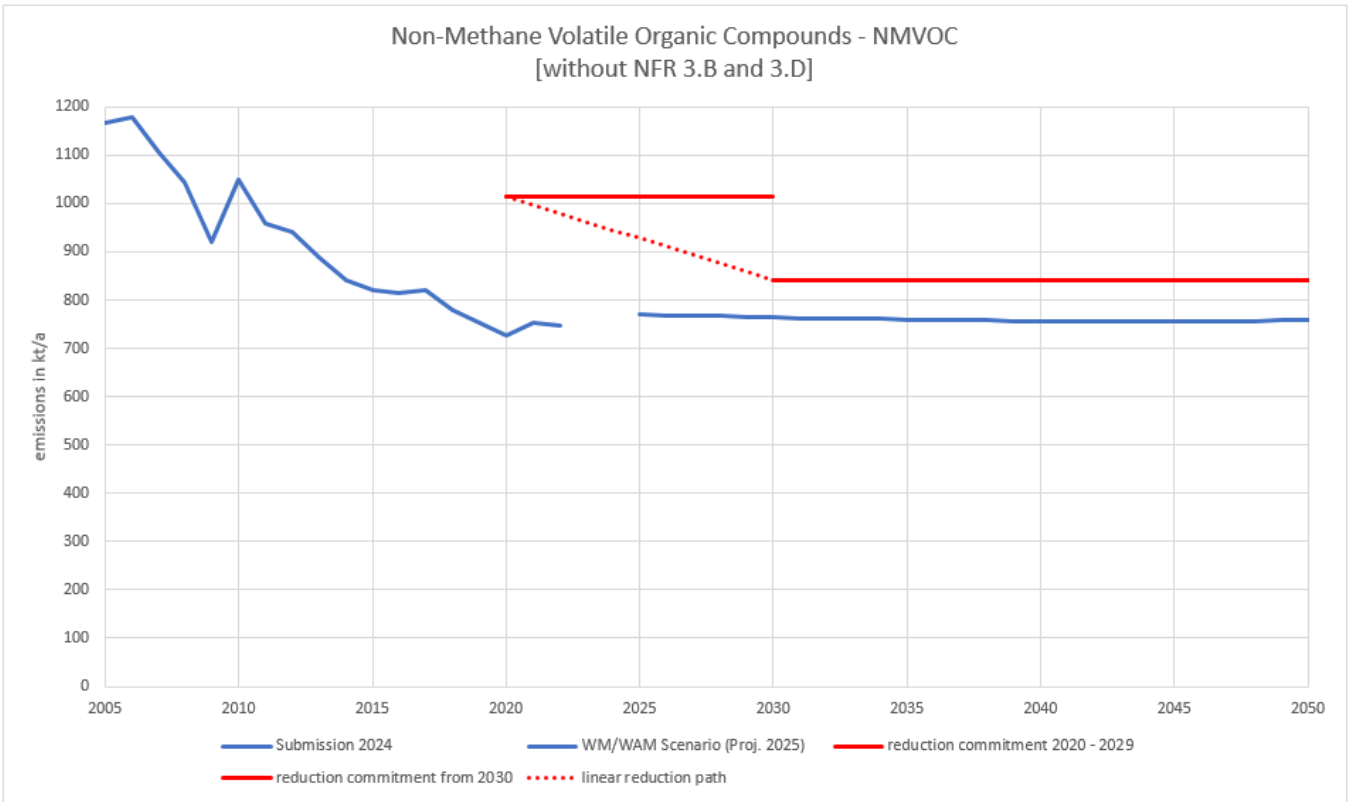
The following figures show the developments for each pollutant in the WM and WAM scenarios (WAM only for NO_x and $PM_{2.5}$ as there are no differences between both scenarios for all other pollutants). In addition, the reduction commitments for 2020 to 2029 and from 2030 onwards as well as the indicative linear reduction path are shown. Please note that projected emissions were only calculated for the years 2025, 2030, 2035, 2040, 2045 and 2050. A linear reduction in the years between cannot be assumed, but is shown in the graphs just for illustrative reasons.



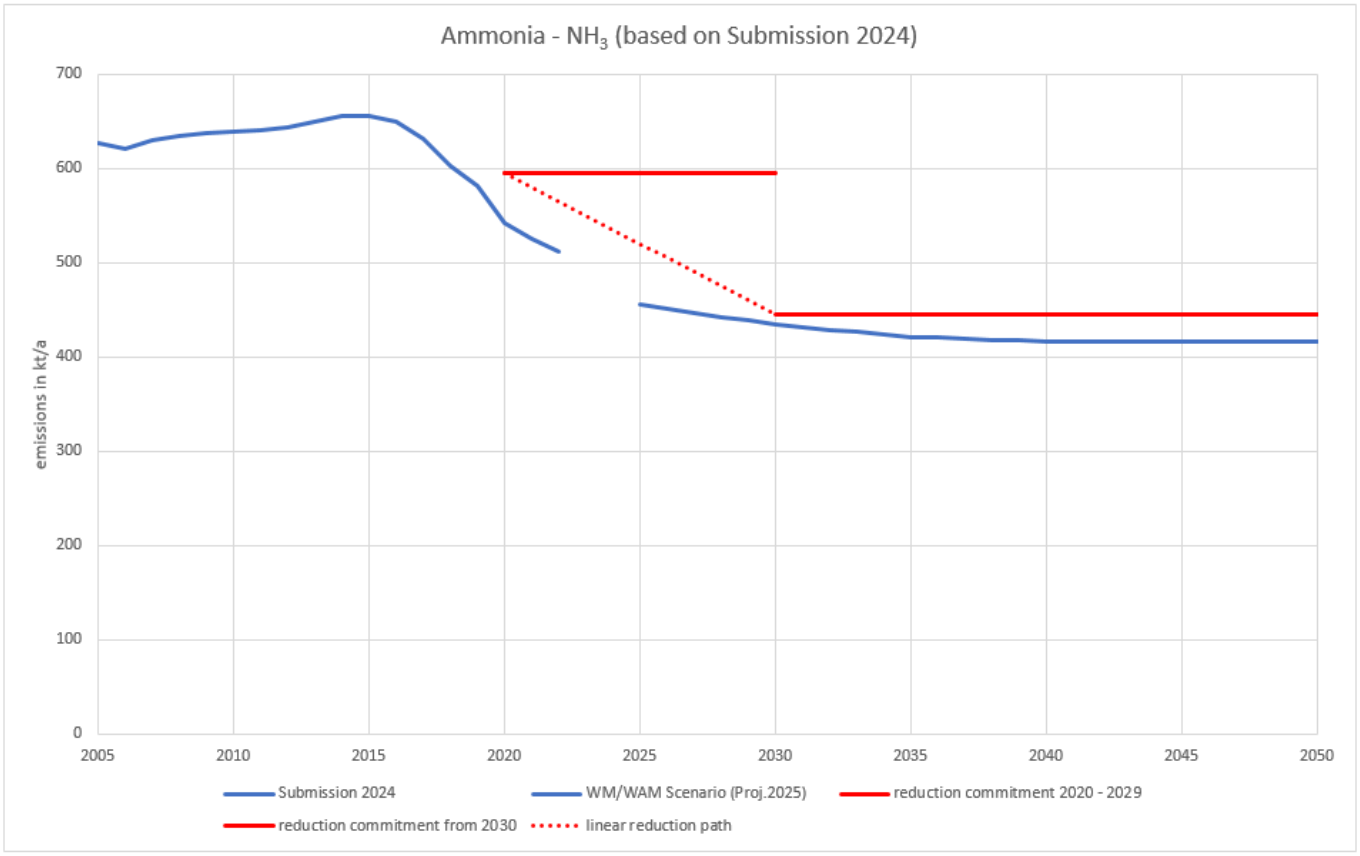
Please note that projected emissions were only calculated for the years 2025, 2030, 2035, 2040, 2045 and 2050. A linear reduction in the years between cannot be assumed but is shown in the graphs just for illustrative reasons.



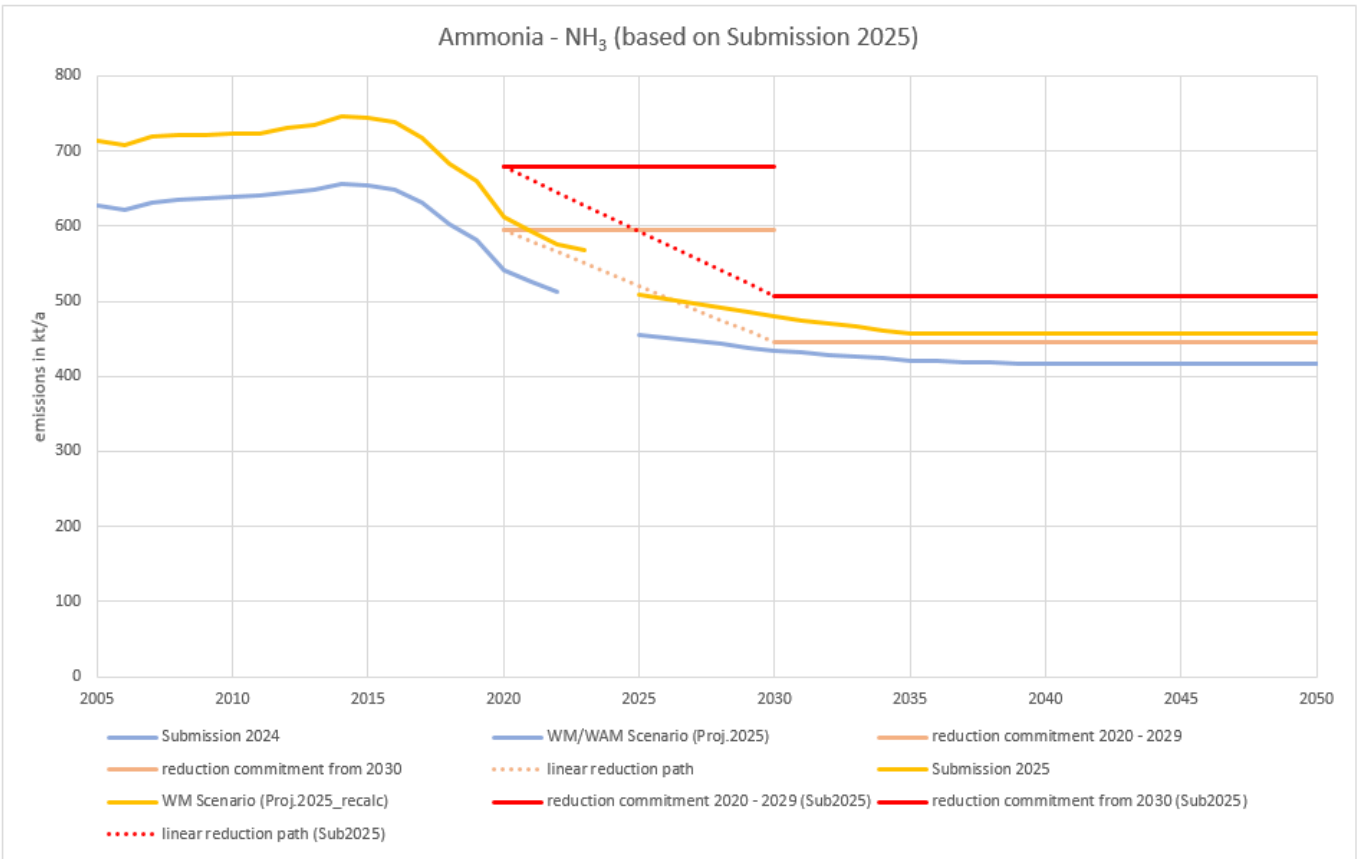
Please note that projected emissions were only calculated for the years 2025, 2030, 2035, 2040, 2045 and 2050. A linear reduction in the years between cannot be assumed but is shown in the graphs just for illustrative reasons.



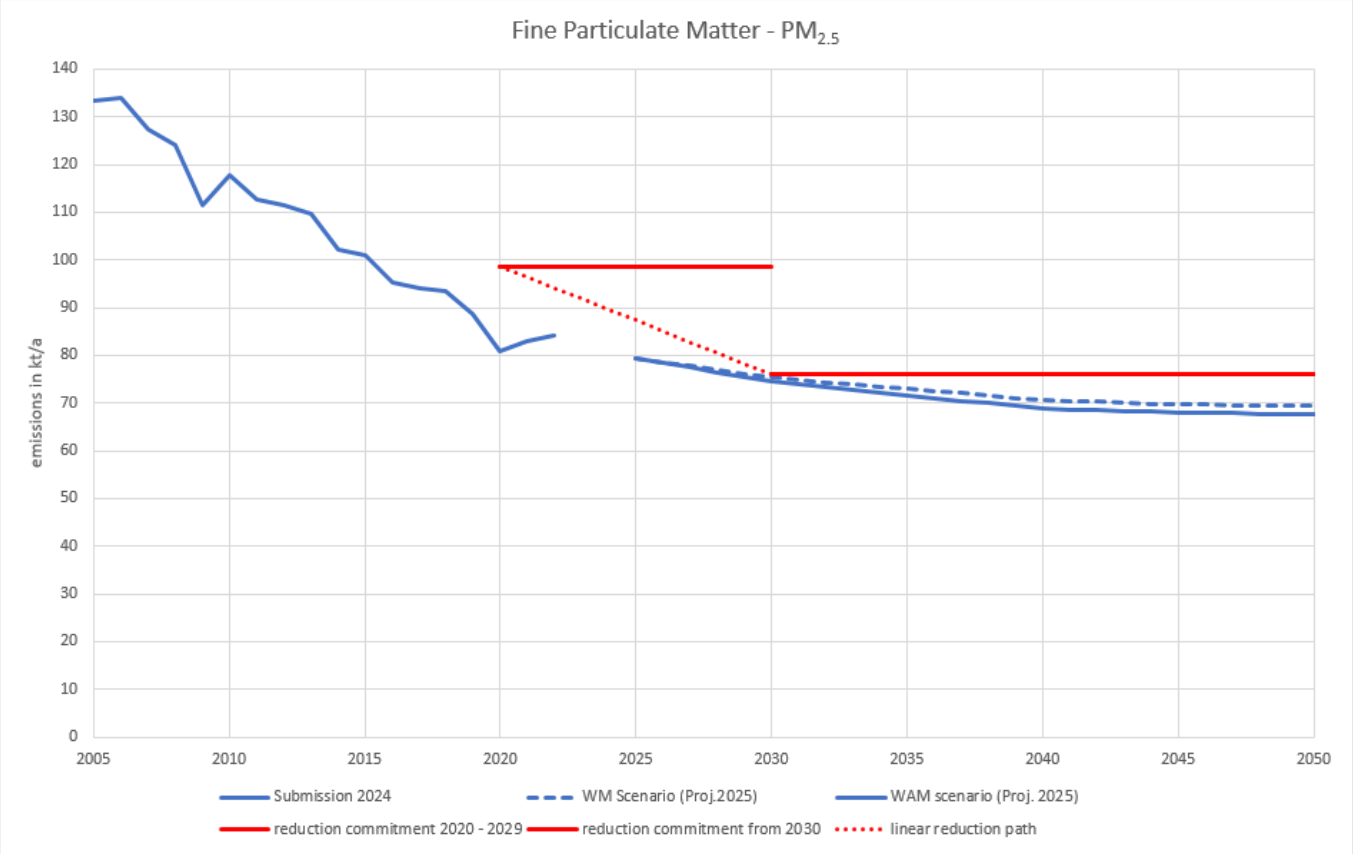
Please note that projected emissions were only calculated for the years 2025, 2030, 2035, 2040, 2045 and 2050. A linear reduction in the years between cannot be assumed but is shown in the graphs just for illustrative reasons.



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Please note that projected emissions were only calculated for the years 2025, 2030, 2035, 2040, 2045 and 2050. A linear reduction in the years between cannot be assumed but is shown in the graphs just for illustrative reasons.

[1)] (EU) 2015/1185: Commission Regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel local space heaters; http://data.europa.eu/eli/reg/2015/1185/oj

[2)] (EU) 2015/1189: Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel boilers; https://eur-lex.europa.eu/eli/reg/2015/1189/oj

[3)] Thirteenth Ordinance on the Implementation of the Federal Immission Control Act (Ordinance on Large Combustion Plants and Gas TurbinePlants – 13. BImSchV) https://www.gesetze-im-internet.de/bimschv_13_2021/

Calculation documentation

In general, data basis of the emission projections calculation was the inventory submission 2024 with all the included processing of the emission data. Only for ammonia also a calculation based on inventory submission 2025 under otherwise identical assumptions was carried out.

For its national emission projections, Germany takes into account projected activity data for GHG projections and category-specific reports on air pollution emission factor development in the future. For all sectors, emission scenarios were developed in the greatest possible consistency with the latest available energy and greenhouse gas emission scenario for Germany, which was at the time of preparation of the emission projections for reporting in 2025 the MMS (WEM, with existing measures scenario) of 'Treibhausgas-Projektionen 2024 für Deutschland'[85)] published in mid-2024. This is also consistent with the current NECPR-reporting according to art. 17 of regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action. However, reporting of updated GHG emission projections in 2025 according to art. 18 of regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action could not be reflected for the current air pollutant emission projections, except for ammonia (reported in a separate file).

In the scenario "with measures" (WM), for the majority of the emission sources in the sectors 1.A.1 (energy industry), 1.A.2 (manufacturing industry), 1.A.4 (other combustion systems), 1.A.5 (military), 1.B (diffuse emissions from fuels), 2 (industrial processes) and 5 (waste and wastewater treatment) projected development of the activity rates is based on the with existing measures scenario (MMS=WEM) of the 'Treibhausgas-Projektion 2024 für Deutschland'. The MMS of the 2024 GHG emission projections for Germany includes all climate protection-relevant measures and instruments adopted by July 31, 2023.

In contrast to this comprehensive projection of activity data, transport emissions are calculated using the TREMOD model ("Transport Emission Model"). To estimate the future development of transport-related energy consumption and emissions, a trend scenario up to 2050 was developed, which is updated annually. Version 6.53 of TREMOD formed the basis for the current emission projections (see Allekotte et al., 2024[86)]). Therefore, road transport measures from the WAM scenario of the German NAPCP 2023[87)], including the expansion of the truck toll system and a package of measures to promote electromobility, which have since been implemented, become part of the trend scenario. Beyond the trend scenario, findings from ongoing work for the upcoming HBEFA 5.1 update (Handbook of Emission Factors for Road Transport[88)]), such as an increase in the implied emission factors for trucks and coaches with Euro V and VI due to defective or manipulated exhaust aftertreatment systems were considered[89)] in the current WM scenario. In addition, the introduction of Euro 7 on the basis of Regulation (EU) 2024/1257 was considered in the WM scenario, leading to further decline of implied emission factors of the fleet, especially beyond 2030. Those additional assumptions are documented in Allekotte et al. (2025)[90)]. Furthermore, assumptions about emissions from road abrasion as well as tyre and brake wear from electrically driven mileage were included according to EMEP/EEA air pollutant emission inventory guidebook 2023[91)]. In order to reflect the Euro 7 Regulation also regarding particle emissions from tyre and brake wear the emission factors of the historical emissions were further adjusted for the emission projections.

The projection for the agricultural sector (NFR 3) was created by the Thünen Institute (TI) using the py-GAS-EM reporting model twofold, once based on the inventory submission 2024 and the MMS (WEM, with existing measures) of the "Treibhausgas-Projektionen 2024 für Deutschland" and once based on the current inventory submission 2025 and the MMS (WEM, with existing measures) of the "Treibhausgas-Projektionen 2025 für Deutschland"[92)]. For both projections, the most important input data for the calculation of the agricultural emissions (animal numbers, animal performance, mineral fertilizer use) were derived for the first time using the CAPRI model, based on the current Thünen-Baseline 2024-2034 (2024)[93)]. Further assumptions for the sector agriculture were assumed as in the WM scenario of the German NAPCP 2023 and are described below for the year 2030.

For dairy cows, the proportion of cows kept in tied housing systems was reduced by 50 % compared to 2020 (weakened trend projection). In the past, the decline in tied housing systems has not had the same impact on the decline in the number of dairy cows in Germany. It is assumed that this will not be the case in the future either. For other cattle, tied housing systems will also be reduced by 50 % compared to 2020.

Due to the further implementation of the German Fertiliser Ordinance, strip application on cultivated fields (since 2020) and grassland (from 2025) as well as immediate incorporation on uncultivated farmland after no more than one hour (from 2025) is becoming mandatory. On cultivated fields, the current proportions of broadcast application were redistributed to trailing hose application. On grassland, 80 % of the current proportions of broadcast application were redistributed to trailing shoe application and 20 % to trailing hose application. This roughly corresponds to today's ratio of trailing hose and trailing shoe on grassland.

The proportion of the share of liquid manure spread using injection and slot technology was extrapolated based on the increasing trend between 2010 and 2020.

The use of manure in biogas plants is statically updated based on the year 2023. The use of energy crops in biogas plants was assumed to be declining, as described in the Thünen Baseline 2024-2034. This corresponds to a reduction in the amount of energy crops used in 2030 compared to 2023 of around 61 % based on the nitrogen contained (and to a reduction of 80 % for the projection year 2035).

With the assumptions described above, a significant reduction of ammonia emissions compared to the current annual emissions will be achieved by 2030. For the WM projection based on inventory submission 2025 a buffer of roughly 16 kt results for 2030 (for the current WM projection based on inventory submission 2024 there would be no buffer without the further assumptions described below).

In addition, potential emission reductions as a result of the new version of the first general administrative regulation for the Federal Immission Control Act (Technical Instructions for Air Pollution Control - TA Luft)[94)], which came into force on December 1st, 2021, were evaluated. These bring about a reduction effect of a further 11.8 kt of ammonia in 2030. In total, this results in a buffer of roughly 28 kt in the current WM scenario based on inventory submission 2025 for complying with the reduction obligation for ammonia in 2030 (or roughly 11 kt in the current WM projection based on inventory submission 2024). The assumed reduction effects through the TA-Luft are divided into three sub-areas.

- For farms falling in the category ‚G' (according to Annex 1 of the 4th BImSchV for keeping or rearing of sows, fattening pigs, piglets, laying hens, pullets and broilers) it was assumed that the current status of air scrubber systems for pigs remains constant (with a reduction performance of 80 %) and that the current status for poultry increases slightly (with a reduction performance of 70 %). For almost the entire remaining stock of the respective animal category in G-systems, it was assumed that 40 % of the emissions in the barn are reduced by further system-integrated measures. This can be achieved, for example, with a less effective air scrubber system or other technical measures in animal housing. These assumptions are conservative since they only reflect the minimum requirements with regard to emission reductions according to the current legal situation and implementation practice. The TA Luft prescribes the cleaning of the exhaust air as state of the art for new systems. This also applies to existing systems – with various transitional periods – unless retrofitting is not proportionate or technically possible. In this case, other mitigation measures must be implemented. Alternatively, the TA Luft enables the use of quality-assured housing facilities that demonstrably serve animal welfare and, if designed appropriately (e.g. animal-friendly, emission-optimized outdoor climate stable), at the same time achieve relevant emission reductions that are quantitatively specified in the TA Luft. It is currently not possible to reliably estimate what proportion of the existing systems can be retrofitted with air scrubbing systems and what proportion of the new construction or replacement construction will take the form of quality-assured, animal-friendly and emission-optimized husbandry systems. Therefore, for the entire (heterogeneous) group, only the minimum achievable reductions when implementing the legal requirements were initially assumed in the sense of a conservative total analysis.
- For 30 % of the animal stocks falling into the category ‚V' (according to Annex 1 of the 4th BImSchV for keeping or rearing of sows, fattening pigs, piglets, laying hens, pullets and broilers), it was assumed that these reduce emissions by 40 % through system-integrated measures in animal housing. As explained above, this is also a conservative assumption (e.g. with regard to retrofitting and the new construction of animal-friendly husbandry systems) in order not to overestimate the emission reduction.
- For 80 % of the slurry from G and V systems, it was assumed that in 2030 they would be stored covered at least with foil or comparable technology.

The NMVOC emissions from NFR sector 2.D.3, which includes emissions resulting from the use of solvents and solvent-containing products, as well as their manufacturing, are not calculated using activity rates and emission factors within the inventory. Instead, a separate model developed and expanded steadily over the past 15 years primarily by the Institute for Environmental Strategies (Ökopol GmbH) is utilized to calculate these emissions, and the results are imported into the inventory database. This model also provides emission projections based on economic forecasts specific to certain branches of industry. These economic projections were last updated for the emissions projections reported in 2023 using the Prognos report (2019) titled “Deutschland Report 2025 | 2035 | 2045”. The methodology for updating the NMVOC inventory and projections is detailed in Zimmermann and Memelink (2023[95)]).

In a more recent project, Zimmermann et al. (2025[96)]) conducted a comprehensive review of the previous methods used for projecting NMVOC emissions in the sectors of printing (NFR 2.D.3.h) and coating applications (NFR 2.D.3.d). They developed new projection methods for the years 2025 to 2050. The updates made for the individual SNAP codes can be summarised as follows:

SNAP 60101 demonstrated a clear correlation with automobile production. A forecast for production in Germany has been established based on EU production forecasts and used in the emission projections. For SNAP 60102, emissions showed a correlation with vehicle fleet size from 2015 onward. Forecast data on the vehicle population was taken from the study (Adolf et al., 2014[97)]) and used for the projection. SNAP 60103 showed that employee numbers and annual construction output correlated with emissions from 2018 on. Projections have been implemented using data from BMAS (2021[98)]) and the

Prognos report (2019). For SNAP 60104, a correction factor to the “population development” indicator has been applied to update projections. SNAP 60105 showed a significant correlation with the completion of commercial buildings. Due to the lack of specific forecasts for this indicator, automotive production data (from SNAP 60101) has been used as an alternative. SNAP 60106 faced challenges in identifying suitable indices for emissions. A weak correlation with boat and shipbuilding turnover has been noted and additional corrections to enhance projection accuracy have been applied. In the case of SNAP 60107, no meaningful correlations were established, prompting to create emission projections based on trend extrapolations. Future investigations into specific SNAP areas will yield better methodologies. SNAP 60108 required careful analysis of several sub-areas. No correlation of the emissions to economic (or other) variables could be determined for several sub-areas, which is why some of the emissions were updated using trend progression. In the future, it may be useful to take a closer look at the individual areas of the SNAP code that are particularly relevant to emissions and the developments taking place in these areas to identify suitable alternative approaches for creating projections. No correlation could be established between SNAP 60109 and the indices used to date. However, with the “Other expenditure, inflation-adjusted” index, an alternative suitable forecast index could be used for the projection.

SNAP 60403 showed a high correlation with relevant economic indices and emissions. However, the available and previously used forecast for the “wood, paper and printing” sector is more highly aggregated and, in turn, hardly appears suitable for projections for the sub-sector. It was therefore decided to fall back on forecasts of employment trends. The employment figures also showed a high correlation with emissions in the retrospective analysis.

Despite the existing uncertainties and obstacles related to the creation of NMVOC emission projections, the quality of the projections for the SNAP codes mentioned above has been significantly improved by Zimmermann et al. (2025). In the past, indices were often used to create projections without a clear correlation to emissions. Now, more suitable parameters have been identified and utilized wherever possible. In other instances, trend extrapolations have been made based on historical emission data. Additionally, assumptions about technological developments have been incorporated. For future projections, an equally thorough review and update of the relevant NFR sectors that were not included in the current analysis is planned to ensure comprehensive coverage. In this regard, for the entire sector of 2.D.3 consultations with industry experts will be continued and deepened. The results of Zimmermann et al. (2025) will be regularly re-evaluated using new emission data and statistics to validate or adapt the projection preparation process.

Starting from these activity data set as a basis, future emission factors for air pollutants were modelled for each of the policies and measures individually. For each measure, the relevant emissions factors were identified and the existing historic time series in the database was extended to 2025, 2030, 2035, 2040, 2045 and 2050. Then, the future activity data for those years were multiplied with the modelled emission factors to derive projected emissions. This approach allows detailed calculations of mitigations attributable to each measure.

General assumptions

The emission inventory aims to record the true emissions of all German emission sources. For emission projections the future emission sources are often not yet existing and true emissions cannot be measured already. Emission projections for power plants, for example, are therefore estimated using regulatory limit values. Because emission limit values in the 13th BImSchV and in the accompanying BAT conclusions are usually given in mg/Nm^3, a conversion into kg/TJ is necessary to multiply emission factors with activity rates (fuel use). Table 4 shows an example of the conversion factors for NO_X (Rentz et al., 2002)[99)] which are used to convert mg/Nm^3 into kg/TJ for the regulations under consideration. For each relevant pollutant, a fuel-specific conversion factor is given, taking into account the reference oxygen content in percent.

Table 4: Fuel-specific conversion factors for air pollutants according to Rentz et al. (2002)

Pollutant	Fuel	Reference oxygen content 3 %	Reference oxygen content 6 %	Reference oxygen content 11 %	Reference oxygen content 15 %
NO_X	Hard coal		2.75		
	Lignite	2.88	2.40	1.60	
	Heavy fuel oil	3.39			
	Light heating oil	3.49			
	Natural gas	3.57			
	Natural gas (gas turbines)	3.45		1.15	1.15
	Heavy fuel oil (gas turbines)	3.53		1.18	1.18

85)
https://www.umweltbundesamt.de/publikationen/technischer-anhang-der-treibhausgas-projektionen
86)
https://www.umweltbundesamt.de/publikationen/aktualisierung-tremodtremod-mm-ermittlung-der

87) https://iir.umweltbundesamt.de/2023/general/projections/wam-scenario
88) https://www.hbefa.net/
89) https://ermes-group.eu/sites/default/files/2024-12/1.2_Hausberger.pdf
90) not yet published, (Link will be added as soon as the report is published.)
91) https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023
92) see chapter 6 for agriculture:
https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/projektionen-2025-zentrale-annahmen.pdf
93) https://literatur.thuenen.de/digbib_extern/dn068888.pdf
94) http://www.verwaltungsvorschriften-im-internet.de/bsvwvbund_18082021_IGI25025005.htm
95) https://www.umweltbundesamt.de/publikationen/aktualisierung-des-deutschen-inventars-fuer-nmvoc-0
96) https://www.umweltbundesamt.de/publikationen/nmvoc-projektionen
97) https://www.prognos.com/sites/default/files/2021-01/140900_prognos_shell_studie_pkw-szenarien2040.pdf
98) https://www.bmas.de/SharedDocs/Downloads/DE/Publikationen/Forschungsberichte/fb526-3-aktualisierte-bmas-prognose-digitalisierte-arbeitswelt.pdf?__blob=publicationFile&v=2
99) Rentz, O., Karl, U., Peter. H. (2002): Determination and evaluation of emission factors for combustion installations in Germany for the years 1995, 2000 and 2010, on behalf of the German Environment Agency (UBA), Project-Nr.299 43 142.

Measures that have already been implemented or measures whose implementation has been decided are assigned to the WM scenario.

Reductions in large combustion plants through implementation of the 13th and 17th BImSchV as well as minimum requirements of recent BAT conclusions:

Measures for large combustion plants (LCP) that have already been implemented through the 13th and 17th BImSchV or do have future reduction effects from the existing regulations as well as minimum requirements of recent BAT conclusions are considered in the WM scenario. The amendment of the 17th BImSchV, part of the WAM scenario of the NAPCP 2023, has been implemented on 13th February 2024 and future mitigation potential is estimated in the current WM scenario.

The measures affect time series of NFR sectors under 1.A.1 and 1.A.2 and lead to a reduction in the emission factors. Potential mitigation effects emerge from BAT conclusions according to Directive 2010/75/EU (amended by Directive (EU) 2024/1785). If the current inventory submission 2024 shows that the emissions in the time series are already below the upper ends of the specified emission ranges and thus the statutory maximum limit values will be fulfilled, these will be updated unchanged. In the case of time series above the upper range, the maximum permitted annual limit values are used as a result of the measure in the sense of a conservative estimation and the emission factors of the pollutants for each source group are recalculated.

The calculations always follow the same procedure. Important elements are the specific limit values of the 13th and 17th BImSchV as well as the distribution of the plants according to their rated thermal input (RTI) in megawatts (MW). In addition, it is assumed that all new and existing plants correspond at least to the standard of the upper range of the associated BAT conclusions. The lower emission factor out of both calculations is than compared with the reference value. If the recalculated emission factor of the source category under consideration is greater than the current reference value, the reference value from the 2024 submission will be updated unchanged. If the reference value is higher, the new value is set and projected[100)].

According to expert estimates, the plant inventory is split as in Table 5 according to the RTI (in MW). These (cumulative) proportions are necessary for the calculation of the mean values in relation to the upper range of limit values for each source category and pollutant.

Table 5: Proportionate inventory of LCPs according to their power range

RTI in MW	Proportion
<100	4.5 %
100-300	14.5 %
300-1000	68 %
>1000	13 %

The limit values of LCP are set according to their power ranges. The table shows the estimated proportion of LCP in Germany in relation to the RTI provided.

Example 1

The concrete procedure is illustrated using the example of NO_x emissions from the use of raw lignite as fuel for heat generation in public district heating plants.

The specific BAT-associated emission levels for lignite can be found in Commission Implementing Decision (EU) 2017/1442 BAT 20. With a reference oxygen of 6%, the plants are differentiated according to size and specified with the emission levels in mg/Nm³. The upper end of the emission levels is interpreted as a maximum limit value and converted into kg/TJ using the specific conversion factor of 2.40 (see Table 4). The calculated maximum limit value is therefore averaged for each plant size, taking into account the number of plants, and thus, the estimated value for the necessary NO_x emission factor for compliance with the maximum limit value is calculated in accordance with the BAT conclusions. The necessary data can be found in Table 6. This shows the plants subdivision according to their RTI with the assigned maximum limit values as annual averages in mg/Nm³ and kg/TJ.

Table 6: Emission limit values (annual averages) when using raw lignite in existing plants

Plant size according to RTI in MW	max limit value in mg/m³	max limit value in kg/TJ	Proportion
<100	270	112.70	4.5 %
100-300	180	75.13	14.5 %
>300	175	73.04	81 %

The LCP emission limit values for the use of raw lignite are regulated in (EU) 2017/1442 BAT 20. There are separate limit values for each RTI of the plant. The upper range is shown here as a limit value for existing plants as annual averages in mg/Nm³ and kg/TJ.

The implied emission factor is calculated as follows:

$$EF_{lignite} = 112.70 \frac{kg}{TJ} \bullet 4.5\% + 75.13 \frac{kg}{TJ} \bullet 14.5\% + 73.04 \frac{kg}{TJ} \bullet 81\% = 75.13 \frac{kg}{TJ}$$

The comparison with the current submission 2024 shows that the calculated emission factor (75.13 kg/TJ) is lower than that of the reference value from 2022 (76.8 kg/TJ). Thus from 2025 onwards the emission factor will be replaced by the new value and used for the projection.

This procedure is analogous for the evaluation of all source groups and pollutants.

Example 2

According to the Commission Implementing Decision (EU) 2017/1442 of 31st July 2017 on Conclusions on Best Available Techniques (BAT) according to Directive 2010/75/EU of the European Parliament and of the Council for large combustion plants, the maximum permissible pollutant emission for NO_x while using heavy fuel oil in plants <100 MW is 270 mg/Nm³ and in plants >100 MW is 110 mg/Nm³ as yearly average for existing plants with more than 1,500 operating hours per year (BAT 28).

13th BImSchV in the version of 2021 sets limit values for NO_x as 270 ng/Nm³ in plants <100 MW with more than 1500 operating hours per year and 400 mg/Nm³ in plants <100 MW with less than 1,500 operating hours per year. For existing plants >100 MW 270 mg/Nm³ and for new plants >100 MW 110 mg/Nm³ are set. The values are converted into kg/TJ according to the specific flue gas volume of heavy fuel oil (Table 4).

Assuming a 50% share of plants within each size class, lacking specific data, from 2030 onwards a projected implied NO_x emission factor of 58.0 kg/TJ results after conversion as indicated in the following equation:

$$EF_{heavy\,fuel\,oil} = \left(400 \frac{mg}{Nm^3} \div 3.39\right) \bullet 4.5\% \bullet 0.5 + \left(270 \frac{mg}{Nm^3} \div 3.39\right) \bullet 4.5\% \bullet 0.5 + \left(270 \frac{mg}{Nm^3} \div 3.39\right) \bullet 95.5\% \bullet 0.5 + \left(110 \frac{mg}{Nm^3} \div 3.39\right) \bullet 95.5\% \bullet 0.5 = 58.0 \frac{kg}{TJ}$$

Thus, the maximum emission quantity is applicable law and is below the inventory emission factor for the reference year 2022 under conservative assumptions and therefore assigned to the WM scenario for 2030 and beyond. The emission factor for 2025 was linearly interpolated between 2022 and 2030.

Special features of the evaluation of the emission factors

When using liquid fuels (specified in the database as “other mineral oil products”) in LCP, the specific conversion factor of 3.39 (see Table 4) is used for the assessment of NO_x emissions, analogous to heavy fuel oil.

When calculating the potential SO_2 emissions from source group “Mitverbrennung in öffentlichen Fernheizwerken” and “Mitverbrennung in öffentlichen Kraftwerken” for other liquid fuels, a clear distinction is made in the 17th BImSchV between existing plants and new plants. The implied emission limit value of existing plants is 78.44 kg/TJ. It is assumed that by 2040 all plants will correspond to the latest technology and will therefore from 2040 onwards retain at least the limit value for new plants, estimated at 61.81 kg/TJ.

Reduction in large combustion plants burning lignite through the coal phase-out:

The German Coal Power Generation Termination Act (“Kohleverstromungsbeendigungsgesetz”) from August 2020, last modified in December 2023, stipulates to gradually phase out coal power plants burning lignite until 31st December 2038, in the Rhenish coalfields until 31st March 2030.

However, the electricity market simulation assumes a market-driven coal exit until 2031. As a result, there is no further mitigation potential of an accelerated coal phase-out, as estimated in the WAM scenario of the NAPCP 2023. Projection of the activity rates was taken from the WEM scenario (MMS) of the “Treibhausgas-Projektionen 2024 für Deutschland” and disaggregated to the German lignite mining districts within the project as shown in Table 7.

Table 7: Primary energy use for lignite in LCP (>50 MW) according to the WEM scenario of the “Treibhausgas-Projektionen 2024 für Deutschland” in the years 2022 to 2040

District	Primary Energy Use 2022	Primary Energy Use 2025	Primary Energy Use 2030	Primary Energy Use 2035	Primary Energy Use 2040
	in TJ	in TJ	in TJ	in TJ	in TJ
Lausitz	365,425	272,958	0	0	0
Central Germany	176,494	160,652	1,885	0	0
Rhineland	521,039	283,443	6,028	0	0
Total	**1,062,958**	**717,053**	**7,913**	**0**	**0**

Emission factors of public heating and thermal power plants for NO_x are therefore reassessed. When calculating the NO_x emission factors as a result of the phase-out, the districts of Central Germany, Lausitz and Rhineland are considered separately. The individual districts will be subdivided into their existing power plants.

For each power plant, the total activity rate and the emission factors for NO_x for the years 2004 to 2017 in TJ or kg/TJ according to the 2020 submission are adopted as data basis. In order to take into account fluctuations in the emission factors, the emission factors are averaged per plant over the last years, in which no new blocks went into operation (e.g. Block R of Boxberg IV in the Lausitz district started continuous operation in 2012). In addition, the mean value for all power plants in a district is calculated for the formation of the implied emission factor by weighting according to their activity rates. Hence, each district is assigned a current implied emission factor. With the shutdown of the last block of a power plant, this plant is considered to be shut down and from this point in time it is no longer included in the calculation of the implied emission factor of a specific district.

Reduction in small combustion installations through the 1st BImSchV and funding programmes:

The amendment of the Building Energy Act (Gebäudeenergiegesetz – GEG) of 16th October 2023 was assumed to further incentivise the use of solid biomass for heat generation in the building sector. Hence, potential increase in PM emissions was estimated in the WAM scenario of the NAPCP 2023. Estimation of the potential effects of the GEG was incorporated in the WEM scenario (MMS) of the "Treibhausgas-Projektionen 2024 für Deutschland" and is therefore part of the current WM scenario.

On the other hand, reductions of dust emission factors from small combustion installations are assumed in the NFR sectors 1.A.4 and 1.A.5 through the implementation of the 1st BImSchV flanked by several funding programmes, last the "Bundesförderung effiziente Gebäude" (BEG)[101)]. The calculation of the future emission factors is based on the projection of the "Energiewende" scenario (EWS) from Tebert et al. (2016)[1)], while the current underlying projection is containing a greater use of solid biomass in 2030 than the EWS. The developments in the area of small combustion installations, in particular the development of fuel use and the existing plant inventory, are difficult to assess and emission calculation is fraught with uncertainties. According to expert assessments, with an increase of solid biomass use, the implied emission factor will further decrease as the share of newer and cleaner installations will go up.

Based on the inventory, a distinction is only made between households ("Haushalte" (HH)) and commerce, trade, services ("Gewerbe, Handel, Dienstleistungen" (GHD)), but the calculation of the emissions factors is further sub-divided in several installation type categories of local space heaters and solid fuel boilers, with different emission limit values set by the 1st BImSchV and additional funding requirements changing from time to time. Resulting emission factors for TSP (total suspended particles) used in the WM scenario are shown in Table 8.

Table 8: TSP emission factors in small combustion installations for solid biomass in the WM scenario

sub-sector	2022 in kg/TJ	2025 in kg/TJ	2030 in kg/TJ	2040 in kg/TJ	2050 in kg/TJ
households (HH)	59.5				
1st BImSchV + funding		47.2	44.7	39.4	39.4
commerce, trade, services (GHD)	37.4				
1st BImSchV + funding		26.8	25.4	22.7	22.7

For calculation of $PM_{2.5}$ and PM_{10} emission factors, specific shares per installation type category were used. For 2030 the proportions of PM_{10} and $PM_{2.5}$ in TSP (total suspended particles) are given in Table 9.

Table 9: Proportions of PM_{10} and $PM_{2.5}$ in TSP in 2030 for solid biomass small combustion installations

sub-sector	PM_{10}/TSP in %	$PM_{2.5}$/TSP in %
households (HH)	95	88
commerce, trade, services (GHD)	98	93

Reduction in industrial processes through low-dust filter technology in sinter plants:

The assumed potential for reducing dust emissions from sinter plants is taken from the final report of the UBA project LUFT 2030 (Jörß et al., 2014)[2)], where measure P 009 results in dust emissions of less than 10 mg/Nm^3 due to better filter technology, which was assumed to correspond to 66.7 g dust per ton sinter. The affected time series are assigned to the NFR sector 2.C.1. According to the LUFT 2030 project, this technology also causes new split factors for the calculation of $PM_{2.5}$ and PM_{10}.

The emission factor for PM_{10} is calculated by dividing the emission factor for dust by the split factor for PM_{10} (0.9). Consequently, the emission factor for $PM_{2.5}$ is calculated by dividing the emission factor for dust by the split factor for $PM_{2.5}$

(0.84).

The calculated emission factors are assumed to be fully achieved in practice in the year 2030 and are used for the WM scenario.

Reduction in medium combustion plants through implementation of the 44th BImSchV:

Medium combustion plants (MCP), including gas turbines and combustion engine plants are regulated by the national 44th BImSchV, which implemented the MCP directive (EU) 2015/2193 into national law and entered into force in June 2019, and are therefore part of the WM scenario. The underlying limit values of the emission calculation are taken from the 44th BImSchV. The measure leads to a reduction in the emission factors of the affected time series in several NFR sectors under 1.A.

The data basis for the calculation is the submission 2024. The source categories are reassessed separately according to the pollutants and the relevant fuel inputs. The expected average years in service plants are taken into account (see Table 11) as well as a distinction between old and new plants and the rated thermal input (RTI) of the plants in MW (see Table 10). Table 10 shows the plant split for various fuels taking into account the RTI.

Table 10: Proportional plant split of the MCP according to fuel consumption and RTI

Plant split according to fuel consumption	RTI in MW	Proportion
Biomass	1-5	11 %
	5-20	30 %
	20-50	59 %
Lignite	1-20	95.8 %
	20-50	4.2 %
Hard coal	1-20	90.2 %
	20-50	9.8 %
Heavy fuel	5-20	68.0 %
	20-50	32.0 %

The limit values of the MCP are specified in the 44th BImSchV according to their performance ranges. The table shows the estimated proportion of MCP in Germany in relation to the RTI provided and the fuel input used.

Table 11: Expected service life of MCP according to type of plant, pollutant and fuel use

	Expected average service life
Combustion plants - solid fuels	20 years
Combustion plants – liquid and gaseous fuels	15 years
gas and steam turbines (GuD) and gas turbines (GT)	22 years
internal combustion engines - biogas	5 years
internal combustion engines – other fuels	10 years

The new emission factors are always calculated according to the same pattern. The limit values of the 44th BImSchV are weighted for each RTI range of the plants and calculated for old and new plants. Assuming that a constant rate of existing plants, depending on the assumed average lifetime, is renewed or upgraded annually, the weighting of the limit values for new plants for the projections in 2025, 2030, 2035, 2040, 2045 and 2050 is increased or, depending on the expected average lifetime of the plant category, only the limit values for new plants are taken into account.

If the current emission factor from the 2022 submission undercuts the calculated value, the current reference value is kept for the projection because it is already below the 44th BImSchV and thus complies with the limit values. The recalculated values for the time series, reflecting the maximum permitted limit values, are assigned to time series in all other cases where the current emission factor is above the 44th BImSchV.

Example:

The exact procedure is exemplified by the NO_x emission factors when using other solid biomass (than wood) as fuel. The procedure is in principle the same for all pollutants and fuels.

The basis for the calculation is the maximum annual average amount of NO_x emissions per cubic meter permitted in the 44th BImSchV §10 (4) and (15) when using other solid biomass (than wood) as fuel (Table 12). After conversion with the specific conversion factor for lignite, assumed as similar to other solid biomass, of 2.39 (see Table 4), the limit values for old and new plants are available in kg/TJ. Table 12 shows the NO_x limit values as annual average for solid biomass according to the RTI range for old and new plants in mg/Nm^3 and kg/TJ.

Table 12: NO_x limit values for other solid biomass (than wood) in MCP according to the RTI for old and new plants

Fuel	**Plant**	**NO_x limit value according to 44th BImSchV in mg/Nm³**			**NO_x limit value in kg/TJ**		
		RTI in MW			RTI in MW		
		1-5	>5	>20	1-5	>5	>20
other solid biomass (than wood)	existing	600		370	250.4		154.4
other solid biomass (than wood)	new	370	300	200	154.4	125.2	83.5
Limit values for solid biomass in MCP for old and new plants according to the 44th BImSchV in mg/Nm^3 and kg/TJ.							

It is assumed that the average service life of the plants is 20 years (Table 11). In addition, it is assumed that a constant annual renewal of the plant will be implemented after the 44th BImSchV comes into force in 2019 and that the limit values for new plants getting greater weight each year.

According to the assumption in 2025 (6 years after the regulation came into force) there is a proportion of 6/20 which fulfil the requirements of new plants and 14/20 which adhere to the limit values of existing plants. In 2030, eleven years after the 44th BImSchV was introduced, the proportion of new plants is 11/20 compared to 9/20 existing plants. After 16 years in 2035, the limit value for new plants is included in the calculation with 16/20. From 2040 only the limit value for new plants is assumed, as it is 21 years after the 44th BImSchV has entered into force.

Taking into account the plants proportions per size measured in RTI in WM (Table 10), a new emission factor of 166.8 kg/TJ for 2025 results, as shown in (3).

```
  (3) emission factor (other solid biomass than wood in 2025) = 14/20 * {(11 % + 30 %) *
250.4 kg/TJ + 59 * 154.4 kg/TJ} + 6/20 * {11 % * 154.4 kg/TJ + 30 % * 125.2 kg/TJ + 59 % *
83.5 kg/TJ} = 166.8 kg/TJ.
```

Since the maximum reference value from the 2024 submission for the year 2022 (137.5 kg/TJ) is already below the calculated limit, it will be kept constant for the year 2025. For 2030 as well, as the calculated limit of 144.3 kg / TJ in 2030 is still above the reference emission factor in 2022. The procedure for calculating the emission factor in 2035 is identical and is shown in (4).

```
  (4) emission factor (other solid biomass than wood in 2035) = 4/20 * {(11 % + 30 %) * 250.4
kg/TJ + 59 % * 154.4 kg/TJ} + 16/20 * {11 % * 154.4 kg/TJ + 30 % * 125.2 kg/TJ + 59 % * 83.5
kg/TJ} = 121.8 kg/TJ
```

In 2035 the newly calculated limit value will be below the reference value, so that the calculated one is assumed as the new implied NO_x emission factor.

Special Feature:

When calculating the NO_x emission factors for using lignite and hard coal as fuel, the plant split is only differentiated according to the RTI of less than 20 MW and greater than 20 MW. The limit values given in the 44th BImSchV are differentiated according to 1-5 MW, 5-20 MW and more than 20 MW.

As a result, the assumption was made that the plant split between 1-5 MW and 5-20 MW in equal proportions would be valued with a factor of 0.5.

According to the 44th BImSchV § 16, the emission limit values for combustion engines will only apply from 1st of January 2025 on, so that the assumption of the partial renewal of plants will only apply from 2025 on. As a result, the reference values from the 2022 submission will be kept constant for 2025 and calculation of implied emission factors considering the limit values for new plants starts from the year 2025.

[1)] Tebert et al. (2016): Tebert, C., Volz, F., Töfke, K. (2016): Development and update of emission factors for the National Inventory regarding small and medium-size combustion plants of households and small consumers, on behalf of the Umweltbundesamt, Project-Nr. 3712 42 313 2

[2)] Jörß et al. (2014): Jörß, W., Emele, L., Scheffler, M., Cook, V., Theloke, J., Thiruchittampalam, B., Dünnebeil, F., Knörr, W., Heidt, C., Jozwicka, M., Kuenen, J.J.P., Denier van der Gon, H.A.C., Visschedijk, A.J.H., van Gijlswijk, R.N., Osterburg, B., Laggner, B., Stern, R., Handke, V. (2014): Luftqualität 2020/2030: Weiterentwicklung von Prognosen für Luftschadstoffe

unter Berücksichtigung von Klimastrategien, on behalf of the Umweltbundesamt, Project-Nr. 3710 43 219, UBA-Texte 35/2014, https://www.umweltbundesamt.de/publikationen/luftqualitaet-20202030-weiterentwicklung-von; ISSN 1862-4804, Dessau-Roßlau, July 2014

100)

Methodology and calculations for large combustion plants are based on Jakobs, H., Schneider, C., Handke, V. (2019): NEC-Richtlinie: Weiterentwicklung von Prognosen für Luftschadstoffe für nationale Luftreinhalteprogramme, Project-Number FKZ 3716512020, on behalf of the German Environment Agency (UBA).

101)

https://www.energiewechsel.de/KAENEF/Redaktion/DE/FAQ/FAQ-Uebersicht/Richtlinien/bundesfoerderung-fuer-effiziente-gebaeude-beg.html

Additional measures that have not yet been implemented are assigned to the WAM scenario

Optional amendment of the 13th BImSchV

The German Federal Government declared in its current NAPCP 2023, that an optional amendment of the 13th BImSchV will be considered for solid (other than coal), liquid and biogenic fuels in case there is non-compliance with the reduction commitment for NO_x projected. Because it is very difficult to define all solid (other than coal), liquid and biogenic fuel uses in installations falling under 13th BImSchV in the inventory database, as there is often not only one single fuel used in those installations or complex calculations for an overall emission limit value of all installations falling under one facility (e. g. for refineries) are necessary, only for three exemplary categories of installations a hypothetical NO_x mitigation potential was quantified. This follows a conservative approach and does not anticipate any political decision. Thus, in the updated WAM scenario reported in 2025 mitigation potential is only assumed for 2035 at the earliest.

- **potential NO_x reduction in pulp and paper production through an optional amendment of the 13th BImSchV:**

According to the existing 13th BImSchV (as of 2021), different maximum amounts of NO_x emissions are permitted according to the production process (sulphate and sulphite process) and the size of the plant (measured in RTI in MW) in pulp and paper production (NFR sector 2.H.1).

It is assumed for the sulfite process that all plants located in Germany are operated with an RTI of 50-300 MW. A maximum emission factor of 300 mg/Nm³ for all plants according to the 13th BImSchV is assumed for the further calculation of the reduction potential. The NO_x emission factor for the sulfite process was taken over from the 2024 submission in the year 2010, which is 2 kg/t. The new emission factor results from the historic emission factor (2 kg/t) and the maximum emission value proposed for the optional amendment (85 mg/Nm³) divided by the calculated mean value of the currently applicable law (300 mg/Nm³). This results in an emission factor of 0.57 kg/t for 2035 onwards as shown in (5).

```
  (5) implied NOx emission factor (sulfite process) = (2 kg/t * 85 mg/Nm³) / 300 mg/Nm³ =
0.57 kg/t
```

In the field of the sulfate process (also known as kraft process) a weighted maximum average emission factor according to the limit values of the 13th BImSchV was assumed as shown in equation (6).

```
  (6) implied NOx emission factor (sulfate process) = 0.36 * 250 mg/Nm³ + 0.64 * 200 mg/Nm³ =
217.78 mg/N³
```

The implied emission factor for the sulphate process was taken over from the 2024 submission in the year 2010. The new emission factor results from dividing the 2010 emission factor and the maximum emission value proposed for the optional amendment of the 13th BImSchV by the calculated mean value of the currently applicable law. This results in an emission factor of 0.68 kg/t for 2035 onwards as shown in equation (7).

```
  (7) implied NOx emission factor (sulfate process) = (1.75 kg/t * 85 mg/Nm³) / 217.78 mg/Nm³
= 0.68 kg/t
```

- **potential NO_x reduction in refineries through an optional amendment of the 13th BImSchV:**

An optional amendment of the 13th BImSchV would lead to emission reductions in the area of refineries and is assigned to the WAM scenario. It causes a reduction in the emission factors in the affected time series of the NFR sector 1.A.1.b. A distinction must be made between refinery plants and the fuel input used by them. For plants using crude oil (naphtha), light heating oil or other petroleum products, the proposed NO_x limit value is set to 85 mg/Nm³ and adopted as the future maximum emission level. Some refineries in Germany get permission by applying a so-called bell rule, whereby individual parts of the plant are allowed to exceed fuel specific limit values, if the facility in total for all installations and used fuels complies with an average limit value calculated with the help of a so-called bell curve.

For plants where a future limit value of 85 mg NO_x/Nm³ is assumed, conversion factors based on specific flue gas volumes for heavy fuel oil or light heating oil (Table 4) were used to convert to kg NO_x/TJ, shown in equation (8) for the example of refinery underfiring in LCP with light heating oil as fuel.

```
  (8) implied NOx emission factor (refinery underfiring with light heating oil) = 85 mg/Nm³ /
3.49 = 24.4 kg/TJ
```

This results in future NO_x emission factors of 24.4 kg/TJ for light heating oil and 25.1 kg/TJ for other petroleum products from 2035 onwards.

For all plants that are assumed to use permission by applying the so-called bell rule, the potential effect of integrating a NO_x limit value of 85 mg/Nm^3 for a part of the fuels used in such plants was quantified by estimating a relative reduction. Therefore, it was assumed that the current mean emission factor for one exemplary refinery permitted by using the so-called bell rule is 274.75 mg/Nm^3. The application of the proposed future limit value for all solid (other than coal), liquid and biogenic fuels used in this plant will lead to a mean emission factor of this specific refinery of 189.75 mg/Nm^3. This results in a relative reduction of 69 percent, as shown in equation (9)

```
  (9) percentage NOx emission reduction (specific refinery) = 1 - (189.75 mg/Nm³ / 274.75
mg/Nm³) = 0.69
```

This exemplary relative reduction was than assumed to apply for all refineries permitted by using the so-called bell rule from 2035 onwards. Therefore, the current emission factor in the inventory out of submission 2024 is multiplied with this relative reduction. As an example, the resulting emission factor applied from 2035 onwards for refinery underfiring with heavy fuel oil is shown in equation (10).

```
  (10) NOx emission (refinery underfiring with heavy fuel oil) = 118 kg/TJ * (1 - 0.69) =
36.5 kg/TJ
```

- **potential NO_x reductions in other large combustion plants through an optional amendment of the 13th BImSchV:**

Emissions from other LCPs, which emerge from the energy balances and cannot be clearly assigned to a specific fuel use or fuel mix, but also show a reduction potential by an optional amendment of the 13th BImSchV are assigned to the NFR sectors 1.A.1.a, 1.A.1.c and 1.A.2.g.viii and a potential reduction in the NO_x emission factors was estimated.

The NO_x emission factors for all non-gaseous materials other than coal for electricity and heat generation are considered and the maximum emission value for NO_x is assumed to be 85 mg/Nm^3 from 2035 onwards. According to the 13th BImSchV, only plants with more than 1,500 operating hours per year are taken into account for which the proposed limit value of 85 mg NO_x/Nm^3 applies. Table 13 shows the estimated relative and absolute plant split of the LCP according to their annual operating time assuming an equal fuel use distribution.

Table 13: Estimated relative and absolute plant split of LCP according to annual operating hours

operation time	RTI in MW	proportion
< 1500 h/a	46573	17.8 %
> 1500 h/a	214990	82.2 %
total	261563	100 %

First, the limit value of 85 mg/Nm^3 is converted into kg/TJ using the fuel specific conversion factor (Table 4). The new emission factor results from the sum of the reduction for the 82.2 per cent of the fuel use with an operating time of more than 1500 h/a and the unchanged value from the 2024 submission for the 17.8 per cent of the fuel use with less than 1500 h/a operating time, that is assumed to be not effected by an optional amendment of the 13th BImSchV.

The calculation is shown using the example of the source category of electricity generation in large public power plants using heavy fuel oil (reference value in 2022: 43.5 kg/TJ) in (11), whereby the procedure is analogous for all other source categories.

```
  (11) NOx emission factor (electricity generation in public power plants with heavy fuel
oil) = (85 mg/Nm³ / 3.39) * 82.2 % + 43.5 kg/TJ * 17.8 % = 28.4 kg/TJ
```

Emission reduction in small combustion installations by amending the emission limits of the Ecodesign Regulations (EU) 2015/1185 and (EU) 2015/1189:

Through amendment of the Commission regulation (EU) 2015/1189 with regard to ecodesign requirements for solid fuel boilers, it was assumed that requirements for placing on the market and putting into service solid biomass boilers regarding emissions of particulate matter will be set at 2.5 mg/m^3 TSP from 2027 (measured according to VDI 2066 Sheet 1, May 2021 edition and based on 13 % reference oxygen content).

Through amendment of the Commission regulation (EU) 2015/1185 with regard to ecodesign requirements for solid fuel local

space heaters, it was assumed that requirements for placing on the market and putting into service solid biomass local space heaters regarding emissions of particulate matter will be set at 20 mg/m^3 TSP from 2029 (measured according to VDI 2066 Sheet 1, May 2021 edition and based on 13 % reference oxygen content).

Considering these assumptions and the projected use of solid biomass in small combustion installations in the current WM scenario, a potential emission reduction of 0.8 kt $PM_{2.5}$ in 2030, of 1.3 kt in 2035 and of 1.8 kt in 2040 was quantified in the current WAM scenario. The absolute emission mitigation potential in 2030 and onwards very much depends on the projected biomass use as well as the year, when the proposed amendment will apply for new installations. The higher the use of solid biomass in the building sector is projected, the higher the mitigation potential of the proposed amendment of the Ecodesign requirements will be. Less stricter requirements regarding particle emissions in national policies (e. g. funding programmes) will increase the projected emissions in the WM scenario and thus, will also basically increase the mitigation potential of the proposed amendment of the EU ecodesign regulations.

Apart from that, an ambitious EU-wide regulation of PM emissions of small combustion installations will help a lot to comply with the $PM_{2.5}$ limit values of the new Ambient Air Quality Directive (EU) 2024/2881[102)] as well as the average exposure reduction obligation for $PM_{2.5}$. Otherwise, the use of solid biomass might have to be banned in certain areas or at least temporarily restricted.

Additional reduction in agriculture compared to the German NAPCP 2023:

For the emission projections submission 2025, in contrast to the emission projections submission 2023 as well as to the German NAPCP 2023, no further mitigation potential has been reported in the current WAM scenario regarding additional measures in the agricultural sector (NFR 3). The support measure to increase the co-fermentation of slurry in biogas production to further reduce GHG emissions of the agricultural sector has been stopped in 2024, and currently there is no other concrete measure under preparation. In addition, the support measure was not very effective due to low adoption rates in the first years until 2024. Therefore, no increase in co-digested slurry is expected above the assumptions in the WM scenario until 2030, and thus no increase of NH_3 emissions from digestates. Without an expected increase of emissions, and on the background of a buffer of roughly 11 (based on inventory submission 2024) respectively 28 kt NH_3 (based on inventory submission 2025) in the current WM scenario in the year 2030, no additional measures are necessary, and no specific WAM for NH_3 is calculated. The assumptions on co-fermentation of slurry in biogas production for the projections on greenhouse gas emissions (submission 2025) are documented in “Treibhausgas-Projektionen 2025 für Deutschland”[103)].

In addition, the amount of ammonia emissions from the previous year will be checked annually in the future. This should be carried out for ammonia emissions from agriculture as part of the previous year's estimate of greenhouse gas emissions in accordance with Section 5 Paragraph 1 of the Federal Climate Protection Act. The previous year's estimate is based on current statistics on important activity data for the previous year (livestock, N-mineral fertiliser sales) and must be submitted annually by March 15th. If the ammonia emissions of the previous year's estimate are above the linear target path according to NEC Directive (EU) 2016/2284, the BMEL, in consultation with the BMUV, will develop a bundle of agricultural measures, that will assure compliance with the linear target path as soon as possible. Because of uncertainties in the emission projections a minimum gap of 10 kt is agreed. If the previous year’s estimate in the following year has again a gap of 10 kt or more, the bundle of agricultural measures enters into force immediately.

102)
http://data.europa.eu/eli/dir/2024/2881/oj
103)
see table 116, pages 115-116,
https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/projektionen_2025-instrumentenpapier_korr_2.pdf

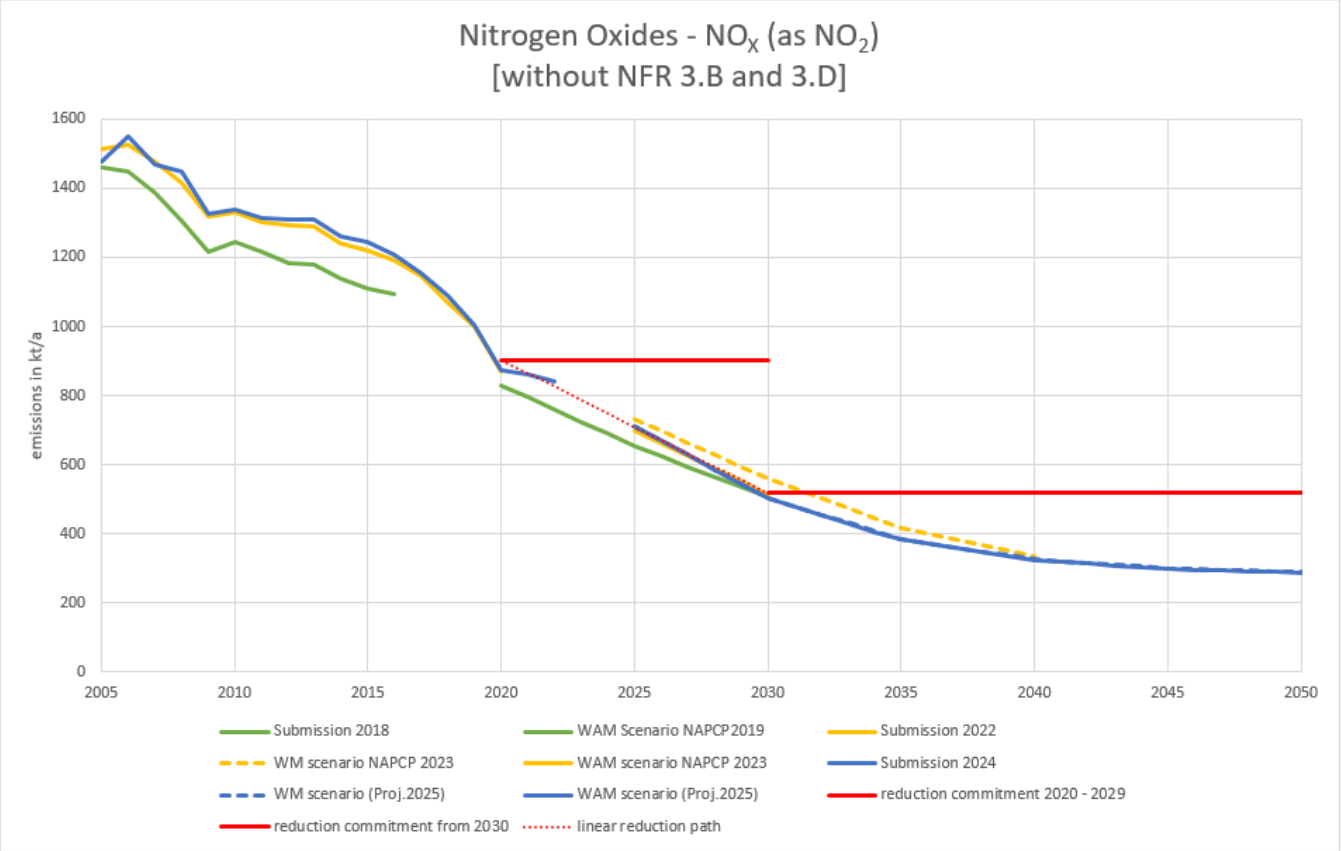
Recalculations

Due to recalculations in each underlying emission inventory submission, all calculations of emission reduction potentials in the WM and WAM scenario of the respective projection are regularly updated. Furthermore, additional measures that had been included in the WAM scenario in the previous projection can become part of the WM scenario in the current projection, as they were put into force in the meantime (e. g. amendment of the 17th BImSchV). In addition, updated GHG emission projections using most recent projections of economic and other parameters result in a new projection of activity rates that needs to be considered for updating the emission projections of air pollutants. For the regular update of the projections under NEC-Directive (EU) 2016/2284, in between the regular update of the National Air Pollution Control Programme every four years, remaining measures in the WAM scenario of the current NAPCP stay and their mitigation potential is reassessed, unless they were dropped by the current federal government. The last is the case for the package of additional agricultural measures in the WAM scenario of the German NAPCP 2023. Thus, it was not reassessed for the current projections.

For each pollutant the following figures show the differences between inventory submissions 2018, 2022 and 2024 for historic emissions as well as the differences between the WAM emission projections reported in 2019 (consistent with the NAPCP 2019), the WM and WAM scenario reported in 2023 (consistent with the NAPCP 2023) and the current WM and WAM scenario reported in 2025. For each pollutant a brief explanation of the most relevant reasons for the occurring differences compared to the previous reporting is given. For explanation of the differences between reporting in 2023 as well as the NAPCP 2023 reported in 2024 and 2021 please see IIR 2024[104)] and for the differences between reporting in 2021 and 2019 please see the IIR of the 2021 reporting[105)].

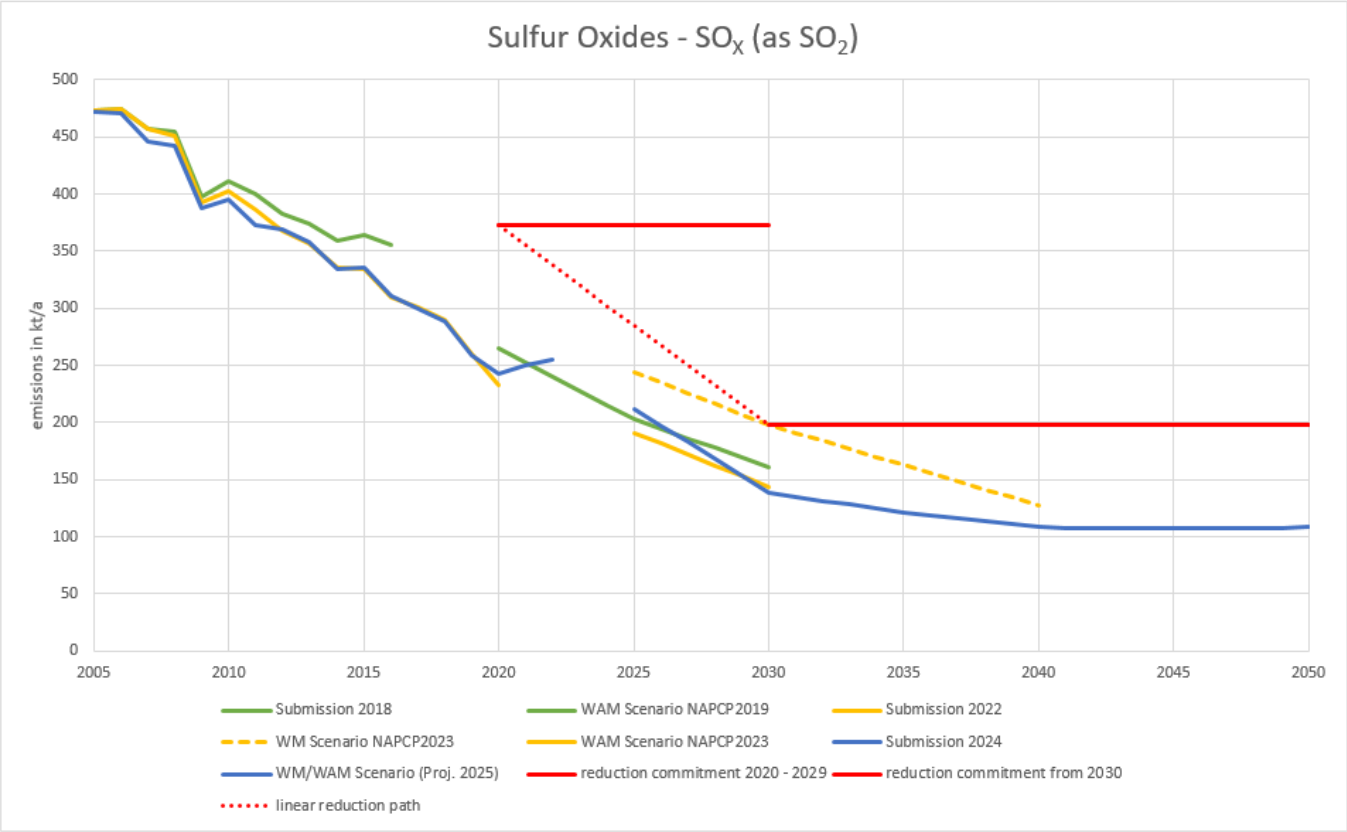
In general, there is not much change in the current projection for **NO_x**, that needs further explanation. Apart from the recalculations in the inventory since submission 2018, explaining most of the differences in 2025 between the NAPCP 2019 projection and the more current projections, there are two relevant reasons for differences between the current WM projection and the previous WM projection of the NAPCP 2023:

- The coal phase-out until 2030 is now included in the WM projection. To some extent because of legislation that did take place in the meantime and to some extent because of updated assumptions on price development of fuels, prices at the energy market as well as for CO_2-prices, making especially the power generation from lignite in the remaining capacities less and less economical.
- Second, most measures from the road transport package of the NAPCP 2023 are now part of the WM scenario as they entered into force in the meantime (e. g. amended truck toll, Euro 7 legislation). There is neither further increase of the share of electrically driven mileage for passenger cars nor further increase of the number of passenger cars in the fleet assumed beyond the WM scenario (for description of assumptions in the road transport sector in the current WM scenario see calculation documentation and referred publications).

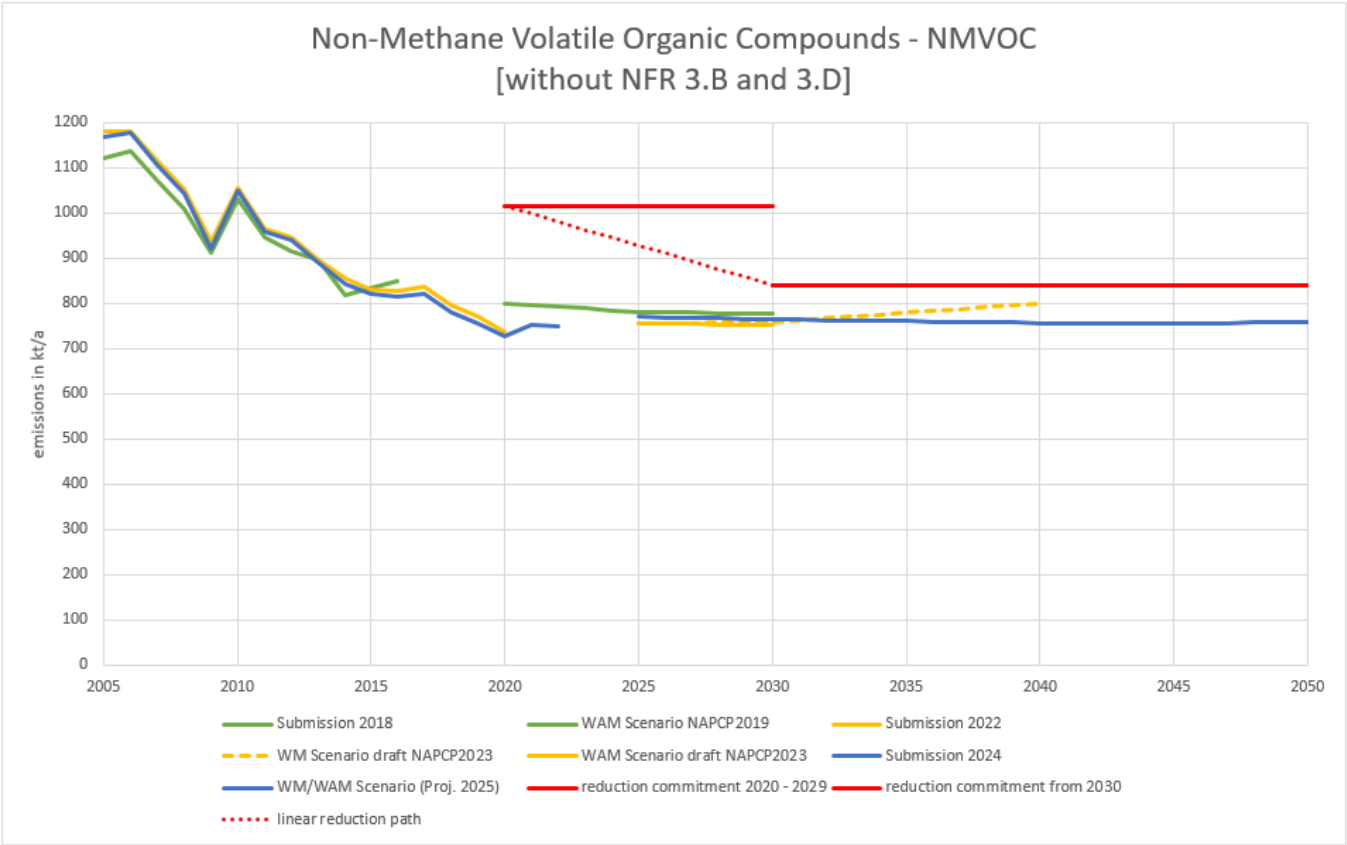


There is also not much change in the current projection for **SO_x**, that needs further explanation. There is only one relevant reason for differences between the current WM projection and the previous WM projection of the NAPCP 2023:

- The coal phase-out until 2030 is now included in the WM projection. To some extent because of legislation that did take place in the meantime and to some extent because of updated assumptions on price development of fuels, prices at the energy market as well as for CO_2-prices, making especially the power generation from lignite in the remaining capacities less and less economical. In the WM scenario of the NAPCP 2023 this was assumed to take place until 2038 (see description of the previous WM scenario in the IIR 2024).

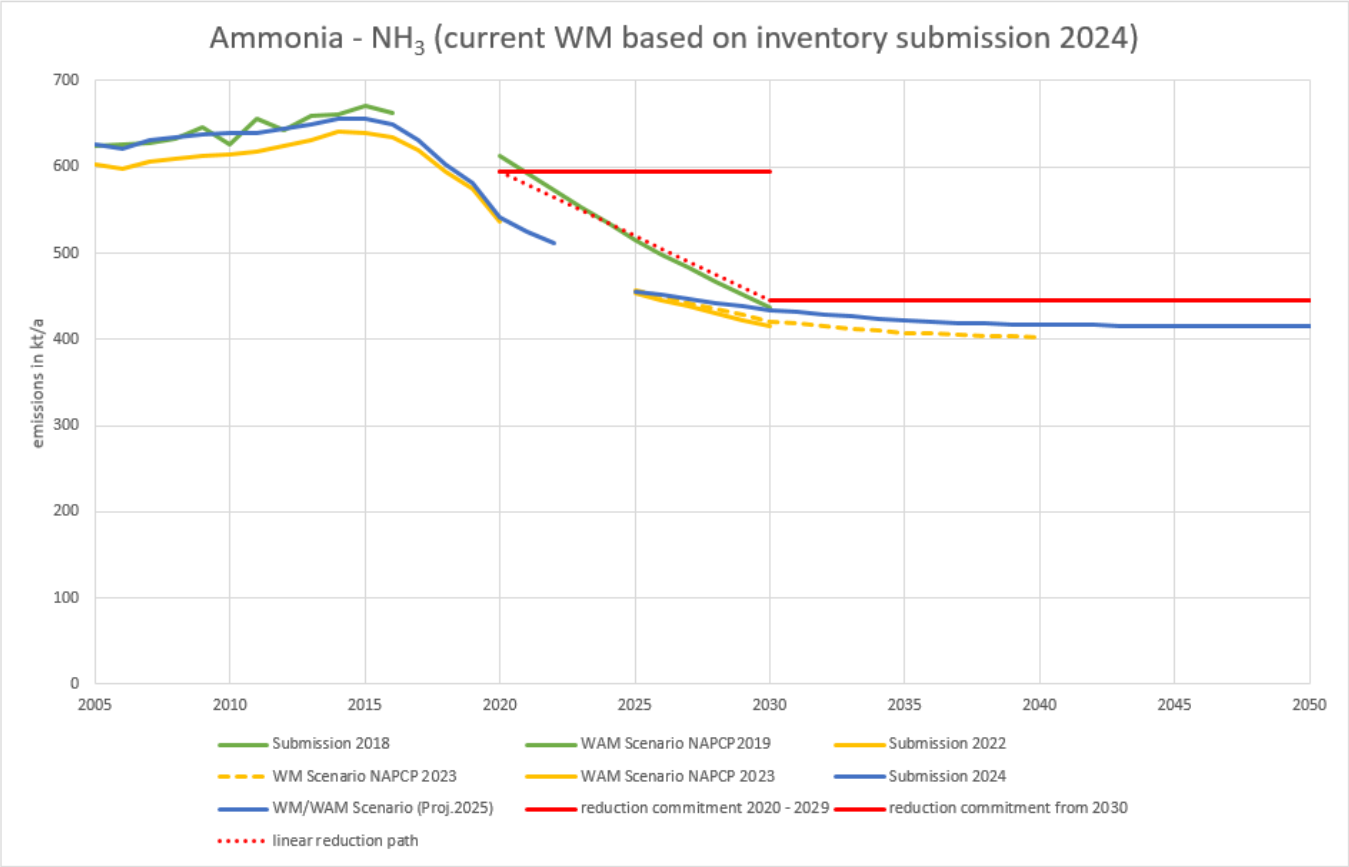


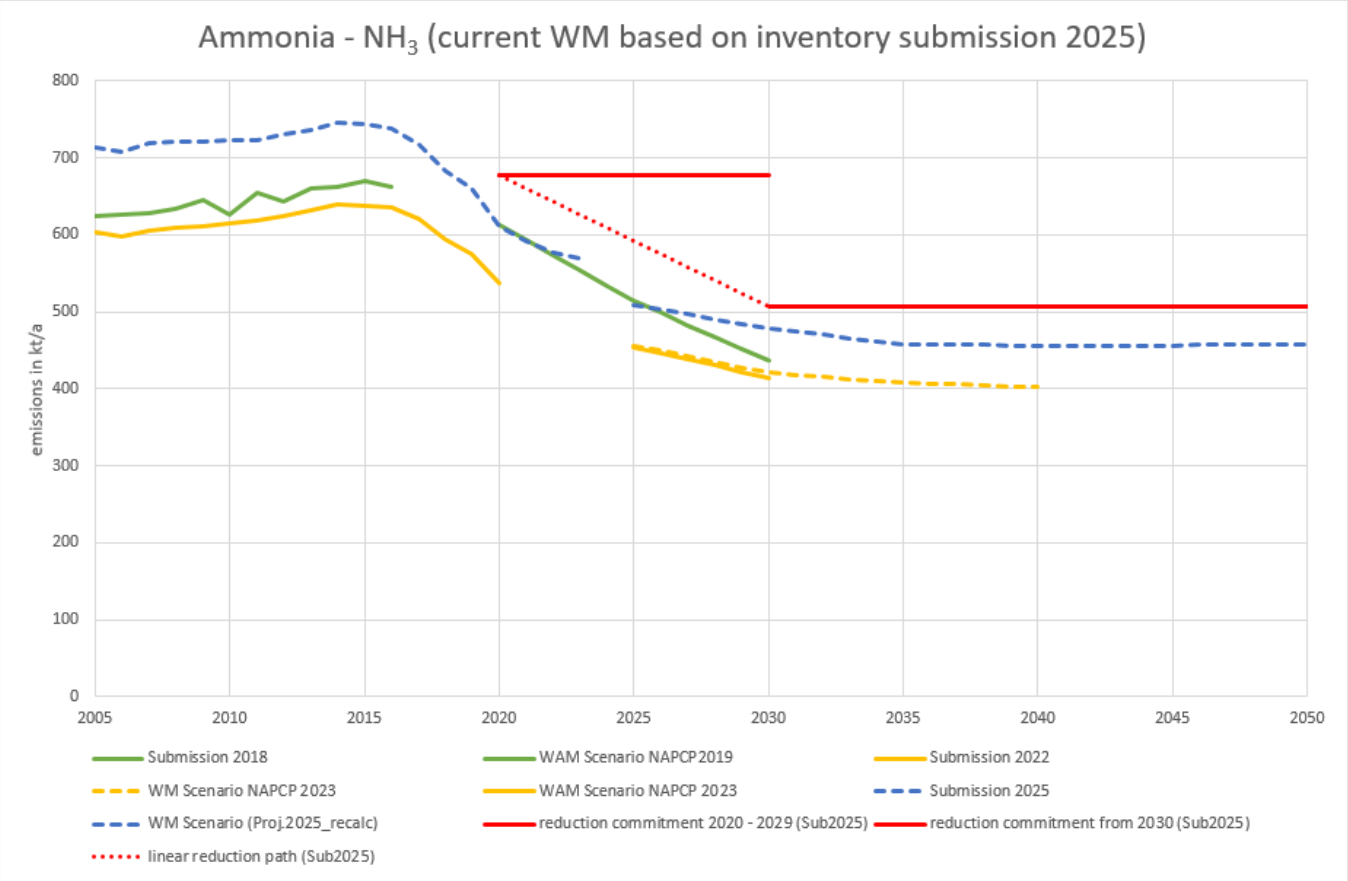
NMVOC emission projections are strongly influenced by economic projections. Updates on these are therefore causing changes in NMVOC emission projections. The deviating trend of the current WM projection against the previous WM projection of the NAPCP 2023 is explained in the chapter calculation documentation. However, the latest historic emissions in 2022 are already below the current WM projection for 2025 to 2050, which is caused by decreases over all sectors.



For ammonia (**NH_3**) two comparisons to previous projections are shown as two WM projections were submitted under NEC-Directive & CLRTAP in 2025, one based on inventory submission 2024 and the other one based on inventory submission

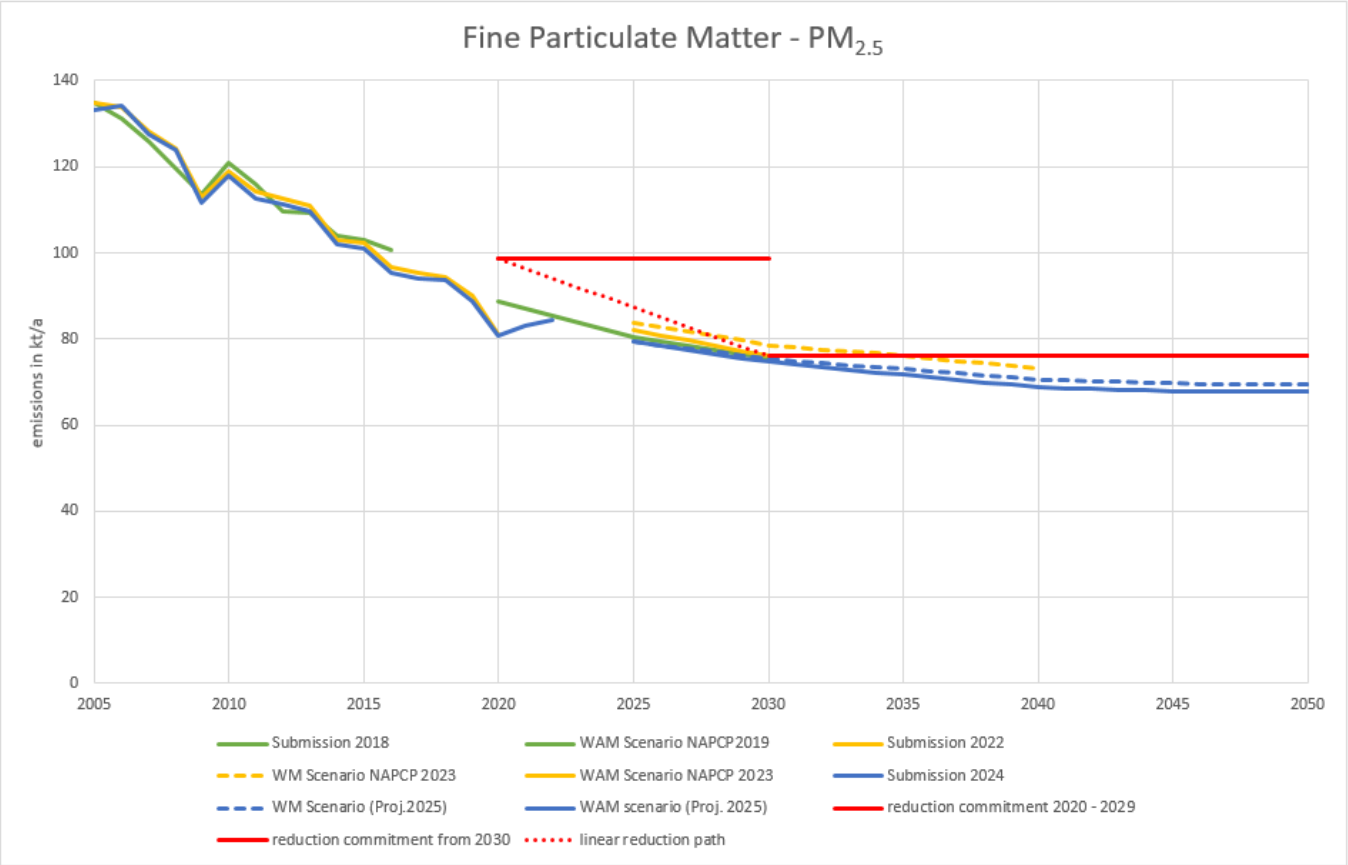
2025 under otherwise identical assumptions. In both cases, from submission 2021 onwards a methodological change in emission calculations for inorganic fertilisers is leading to less variation from one year to another[106)]. Apart from that, current WM projection based on inventory submission 2024 is slightly above the previous WM and WAM scenarios of the NAPCP 2023 in 2030 and beyond as there are slight changes in the assumptions on animal numbers and thus, in the amount of manure and inorganic fertilisers applicated. The current WM projection based on inventory submission 2025 is significantly higher, due to recalculations in the inventory. The main reason for higher emissions are adjusted emission factors for various inorganic fertilisers according to the latest EMEP/EEA air pollutant emission inventory guidebook 2023. Development of historic emissions and projections in the current WM scenario (in both variations) is not parallel, as the amount of fertilisers is multiplied with the emission factors and therefore difference in resulting emissions is not linear.





$PM_{2.5}$ projections are mostly consistent over the various projection reportings. However, the projection of the NAPCP 2019 and later projections are containing mutually compensating assumptions. The WAM scenario of the NAPCP 2019 had assumed a much higher coal use as well as a much lower use of solid biomass in 2030 than the following projections, leading to an almost congruent estimate of the projected national $PM_{2.5}$ total. Thus, the WM scenario of the NAPCP 2023 lies above all other displayed scenarios, because of higher biomass use than in the WAM scenario of the NAPCP 2019 (and also than in the current WM and WAM scenarios) in combination with a lower coal use than in the NAPCP 2019.

However, the assumed coal use in the current WM scenario is almost phased out until 2030 (see description in the WM scenario) in combination with an assumed use of solid biomass that is lower than in the NAPCP 2023 but higher than in the NAPCP 2019. That the WAM scenario of the NAPCP 2023 is also slightly above the current WM projection in the year 2025 is mostly due to a previously projected sharper increase in the use of solid biomass in the building sector than under updated assumptions. Apart from these differing assumptions of coal use in the energy and industry sector and the use of solid biomass in the building sector as well as in the energy and industry sector, also updated assumptions in the road transport sector have a mitigation effect (e. g. Euro 7 regulation introducing limit values for tyre and brake wear). With less biomass in the current WM scenario than in the NAPCP 2023 also the mitigation potential of the revision of the Ecodesign directives for solid fuel boilers and solid fuel local space heaters in the current WAM scenario is slightly lower than in the previous WAM scenario of the NAPCP 2023.



104)
https://iir.umweltbundesamt.de/2024/general/projections/recalculations
105)
https://iir.umweltbundesamt.de/2021/general/projections/recalculations
106)
for further explanation see: https://iir.umweltbundesamt.de/2021/general/recalculations/ammonia

CHAPTER 11.1: Large Point Sources (LPS)

Background

Germany, alongside with the European Union (EU) and EU Member States, has signed the *UN-ECE PRTR Protocol*, whereby Germany commits to establish and operate a national Pollutant Release and Transfer Register (PRTR) for public information. *The E-PRTR Regulation (European Regulation (EC) No 166/2006)* and the *German PRTR Act (SchadRegProtAG)* provide the legal basis for this fact. If pollutant threshold values or waste quantities specified in the E-PRTR Ordinance are exceeded, releases of pollutants to air, water and soil, shipments with wastewater, and disposal of hazardous and non-hazardous wastes from certain industrial activities have to be reported annually for the PRTR. [1)]

Since December 31, 2016, the new *NEC Directive (2016/2284/EU)* on the reduction of the national emissions of certain atmospheric pollutants came into force, replacing the *Directive (2001/81/EC)* on National Emission Ceilings. The new *NEC Directive (2016/2284/EU)* requires EU Member States to achieve new reduction targets from 2030, which in addition to the previously regulated air pollutants SO_2, NO_x, NMVOC and NH_3, also include reduction targets for particulate matter ($PM_{2.5}$) for the first time. This means that the new directive imposes significantly extended reporting obligations on the EU Member States. For the first time, EU Member States are required to create emission inventories for particulate matter, heavy metals and POPs. The inventories must also include emission projections. Furthermore, emissions from large point sources must be reported and emission data must be spatially itemized.

For the first time in 2017 and then every four years, EU Member States must report spatially distributed emissions (raster data) with a resolution of 0.1° x 0.1° (longitude-latitude). Large point sources (LPS) must be reported every 4 years, starting in 2017. Reporting is mandatory for agro-industrial and industrial activities whose annual emissions exceed certain thresholds, which correspond to those for emissions reporting under *the E-PRTR Regulation (European Regulation (EC) No 166/2006)*. [2)]

Annex IV of the Directive indicates, that the Member States shall prepare emission inventories “in accordance with the methodologies recognized by the Parties to the *LRTAP Convention (EMEP reporting guidelines)*” and “shall base their reporting on the *Air Pollutant Emissions Inventory (EMEP/EUA Guidelines)* referred to in the Convention.” *The reporting guidelines (UNECE 2015)* define large point sources as follows:

> “Large point sources (LPS) are defined as facilities whose combined emissions, within the limited identifiable area of the site premises, exceed the pollutant emission thresholds identified in table 1 below.”[3)]
>
> The associated Table 1 identifies thresholds, consistent with those identified in the E-PRTR Regulation (2016), for the following pollutants:
>
> - Sulfur dioxide (SO_2)
> - Nitrogen Oxide (NO_x)
> - Carbon Monoxide (CO)
> - Non-Methane Volatile Organic Compounds (NMVOC)
> - Ammonia (NH_3)
> - Particulate Matter ≤2.5µm ($PM_{2.5}$)
> - Particulate Matter ≤10µm (PM_{10})
> - Lead and compounds (Pb)
> - Cadmium and compounds (Cd)
> - Mercury and compounds (Hg)
> - Polycyclic Aromatic Hydrocarbons (PAHs)
> - PCDD & PCDF (Polychlorinated Dibenzo-Dioxins and -Furans)(as Teq)
> - Hexachlorobenzene (HCB)
> - Polychlorinated Biphenyls (PCBs)

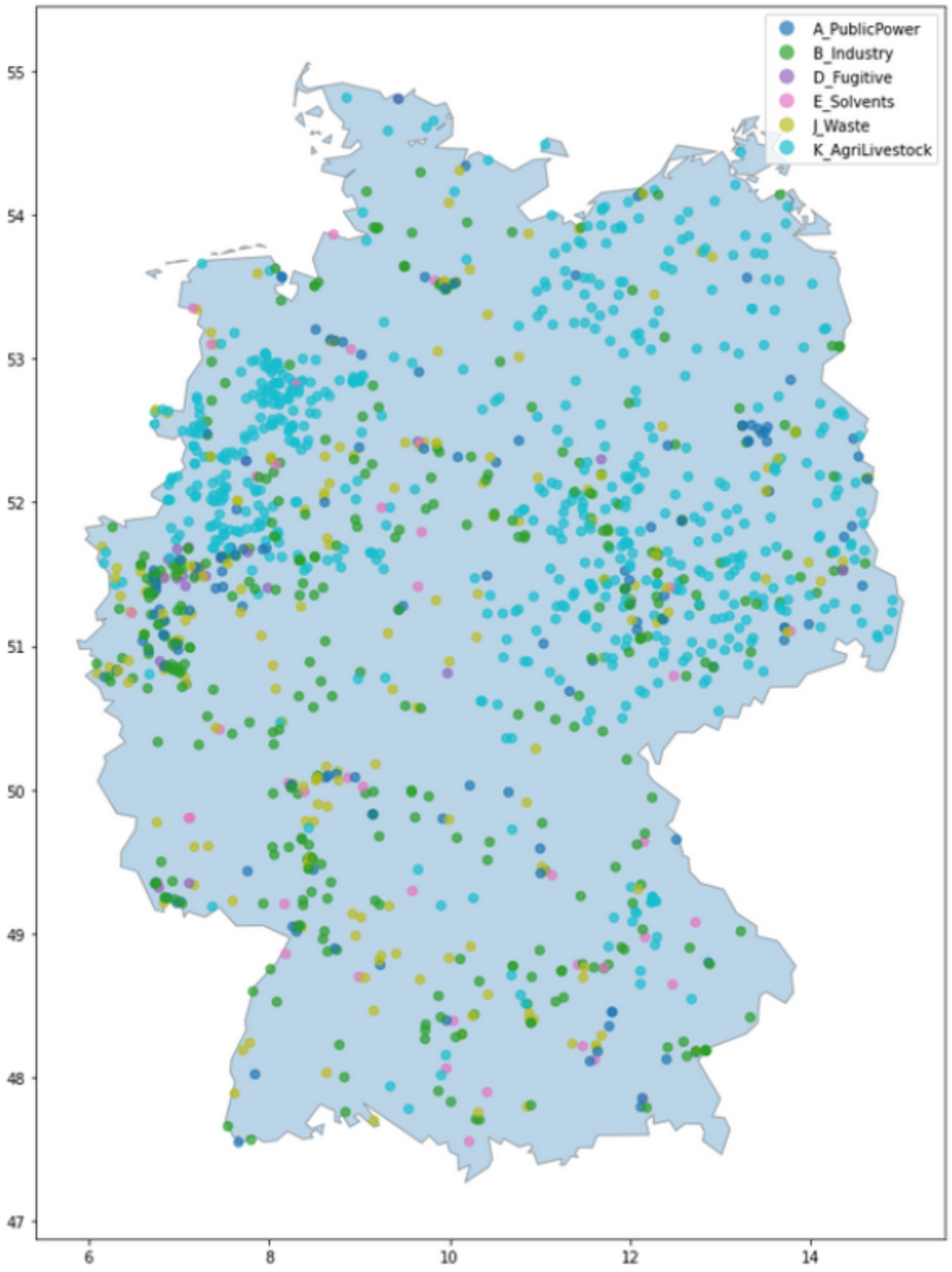
Reporting

Germany provided its point source data under the LRTAP convention for the first time in 2017. In principle, the German LPS

data submission is mainly a copy of the ePRTR data available on both the national and European websites. However, as some additional information is missing in the ePRTR dataset, such as stack heights, which are not available at the federal level, some gap filling is needed and explained below.

The most recent provision of large point source data, submitted in 2025, is using the 2023 ePRTR data.

Figure 2: **Large point sources for different GNFR sectors for Germany for the year 2023**



Source of data: https://cdr.eionet.europa.eu/de/un/clrtap/lps/envaan4gq

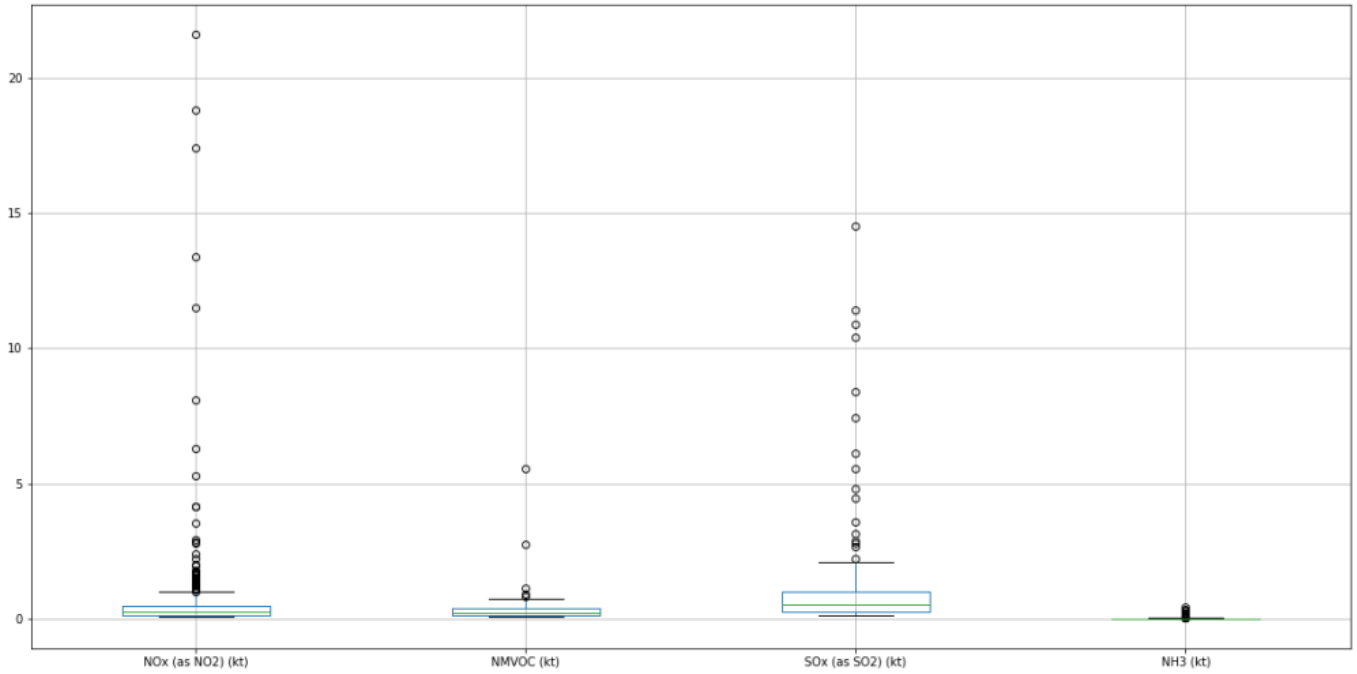
Methodology

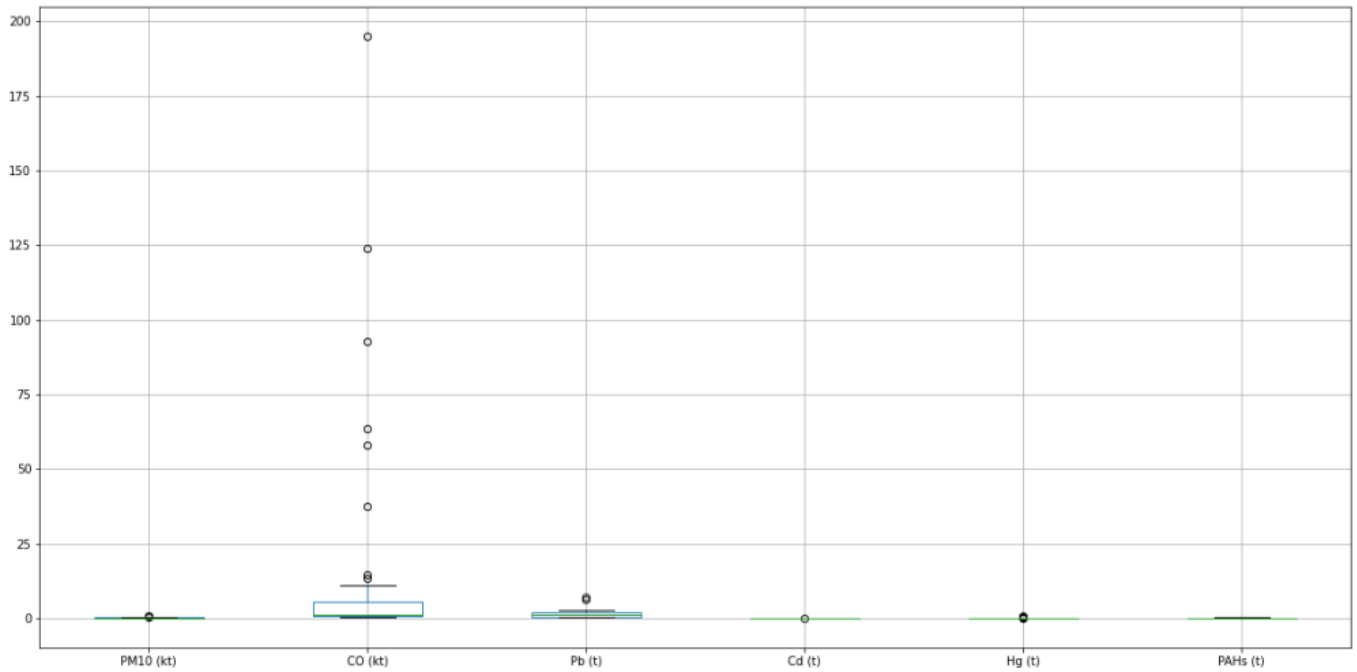
Quality checks

Various quality checks of the data were carried out before submission. The data from the ePRTR database was cleaned, processed and missing data was added. Then, the data was transferred into a suitable format (Excel template under LRTAP convention). Before the data could be transformed into the appropriate format for submission, several data preconditions were determined. Furthermore, data quality checks were performed. Below is a list of the quality checks that have been performed.

- Calculation of the sum of LPS emissions and comparison with the NFR tables
- Unit mistakes checks
- Outlier checks
- Verification of missing information in the data (such as ID’s, stack heights, GNFR, coordinates, etc.)
- Checking whether the coordinates are within Germany
- Checking whether there are duplicates in the coordinates

For example, all point sources identified as outliers in the box plots below were checked individually to be correct:





GNFR codes and stack heights

The ePRTR dataset includes most of the information needed for LPS reporting. However, both GNFR sectors and stack heights are not included. These point source meta data are instead derived from the PRTR activities given and by researching some important point sources individually. In general, GNFR membership and stack height class have been added according to Table 1 below (mainly based on the Environmental Research Plan of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety) [4)].

Table 1: **Stack heights and further information related to the GNFR sectors**

Activity code from ePRTR	ePRTR description	GNFR	Stack height class
1.a	Mineral oil and gas refineries	B_Industry	4
1.b	Installations for gasification and liquefaction	B_Industry	4
1.c	Thermal power stations and other combustion installations (>50 MW)	A_PublicPower	5
1.d	Coke ovens	B_Industry	5
1.e	Coal rolling mills	B_Industry	5
1.f	Installations for the manufacture of coal products and solid smokeless fuel	D_Fugitive	4
2	Production and processing of metals	B_Industry	5
2.a	Metal ore roasting or sintering installations	B_Industry	5
2.b	Installations for the production of pig iron or steel inc. continuous casting	B_Industry	5
2.c	Installations for the processing of ferrous metals	B_Industry	5
2.c.i	Installations for the processing of ferrous metals: (i) hot-rolling mills	B_Industry	5
2.c.ii	Installations for the production of pig iron or steel and processing of ferrous metals (hot-rolling mills and smitheries with hammers)	B_Industry	5
2.d	Ferrous metal foundries	B_Industry	2
2.e	Installations for non-ferrous metals	B_Industry	2
2.e.i	Installations for the production of non-ferrous crude metals from ore, concentrates or secondary raw materials by metallurgical, chemical or electrolytic processes	B_Industry	2
2.e.ii	Installations for the smelting, including the alloying, of non-ferrous metals, including recovered products (refining, foundry casting, etc.)	B_Industry	2
2.f	Installations for surface treatment of metals and plastic materials using an electrolytic or chemical process	B_Industry	1
3.a	Underground mining and related operations; Opencast mining and quarring	D_Fugitive	1
3.b	Opencast mining and quarrying	D_Fugitive	1
3.c	Installations for the production (see below)	B_Industry	2
3.c.i	Installations for the production of: (i) cement clinker in rotary kilns, (iii) cement clinker or lime in other furnaces	B_Industry	2

Activity code from ePRTR	ePRTR description	GNFR	Stack height class
3.c.ii	Installations for the production of: (ii) lime in rotary kilns, (iii) cement clinker or lime in other furnaces	B_Industry	2
3.c.iii	Installations for the production of: (i) cement clinker in rotary kilns, (iii) cement clinker or lime in other furnaces	B_Industry	2
3.d	Installations for the production of asbestos and the manufacture of asbestos-based products	B_Industry	2
3.e	Installations for the manufacture of glass, incl. glass fibre	B_Industry	2
3.f	Installations for melting mineral substances, incl. the production of mineral fibres	B_Industry	2
3.g	Installations for the manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain	B_Industry	2
4.a	Chemical installations for the production on an industrial scale of basic organic chemicals	B_Industry	1
4.a.i	Chemical installations for the production on an industrial scale of basic organic chemicals: simple hydrocarbons (linear or cyclic, saturated or unsaturated, aliphatic or aromatic)	B_Industry	1
4.a.ii	Chemical installations for the production on an industrial scale of basic organic chemicals: oxygen-containing hydrocarbons	B_Industry	1
4.a.iii	Chemical installations for the production on an industrial scale of basic organic chemicals: sulphurous hydrocarbons	B_Industry	1
4.a.iv	Chemical installations for the production on an industrial scale of basic organic chemicals: nitrogenous hydrocarbons	B_Industry	1
4.a.ix	Chemical installations for the production on an industrial scale of basic organic chemicals: synthetic rubbers	B_Industry	1
4.a.vi	Chemical installations for the production on an industrial scale of basic organic chemicals: halogenic hydrocarbons	B_Industry	1
4.a.vii	Chemical installations for the production on an industrial scale of basic organic chemicals: organometallic compounds	B_Industry	1
4.a.viii	Chemical installations for the production on an industrial scale of basic organic chemicals: basic plastic material (polymers, syntetic fibers and cellulose-based fibers)	B_Industry	1
4.a.x	Chemical installations for the production on an industrial scale of basic organic chemicals: dyes and pigments	B_Industry	1
4.a.xi	Chemical installations for the production on an industrial scale of basic organic chemicals: surface-active agents and surfactants	B_Industry	1
4.b	Chemical installations for the production on an industrial scale of basic inorganic chemicals	B_Industry	1
4.b.i	Chemical installations for the production on an industrial scale of basic inorganic chemicals: gases	B_Industry	1
4.b.ii	Chemical installations for the production on an industrial scale of basic inorganic chemicals: acids	B_Industry	1
4.b.iii	Chemical installations for the production on an industrial scale of basic inorganic chemicals: bases	B_Industry	1
4.b.iv	Chemical installations for the production on an industrial scale of basic inorganic chemicals: salts	B_Industry	1
4.b.v	Chemical installations for the production on an industrial scale of basic inorganic chemicals: non-metals, metal-oxides or other inorganic compounds	B_Industry	1
4.c	Chemical installations for the production on an industrial scale of fertilisers	B_Industry	1
4.d	Installations using a chemical or biological process for the production on an industrial scale of basic plant health products and of biocides	B_Industry	1
4.e	Installations using a chemical or biological process for the production on an industrial scale of basic pharmaceutical products	B_Industry	1
4.f	Installations for the production on an industrial scale of explosives and pyrotechnic products	B_Industry	1
5.a	Installations for the disposal or recovery of hazardous waste	J_Waste	3
5.b	Installations for the incineration of non-hazardous waste	J_Waste	2
5.c	Installations for the disposal of non-hazardous waste	J_Waste	1
5.d	Landfills	J_Waste	1
5.e	Installations for the disposal or recycling of animal carcasses and animal waste	J_Waste	2

Activity code from ePRTR	ePRTR description	GNFR	Stack height class
5.f	Urban waste-water treatment plants	J_Waste	1
5.g	Independently operated industrial wastewater treatment plants	J_Waste	1
6	Paper and wood producing plants	B_Industry	2
6.a	Industrial plants for the production of pulp from timber or similar fibrous materials	B_Industry	2
6.b	Industrial plants for the production of paper and board and other primary wood products	B_Industry	2
6.c	Industrial plants for the preservation of wood and wood products with chemicals	E_Solvents	2
7.a	Installations for the intensive rearing of poultry or pigs	K_AgriLivestock	1
7.a.i	Installations for the intensive rearing of poultry or pigs: with 40 000 places for poultry	K_AgriLivestock	1
7.a.ii	Installations for the intensive rearing of poultry or pigs: with 2 000 places for production pigs (over 30 kg)	K_AgriLivestock	1
7.a.iii	Installations for the intensive rearing of poultry or pigs: with 750 places for sows	K_AgriLivestock	1
8.a	Slaughterhouses	B_Industry	1
8.b	Treatment and processing intended for the production of food and beverage products	B_Industry	1
8.b.i	Treatment and processesing intended for the production of food and beverage products from: animal raw materials other than milk	B_Industry	1
8.b.ii	Treatment and processesing intended for the production of food and beverage products from: vegetable raw materials	B_Industry	1
8.c	Treatment and processing of milk	B_Industry	1
9.a	Plants for the pre-treatment (operations such as washing, bleaching, mercerisation) or dyeing of fibres or textiles	E_Solvents	1
9.b	Plants for the tanning of hides and skins	E_Solvents	1
9.c	Installations for the surface treatment of substances, objects or products using organic solvents	E_Solvents	1
9.d	Installations for the production of carbon (hard-burnt coal) or electrographite by means of incineration or graphitisation	B_Industry	2
9.e	Installations for the building of, and painting or removal of paint from ships	E_Solvents	1

References

[1)] Pollutants of the PRTR - Situation in Germany - Reporting years 2007 - 2022, Umweltbundesamt, 2024 External Link
[2), 3), 4)] Analyse der novellierten NEC-Richtlinie bezüglich der erweiterten Anforderungen an die Berichterstattung von Schadstoffemissionen in die Luft - Umweltforschungsplan des Bundesministeriums für Umwelt, Naturschutz, Bau und Reaktorsicherheit, im Auftrag des Umweltbundesamtes, 2019 External Link

CHAPTER 11.2: Gridded Data

Information on the spatial distribution of emissions is important to answer a number of questions in the field of air quality monitoring. Emission data is used to model the dispersion of air pollutants or to visualize the structure of the spatial distribution of emissions. These models show if abatement strategies were successful. For this reason, an ESRI ArcGIS based software has been developed which allows the UBA, independently and on the basis of information generally available, to regularly generate regionalized emission datasets for the complete area of the Federal Republic of Germany.

The following pollutants are currently considered: NO_x, NH_3, SO_2, CO, NMVOC, particles ($PM_{2.5}$, PM_{10},TSP, and BC) and Heavy Metals (HM), POPs (PAHs, HCB, PCBs, PCDD/F - dioxins/furans).

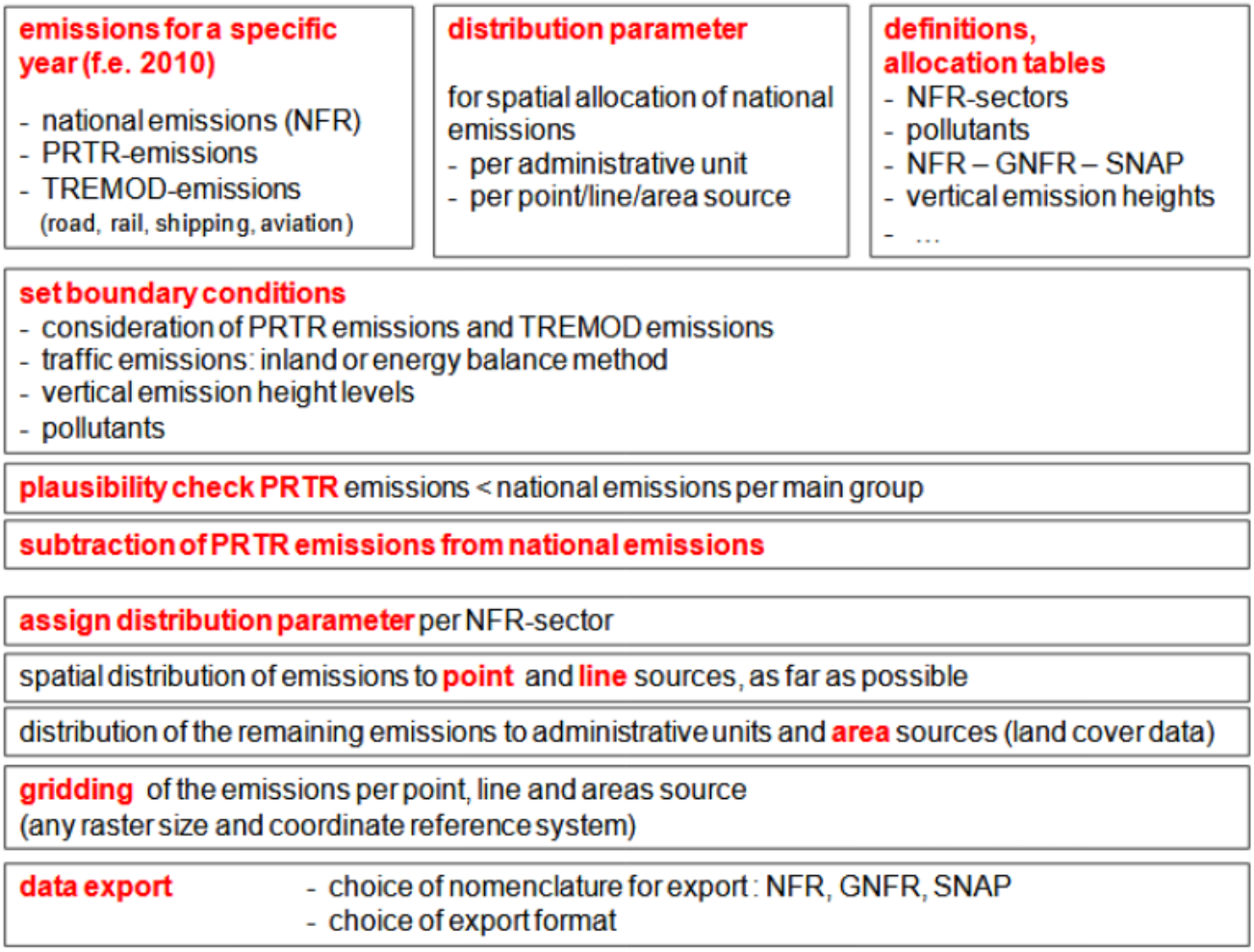
Methodology

- The Gridding Emission Tool for ArcGIS (GRETA) contains a complete set of the required data per base year. This includes emissions, distribution parameters, geometric datasets as well as the necessary definitions and allocation tables.
- The emission data could be distributed using the energy-balanced principle (fuel sold) or inland principle (fuel used). The energy-balanced principle (fuel sold) is used for the official reporting of spatial distributed emissions for Germany.
- The geometric and statistical data, which is used for the spatial distribution, is available for different base years (1990–2023). For example, the traffic network and annual mileage data is updated in a 5-year cycle. Land use / land cover datasets (CORINE Land Cover) are used for different reference years. From 2000 onwards, information about point sources is available from the German PRTR or the EPER. For the earlier years 1990 and 1995, information from point sources was transferred from EPER data of the year 2001 and their emissions were scaled accordingly.
- For each NFR sector, the spatial distribution of the national emissions is determined using distribution parameters, and if possible, as point sources (PQ) and line sources (LQ). The remaining emissions are spatially assigned to distribution parameters on district level and further, considering land cover data, on area level (FQ).

The calculation can be carried out for different arbitrary grid widths and different coordinate reference systems. In Greta, only the national totals are currently distributed. The memo items are not considered yet.

The software and methodology is documented in detail and complies with high standards as to its flexibility and extensibility (see detailed description Gridding Tool). The following description is taken from the summary of the report “ArcGIS basierte Lösung zur detaillierten, deutschlandweiten Verteilung (Gridding) nationaler Emissionsjahreswerte auf Basis des Inventars zur Emissionsberichterstattung”. p.224 presented by Schneider et al. in 2016 [1)]

Figure 3: **Overview of the method for spatial distribution of national emissions**



Significant factors for spatial distribution of national emissions are the so-called distribution parameters. These are characterized in the context of the Gridding Tool as follows:

- A distribution parameter represents a function that fully distributes a total number of emissions (e.g. national emissions Germany) to a specific amount of regional objects.
- The spatial distribution of national emissions is being performed per NFR sector;
- More complex distribution parameters distribute the emissions, for example, to different spatial object classes or by considering a further differentiation of the total emissions.
- For each NFR sector emissions are spatially distributed over one or more distribution parameters. For this purpose it has to be determined which part of the emissions is to be distributed over which distribution parameter.

Distribution parameters are used for allocation of national emissions, spatially as accurately as possible, to individual point, line or area sources depending on the source group. The location of a point source is given clearly by coordinates; typical line sources are, for example, streets, which can consist of many sections. As surface sources such areas are defined in which from many small sources emissions are released, for example, emissions from small combustion plants in built-up areas. A substantial database for distribution of national emissions in the sectors ‘energy supply’ and ‘industry’ are the emissions of individual sites or plants from the PRTR database. In addition, for example, also emissions of air traffic are allocated to point sources by location of the airports, whereas in the case of larger airports an additional local distribution is considered. Emissions from road traffic, rail traffic and inland water navigation are spatially assigned to line sources. The respective route networks consist of individual sections. To each of these network segments (line source) a share of the national emissions is assigned.

The spatial distribution of the emissions that are not distributed to point sources or line sources, is carried out in two steps on area sources. In the first step, these emissions are distributed by means of suitable distribution parameters to the district level.In the second step a more accurate spatial allocation of emissions using land cover data is carried out within the districts. Per NFR sector the areas of the relevant land use classes are chosen and only to these areas emissions are allocated.

Here, emphasis can also be placed on different CLC groups, e. g. the land-cover class ‘residential areas’ could get a higher rating than land-cover class ‘residential areas loose’. As a result, the previously at district level distributed national

emissions are now spatially localized to the relevant land-cover areas within the districts.Aim of the spatial distribution of emissions is the compilation of emissions in a defined grid. For this, the emissions, spatially distributed to individual point, line and area sources, are assigned to the grid cells of the selected grid in a further step. After determination of the coordinate reference system and grid size of the raster, the share of each emission source (point / line / area source) per grid cell is determined. The summation of the emissions of all source shares lying within a grid cell leads to the total of emissions of the grid cell. The spatial distribution of emissions is not only limited to horizontal distribution, but also includes distribution to vertical height levels. Therefore, it was necessary to assign to each source category or to each NFR sector an average characteristic emission height above ground.



For further description of the distribution parameters, please refer to

distribution parameters

Further and more recent Greta improvements are described in additional reports (German only): Pelzer et al. (2018)[2)], Pelzer et al. (2021)[3)], and Pelzer et al. (2024)[4)].

Distribution Parameters

Determination of Distribution Parameters

The PRTR database of UBA (PRTR = Pollutant Release and Transfer Register; Thru.de) represents an important data source for the spatial distribution of national emissions. The emissions contained in this database are on hand as point source emissions and are considered as such for the spatial allocation in the Gridding Tool. Furthermore, it was established in agreement with the UBA that the data of the digital landscape models Germany of the Federal Agency of Cartography and Geodesy (BKG) are used as essential data sources. In detail, these are as follows:

- administrative boundaries (district boundaries, municipal boundaries)
- road network
- streaming water network
- rail network
- location of airports
- land-cover differentiated by classes.

As another relevant data source for spatial allocation of emissions that are not assigned by point or line sources, the Corine Land Cover (CLC) data set was stipulated. These data are differentiated in 43 land cover classes. For the usage within the scope of the Gridding Tool these have been merged to 6 CLC groups. Apart from these essential geometric base data sets, further information and data were used for deriving the final distribution parameters. These are, for example, data at district level as to the number of inhabitants or number of employees per business division. The aim was to use per NFR sector those data on the spatial distribution that reflect well the spatial structure of the emission distribution. This also includes typical (effective) vertical heights of sources per NFR sector.

Source categories

Energy and Industry

For the Gridding Tool a methodology has been developed considering PRTR emissions in the spatial distribution of national emissions. Here, the PRTR emissions are first subtracted at a national level from the national emissions. The share of emissions, which is covered by the PRTR emissions, is spatially assigned by the location of PRTR point sources. To avoid negative national residual emissions, this calculation must be made on an aggregated level. For this, the following main groups were defined:

- main group A (energy sector PRTR 1)
- main group B (industrial sectors, PRTR sectors 2,3,4,5,6,8,9)
- main group C (intensive livestock production and aquaculture, PRTR industry 7).

The NFR sectors for which part of the emissions are spatially allocated by means of the PRTR point sources belong to the source groups of energy supply, industry, agriculture and sewage / waste disposal. For the hereby affected NFR sectors, the national (residual) emissions are distributed in a first step by suitable distribution parameters on district level. The distribution parameters are predominantly based on statistical data on numbers of employees in the various sectors and departments of industry. Within the districts, the emissions are distributed via land cover class CLC121 (Industrial and Commercial Units) to the level of area sources.

Other Non-industrial Combustion Plants

The emissions from non-industrial combustion plants (private households, other small consumers, military, agriculture, etc.) are completely spatially distributed over area sources. For this source group, distribution parameters are mainly based on statistical data at district level. The spatial distribution of emissions from small combustion plants of households was carried out via a more complex distribution function since the national emissions are differentiated into the four sub-categories of oil, gas, wood and other solid fuel combustion plants. Then the emissions per energy source are distributed using different distribution parameters to the district respectively community levels. Within the districts (for wood firing within the communities) emissions are again distributed over the relevant CLC classes to the level of the area sources.

Traffic or Transport

For the traffic or transport sector (road, rail, shipping, aviation), at UBA emissions are being determined by means of the TREMOD model. These data are available in a more differentiated way than they are shown per NFR sector in national emissions. Therefore, suitable additional information from TREMOD for the spatial distribution is considered in the Gridding Tool.

For the spatial distribution of national emissions of aviation, in addition to the national totals, additional TREMOD emission data for the 26 largest German airports are available. These emissions are spatially allocated directly to their position. For the remaining smaller airports, airfields and landing sites in Germany, the national residual emissions from aviation, which are not listed in the TREMOD data separately for each airport, are spatially distributed over the number of flight movements per airport. The location of airports is known as a point source. In addition, for the 15 largest (international) airports in Germany the landing and departure sectors were digitized as funnel-shaped three-dimensional sources. This allows a much differentiated spatial distribution of the emissions to local (three-dimensional) sources for these airports.

Emissions of the source group Road Traffic are composed of exhaust emissions, emissions from abrasion (tires, brakes, roads) and emissions due to fuel evaporation. The exhaust and abrasive emissions from road traffic are fully distributed over line sources, since a digital geometric data basis exists for all roads. The distribution parameter for spatial distribution of emissions is derived from data on mileage per route section. For this purpose, data was processed from different data sources. The evaporative emissions are spatially distributed over area sources to the built-up areas.

For rail traffic, emissions resulting from both the operation of diesel engines as well as the abrasion caused by both electrically and diesel-powered trains are taken into account. The distribution of these emissions is carried out entirely on line sources based on the rail network with the section-related emissions of the DB Umwelt AGsignificant being an important data base for the derivation of the distribution parameters.

As described for railways, emissions from national navigation (shipping) are completely spatially distributed on line sources, too. For this purpose, the digital routing network of watercourses as well as the distribution parameters derived from emission data from TREMOD are being applied.

Offroad / Mobile Machinery

This source group includes emissions released by off-road vehicles and mobile machinery (e.g. in the building and construction industry, forestry and agriculture) and by the use of mobile devices and machines in households. Emissions from these sources are allocated as area sources completely. The distribution parameters are mainly based on statistical data at district level.

Solvents and other Product Use

Emissions that are released by application of solvent-based and other products in the private sector as well as in industrial and other sectors, are fully distributed as area sources. The distribution parameters are predominantly based on statistical

data at district level, e.g. employees in economic departments of G-U (Trade and Services) or inhabitants.

Agriculture

Emissions from agriculture consist of the emissions arising from animal husbandry (e.g. cows, pigsetc.), and emissions that occur during agricultural activity on arable land and pastures.

An important data source for spatial distribution is the data of the Thünen Institute, which annually determines the emissions from agriculture at district level for Germany. In addition, emissions from stables that underlay reporting obligations are reported in the PRTR database. They only cover a small proportion of national emissions in agriculture. Therefore, a synthetic stable point source dataset was derived from the German Land Cover dataset (LBM-DE) to distribute the stable (and storage) emissions directly to the stables as point source (PQ). In the past these emissions were distributed to agricultural areas (FQ). To derive the distribution parameters used in the Gridding Tool for the affected NFR sectors, the data of the Thünen Institute, from the PRTR database and synthetic stable point source dataset were considered.

Other NFR Sectors

There are some more NFR sectors, e.g. 1.A.4.c iii (national fishing), 1.B.2a v (distribution of oil products) and 1.A.3.e i (pipeline compressors), which do not belong to the source groups already described. The distribution parameters for these sectors are based on different data; emissions are predominantly spatially distributed as area sources.

Recalculations / Improvements

The Gridding tool GRETA is constantly being further developed.

- Update of base years (PRTR, emission data, statistical data, etc.),
- QA/QC procedures,
- Distribution of new pollutants TSP, BC, HM, POP (PAH, HCB, PCB, PCDD/PCDF (dioxins/ furans),
- Using synthetic stable point sources (derived from national land cover data) to distribute stable (and storage) emissions to point sources,
- For the earlier years 1990 and 1995, information from point sources was transferred from EPER data of the year 2001 and their emissions were scaled accordingly.

Results with the EMEP grid

The results are available via the Central Data Repository CDR maintained by the EEA/EIONET. In 2019, the calculation tools for the gridding data were updated. In 2025, new data were stored on the CDR for the years 1990, 1995, 2000, 2005, 2010, 2015, 2019 and 2023.

The spatial resolution of reported emissions changed from a 50 x 50 km^2 EMEP to a 0.1° × 0.1° long-lat grid in a geographic coordinate system (WGS84). The change should improve the monitoring quality. The new EMEP domain covers the geographic area between 30°N-82°N latitude and 30°W-90°E longitude. More information about the grid development is available under EMEP grid.

In 2025, the EMEP grid, covering only the landmass of Germany, was extended to cover the domain of the baltic and north sea where emissions of the sector national navigation (1.A.3.d ii) are reported.

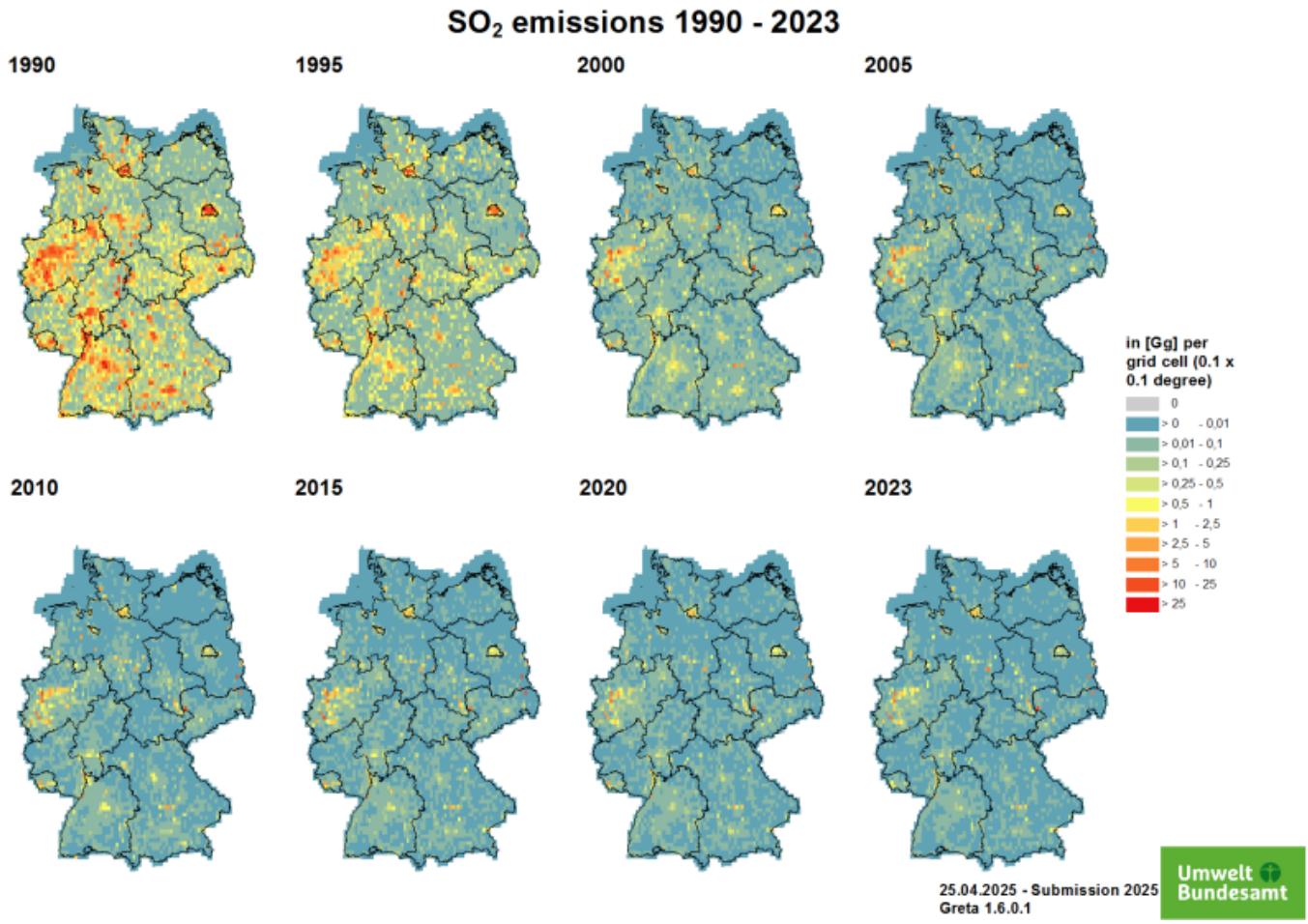
Maps

Acidification, eutrophication and Ground-level Ozone pollutants: Sulphur (SO2), nitrogen oxides (NOx), carbon monoxide (CO), ammonia (NH3) and volatile organic compounds (VOCs).

The significant emission reduction history can be visualized with the following grid maps for the years 1990, 1995, 2000, 2005, 2010, 2015, 2019 and 2023. From 2000 onwards, information about point sources is available from the German PRTR or the EPER. For the earlier years 1990 and 1995, information from point sources were transferred from EPER data of the

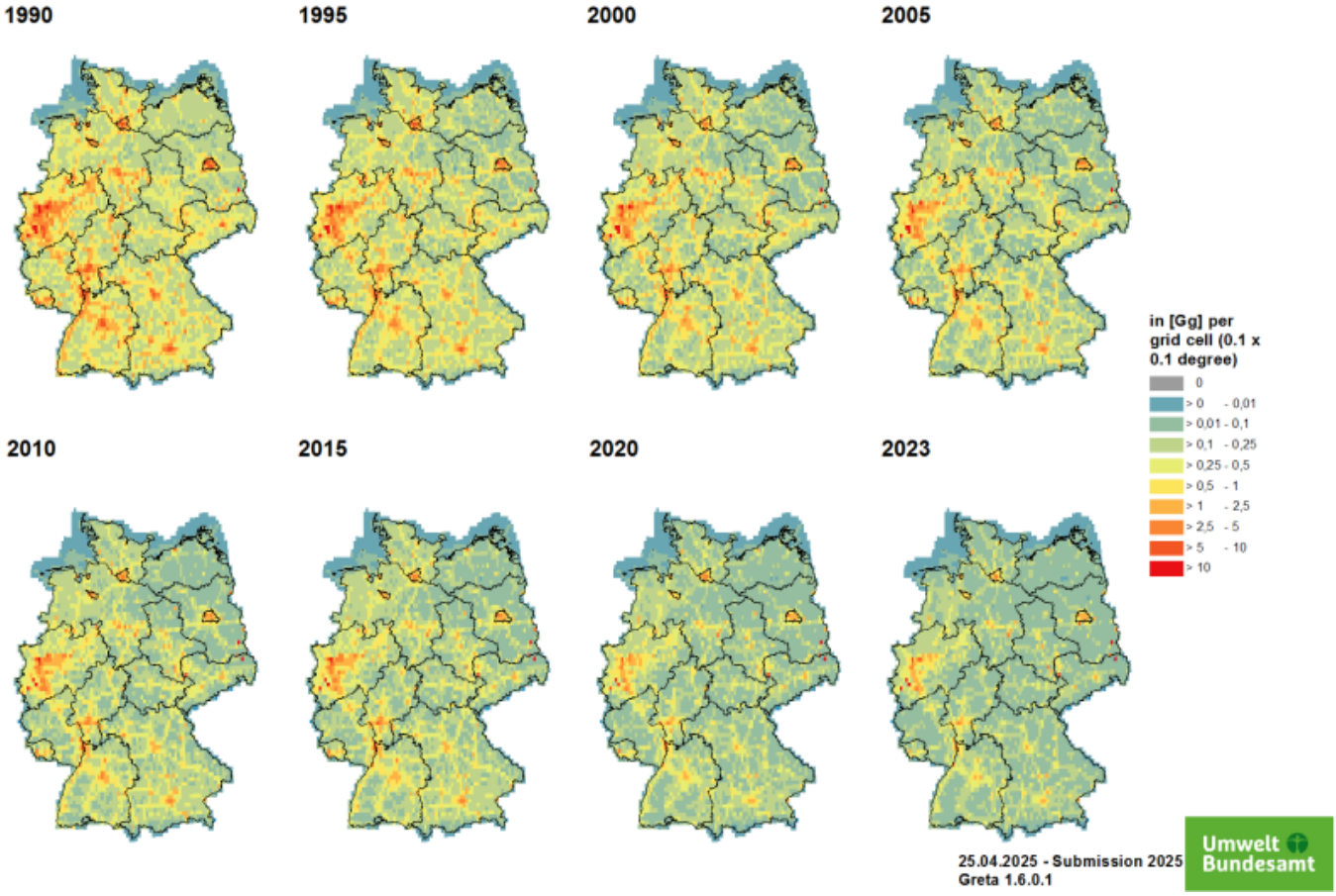
year 2001 and their emissions were scaled accordingly. By presenting the spatial distribution of emissions, the emission hotspots can be precisely identified for all pollutants. In general, these are located in the German cities (e.g. Berlin, Munich or Hamburg) or the conurbations (district of the Rhine-Ruhr area).

The reduction measures of SO_2 emissions are a success story in itself. In the early 1970s, the use of flue gas desulphurization plants in coal-fired power plants and later brown coal power plants led to a significant SO_2 decrease in the air. Since the 1990s, this reduction process has been further advanced by the use of low-sulfur fuels, so that today only a few areas are contaminated with SO_2.

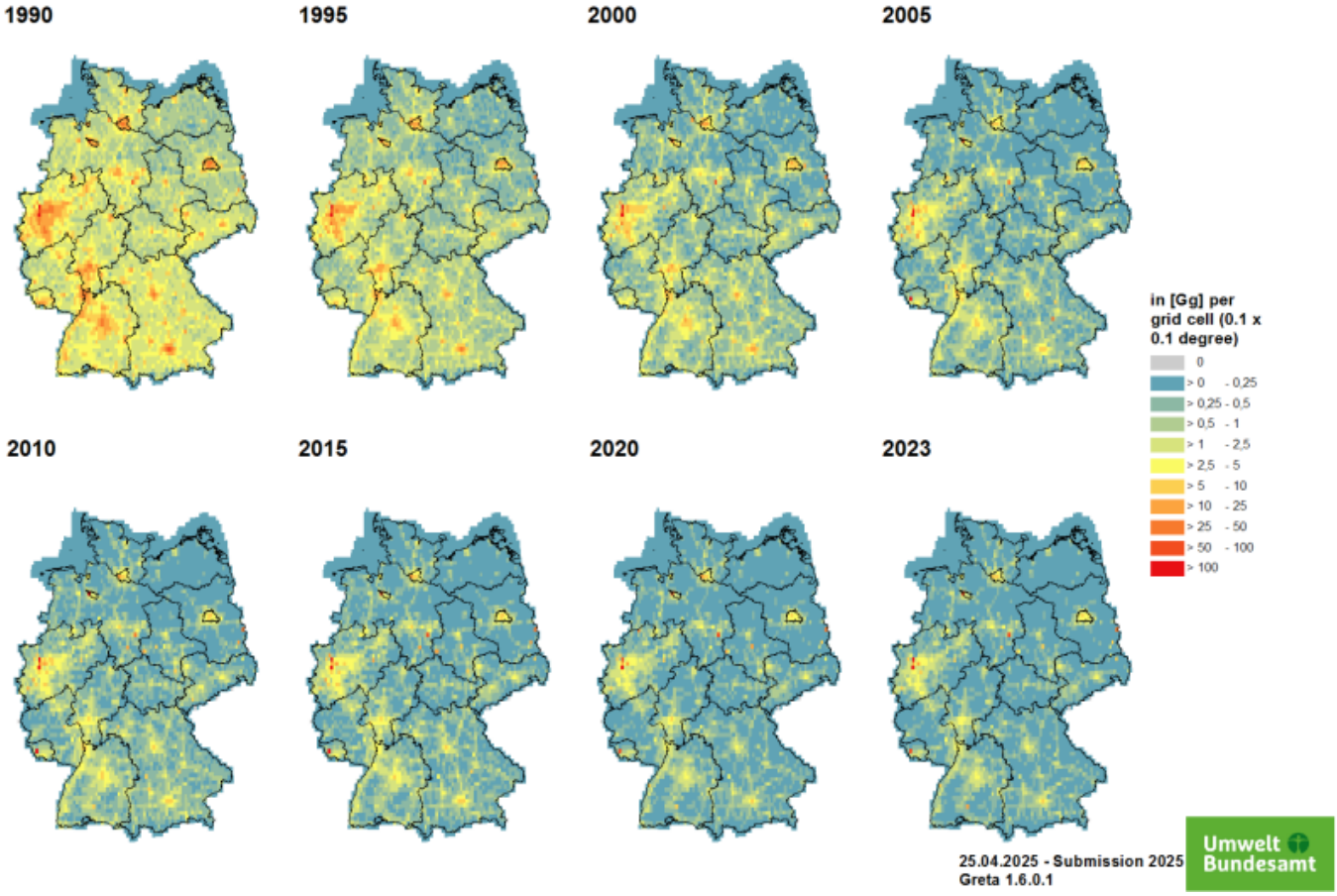


NO_x and CO emissions are not only generated in the energy but also in the transport sector. This is easily recognisable from the motorway structure.

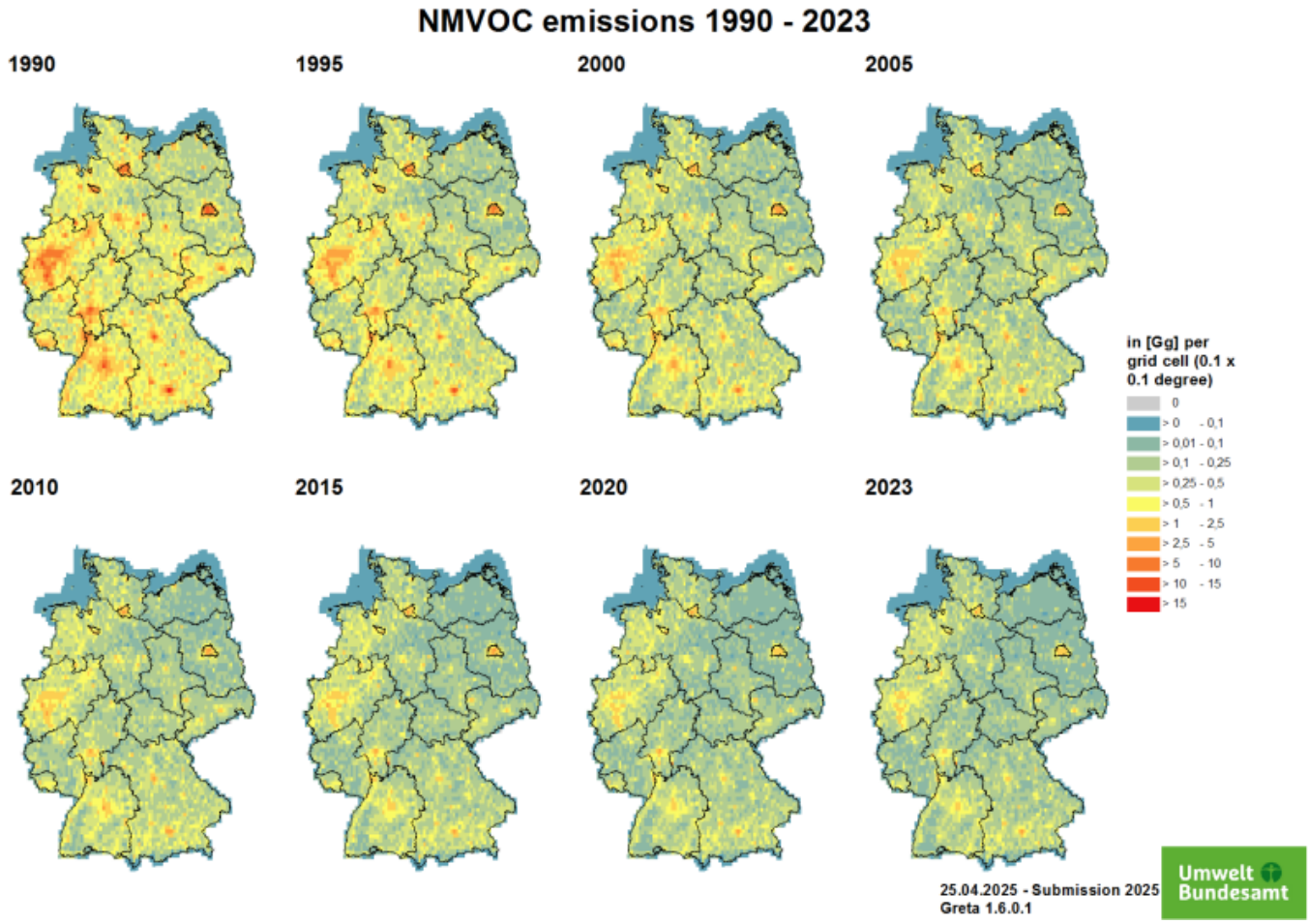
NO_X emissions 1990 - 2023



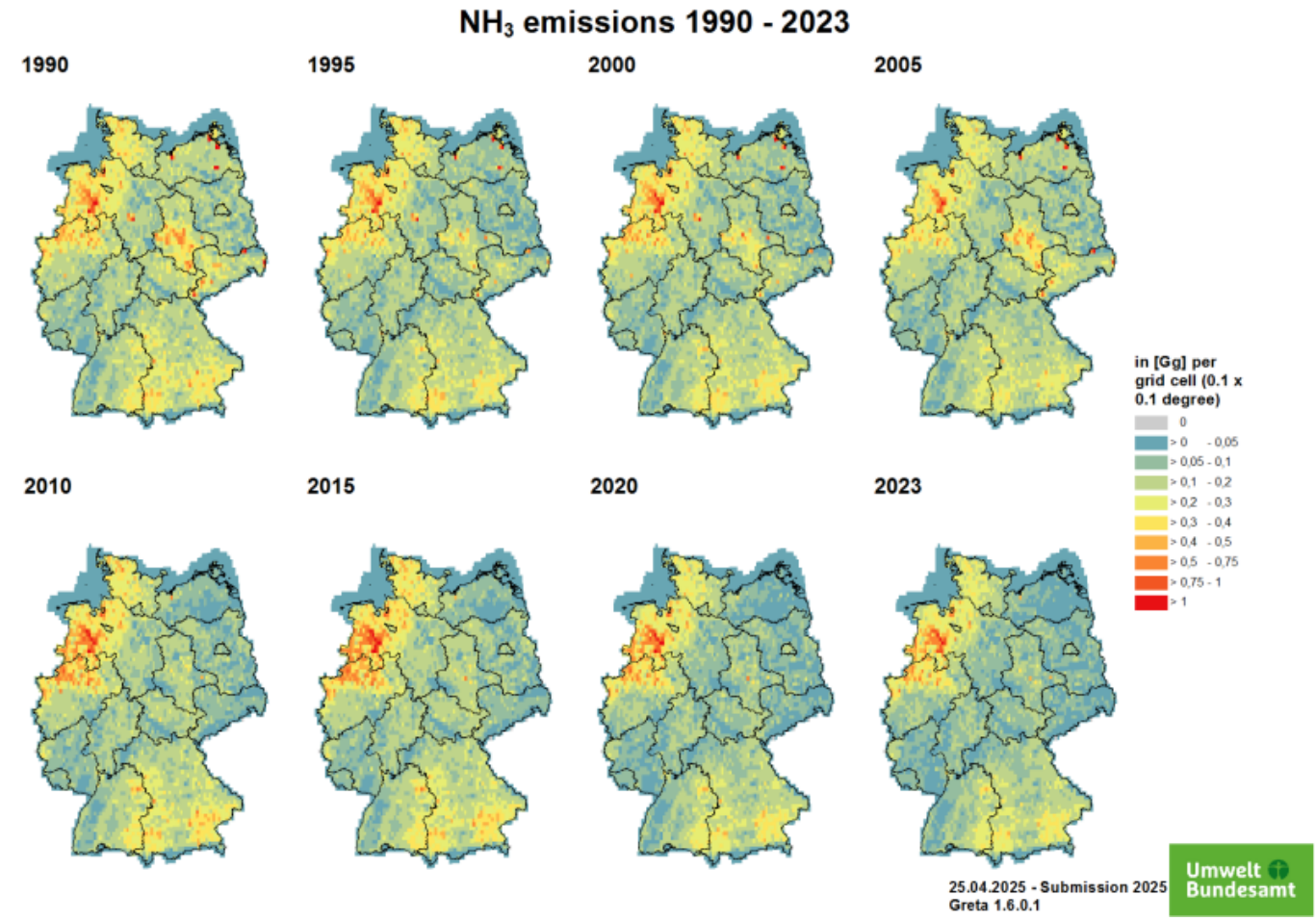
CO emissions 1990 - 2023



The main emitters of NMVOC are the industrial process sector and agriculture. The latter is mainly assigned to area and not to point sources.

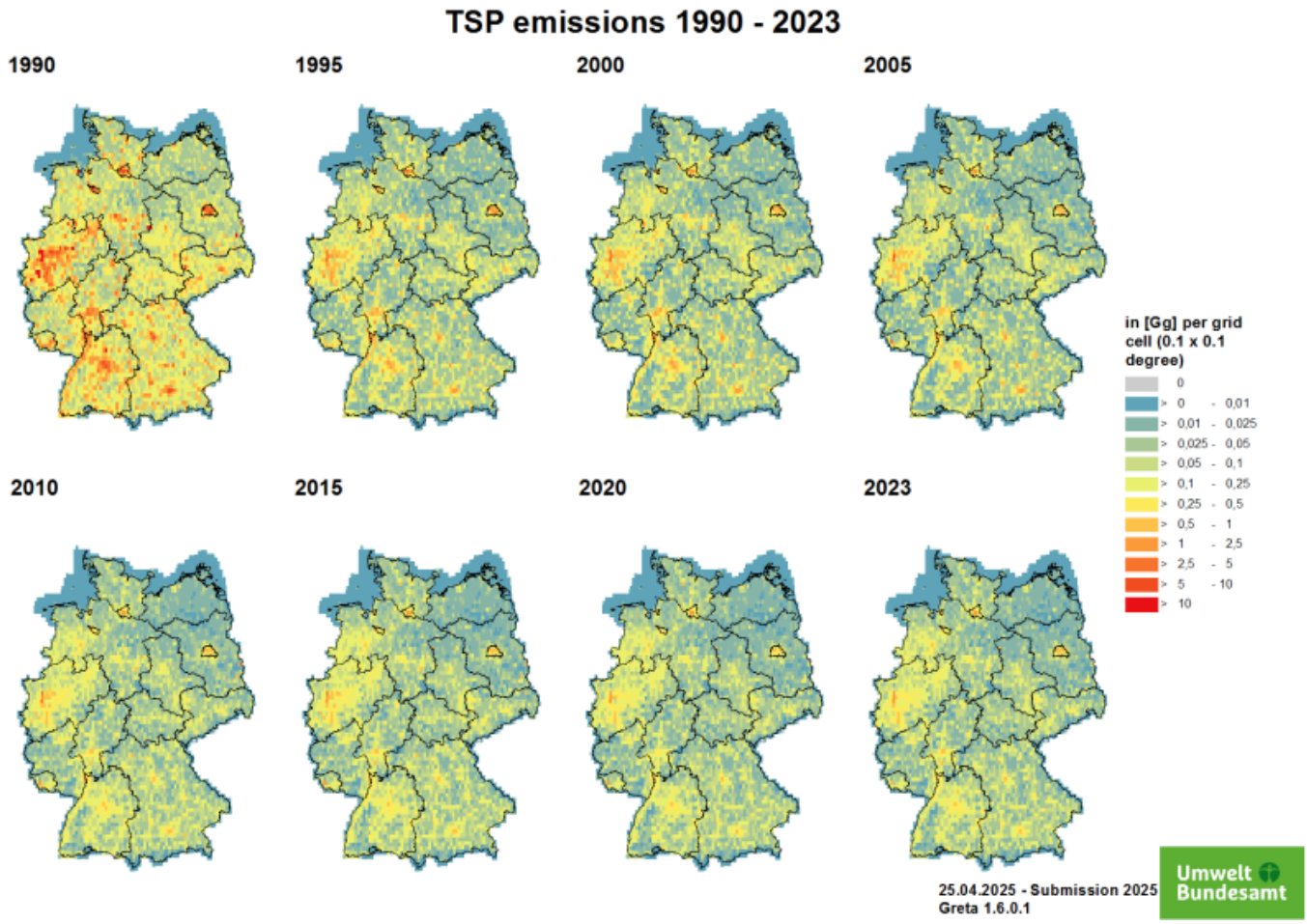


Compared to the above mentioned air pollutants, drastic reduction of ammonia emissions did not occur in the last decades and abatement measures are still a political issue. The highest ammonia emissions occur in rural areas, especially in the north-west of Germany. The emissions from intensive livestock farming (point sources) are clearly visible in the graphics.

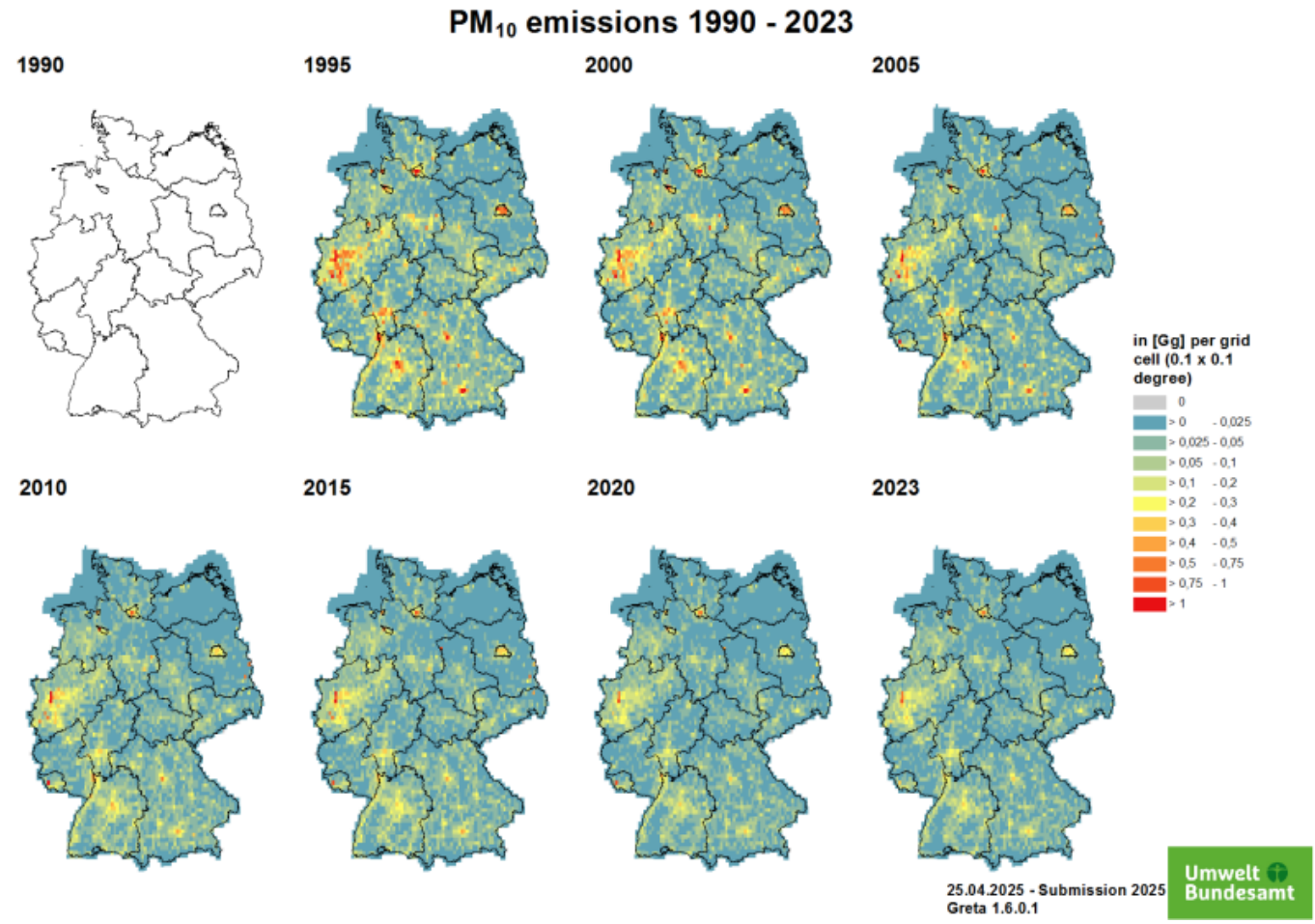


Particle and Fine Particle Emissions

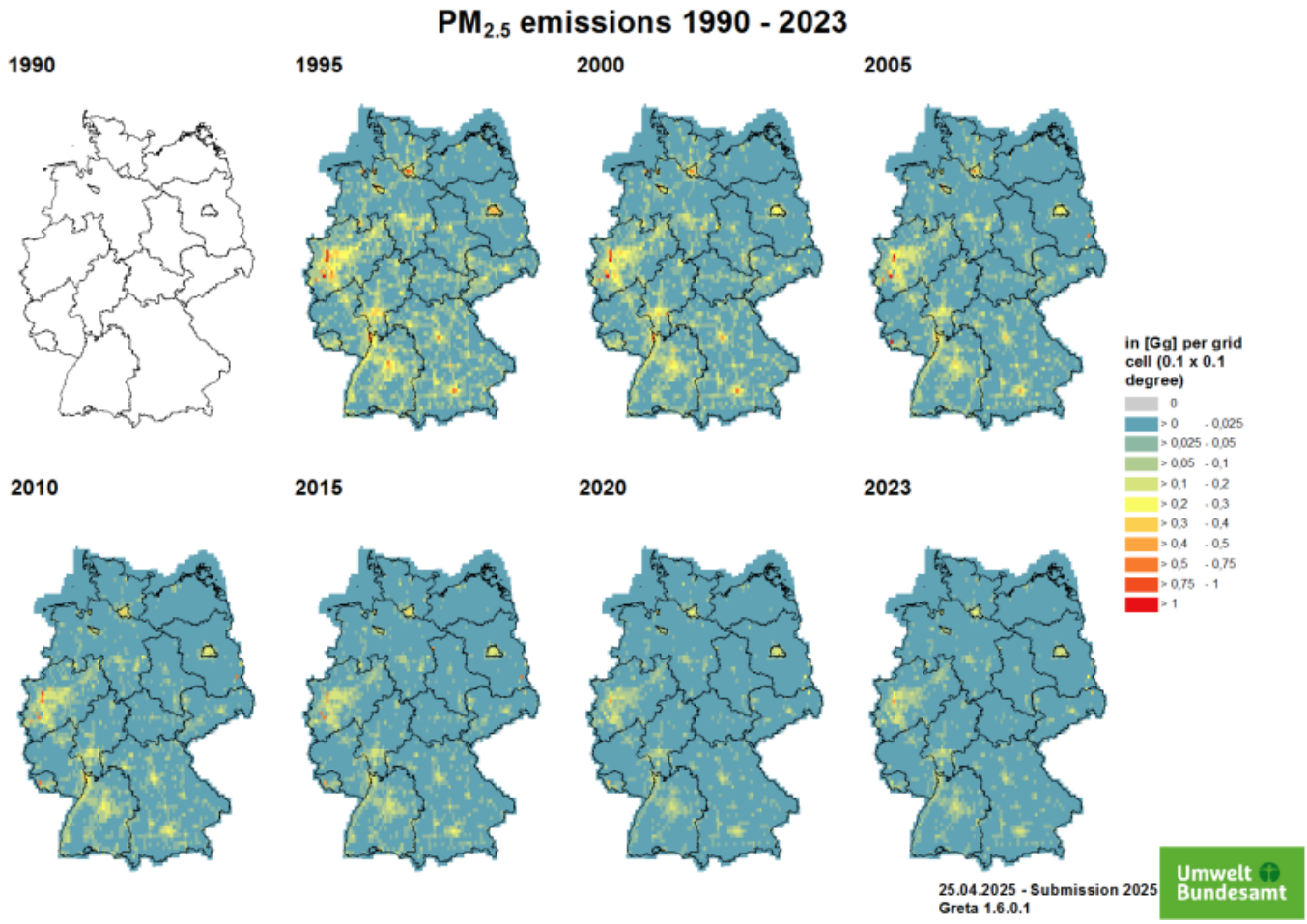
Corresponding to the SO_2 emissions, total suspended particles (TSP) in general could be reduced by additional built-in filters in power plants as well as in vehicles.



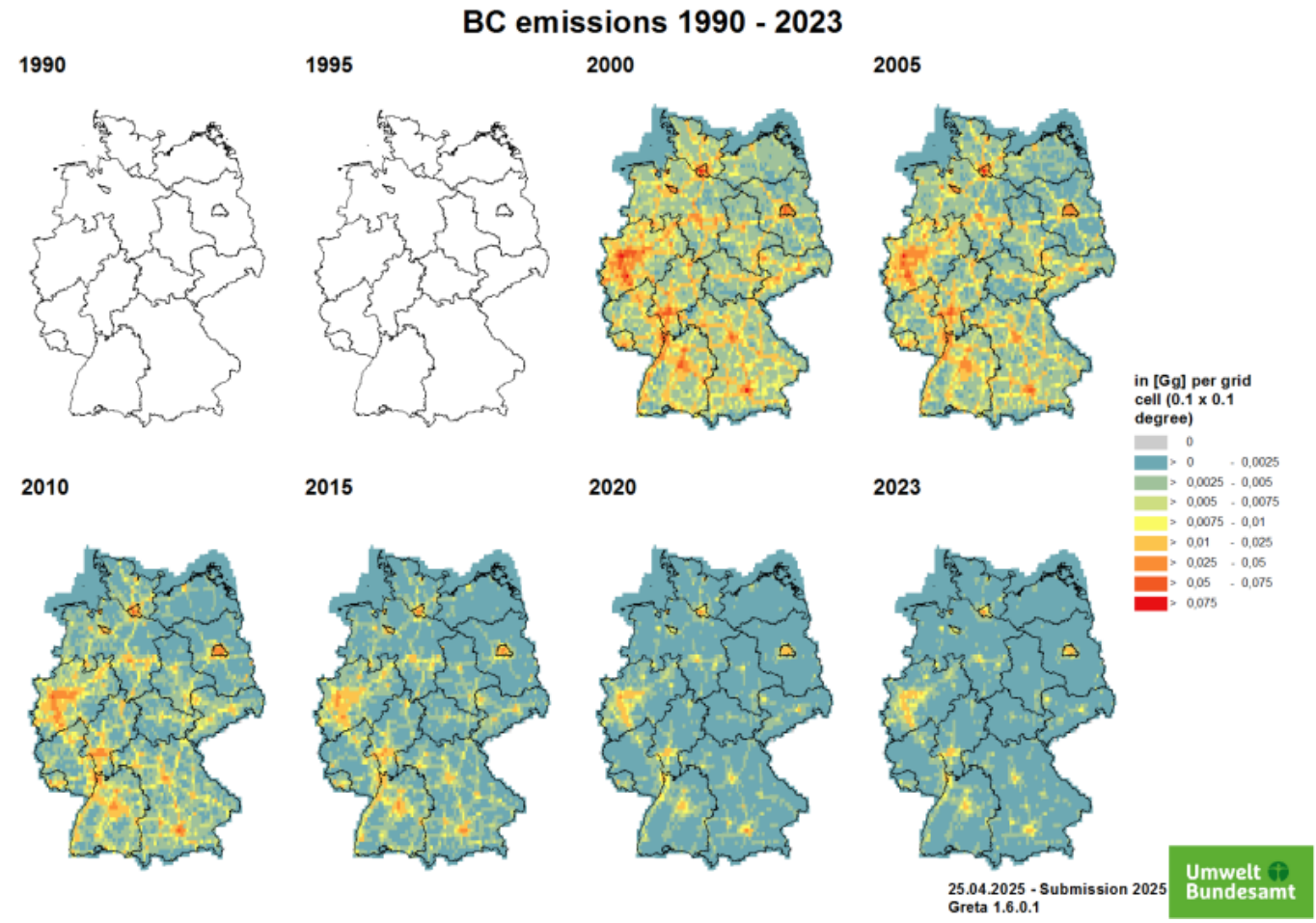
With a decision of the Member States in 2006, PM_{10}, $PM_{2.5}$ and Black Carbon emissions for the years before 2000 are not mandatory in the reporting. In the 1990s, the sampling and analysis of particulate matter differed widely and a comparability was therefore not given. For this reason, the data was only scaled back to 1995.



For $PM_{2.5}$ and TSP, the point source emissions are calculated using the emission ratio between PM_{10} and TSP / $PM_{2.5}$ sector by sector.



In addition to the other particle emissions, the black carbon emissions were also spatially distributed.

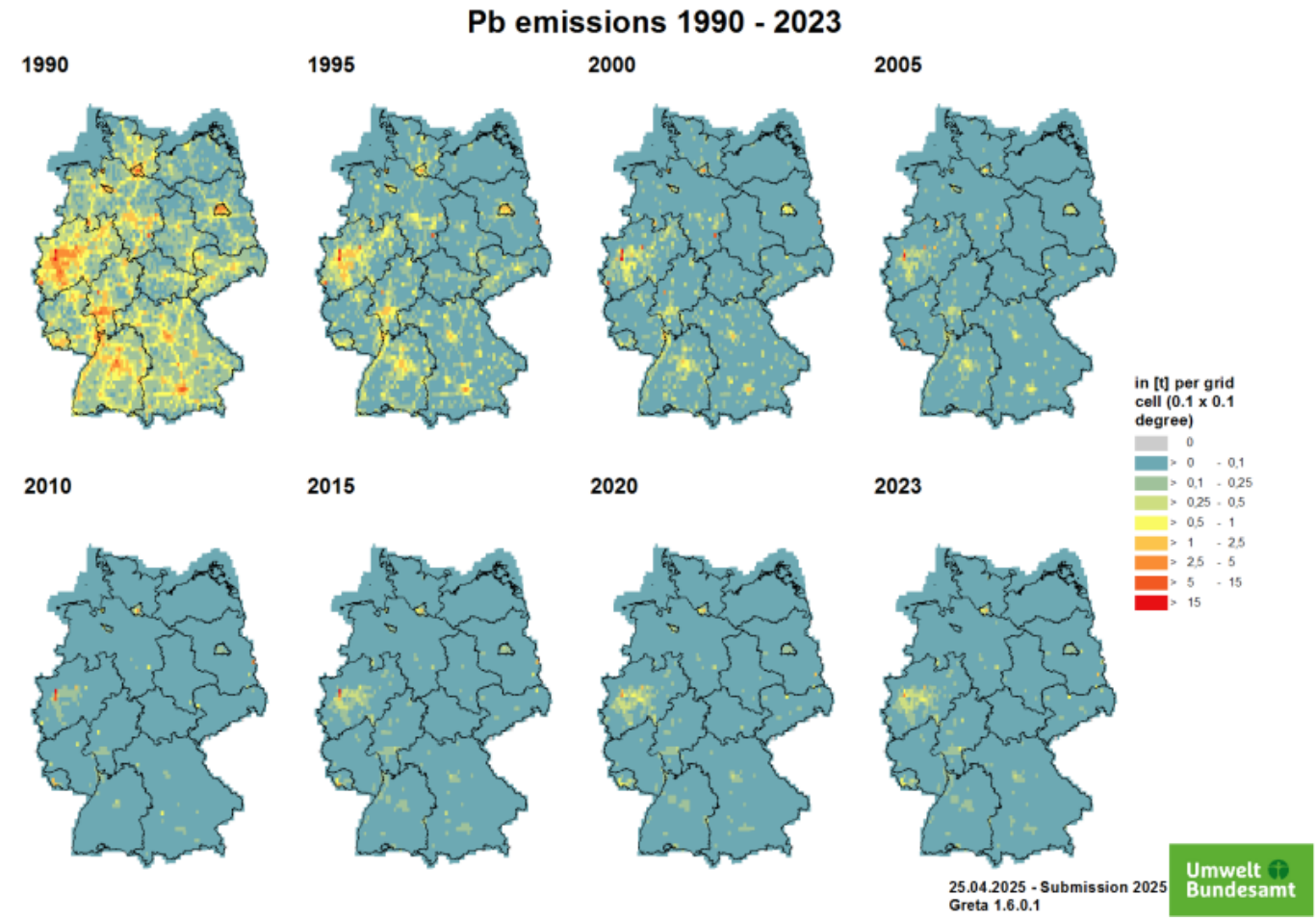


Emissions of Heavy Metals (HM)

Lead Emissions

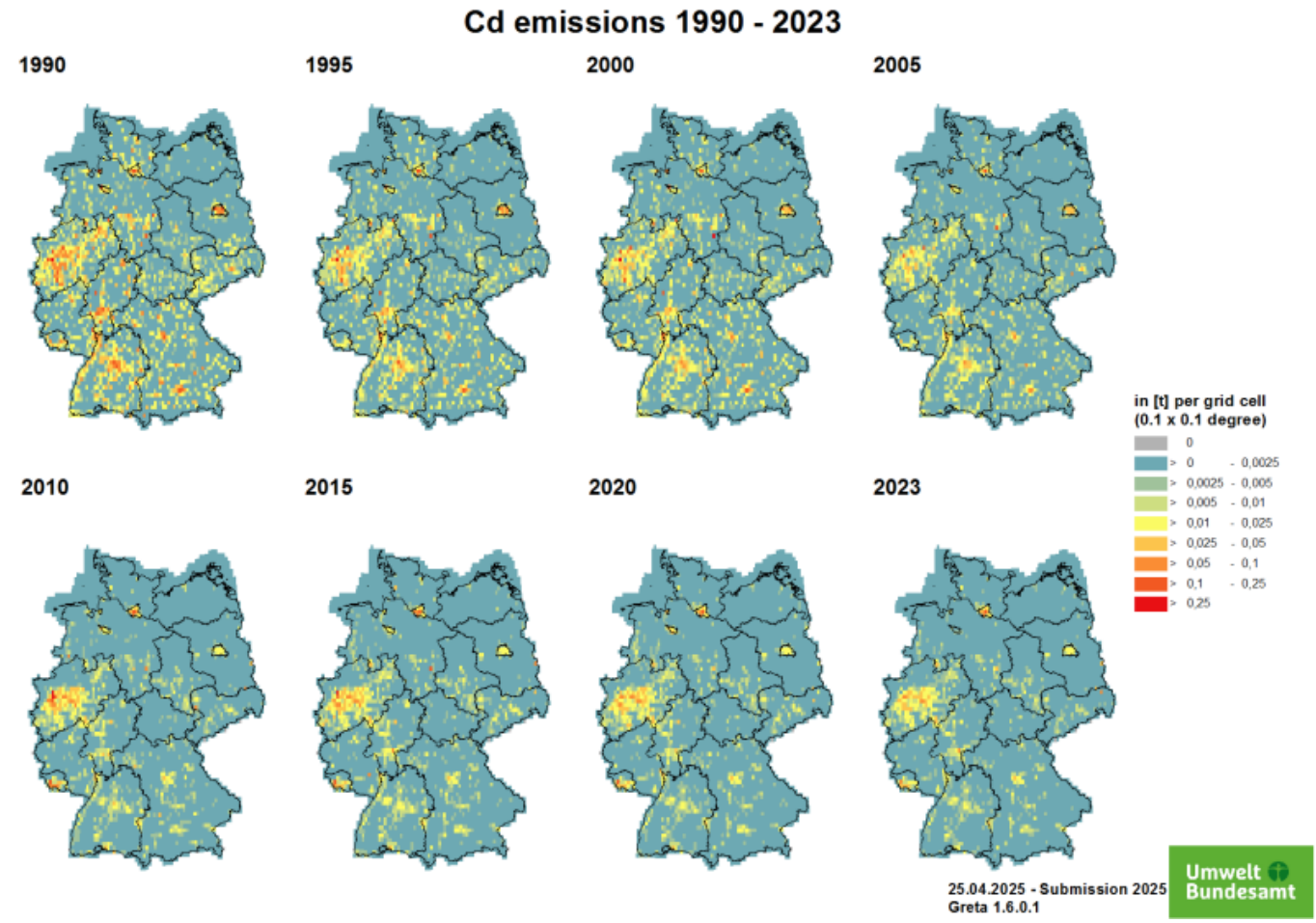
Lead (Pb)-containing compounds are released in particular during combustion processes of coal and fuels. The main emitter here is the transport sector. Due to the toxic effect of these lead aerosols, leaded regular petrol (additive with lead tetraethyl) was banned in West Germany as early as 1988, the ban on leaded premium petrol followed in 1996. The European Union banned leaded petrol on 1 January 2000. Today, part of the Pb emissions still come from the automobile tyre and brake wear sector. This trend can be easily seen in the maps. The distribution parameter is analogous to road exhaust (NFR 1.A.3.b i-iv), the distribution parameter is vehicle mileage.

Another source of emissions is the metal processing industry - iron and steel. The distribution parameter is partially covered by the PRTR point sources; rest: by number of employees per district (metal production and processing).



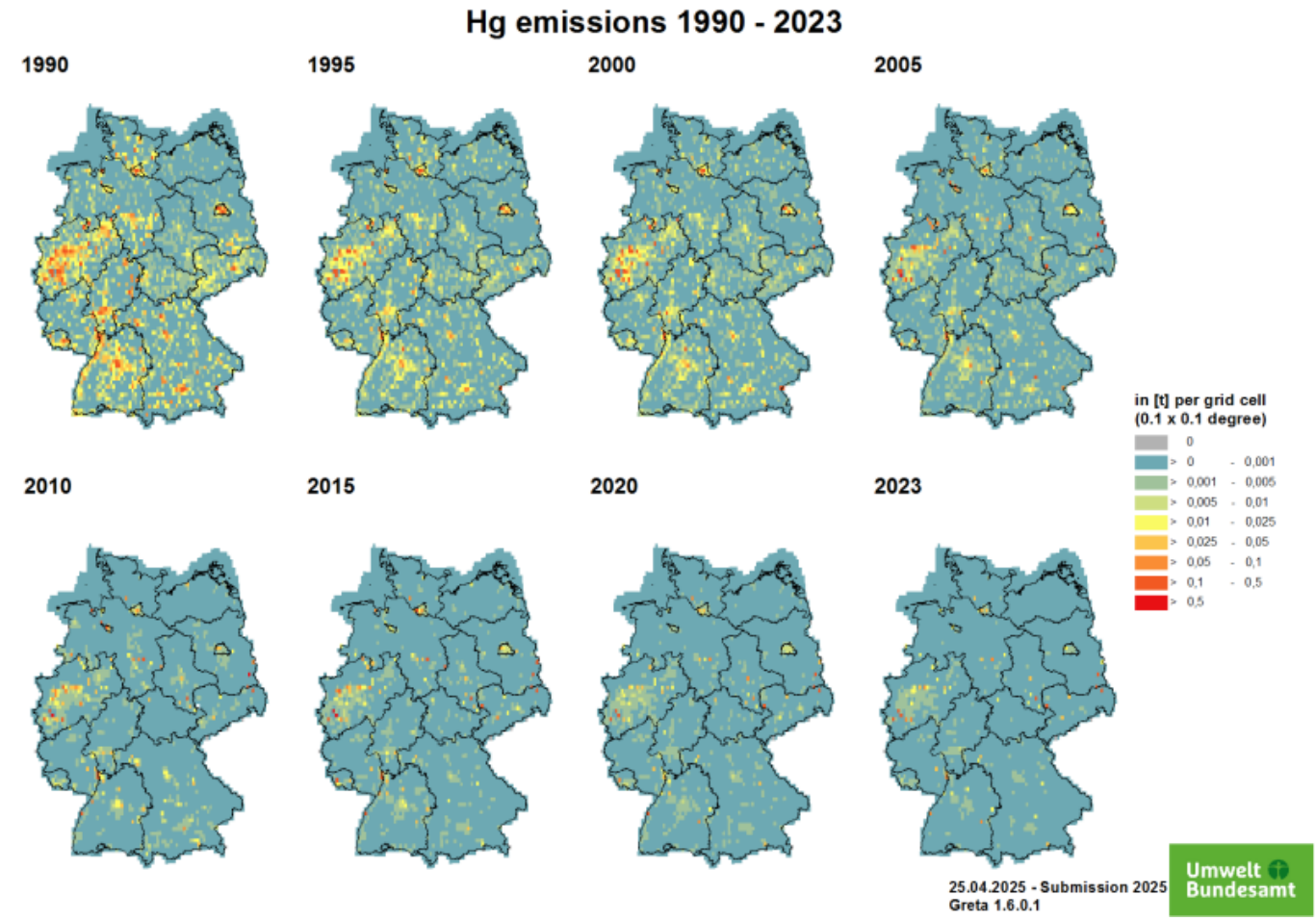
Cadmium Emissions

Cadmium (Cd) is one of the most toxic metals and substances for humans and the environment. The metal occurs in the body as a trace element and is incorporated through food. It is found in tobacco smoke, PVC and plastic and paint pigments. In the chemical industry, cadmium is a by-product of the extraction of zinc, lead or copper. The most important emission sources in Germany are the sectors of the metal processing industry - iron and steel, and copper production. It is also emitted by petroleum refineries and coal and oil combustion. For the latter, it can be captured via appropriate particle filters and thus reduced. For the dominant emission sources, the distribution is partially covered by PRTR point sources; the rest: by number of employees per district (metal production and processing).



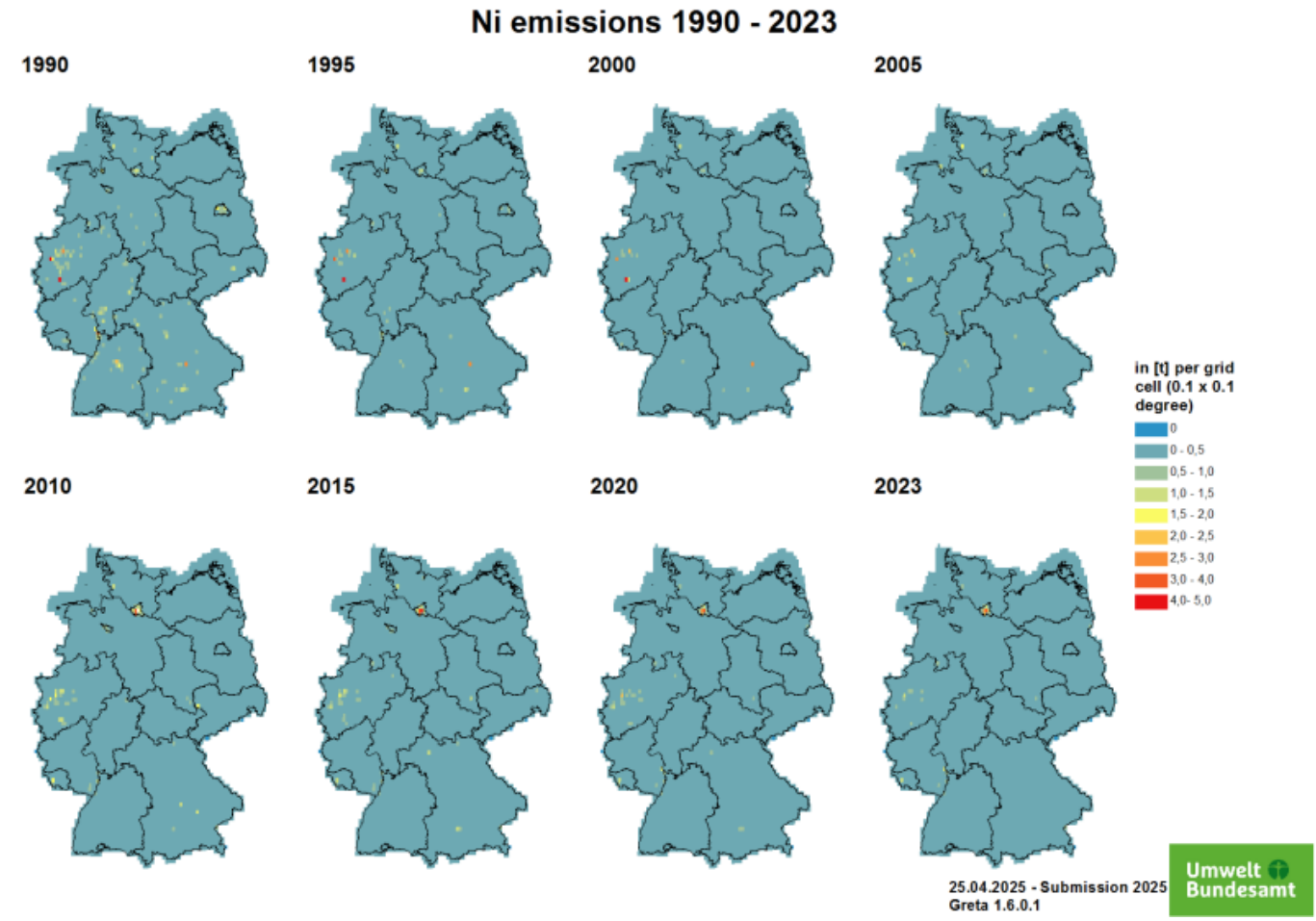
Mercury Emissions

Mercury (Hg) belongs to the group of heavy metals that occur both naturally (e.g. volcanic eruptions) and through industrial processes (e.g. mining, burning coal or heating oil) in the environment. A distinction is made between elemental (metallic) mercury (Hg0), inorganic mercury (iHg) and organic mercury compounds such as methylmercury (MeHg). It is mostly emitted bound to fine particles. It is mainly released during energy production from fossil fuels such as coal, oil and natural gas, and during metal-producing processes such as iron and steel production.The spatial distribution is made for energy supply via PRTR point sources (the rest: number of other power plants (<25 MW electric) for public supply per district).



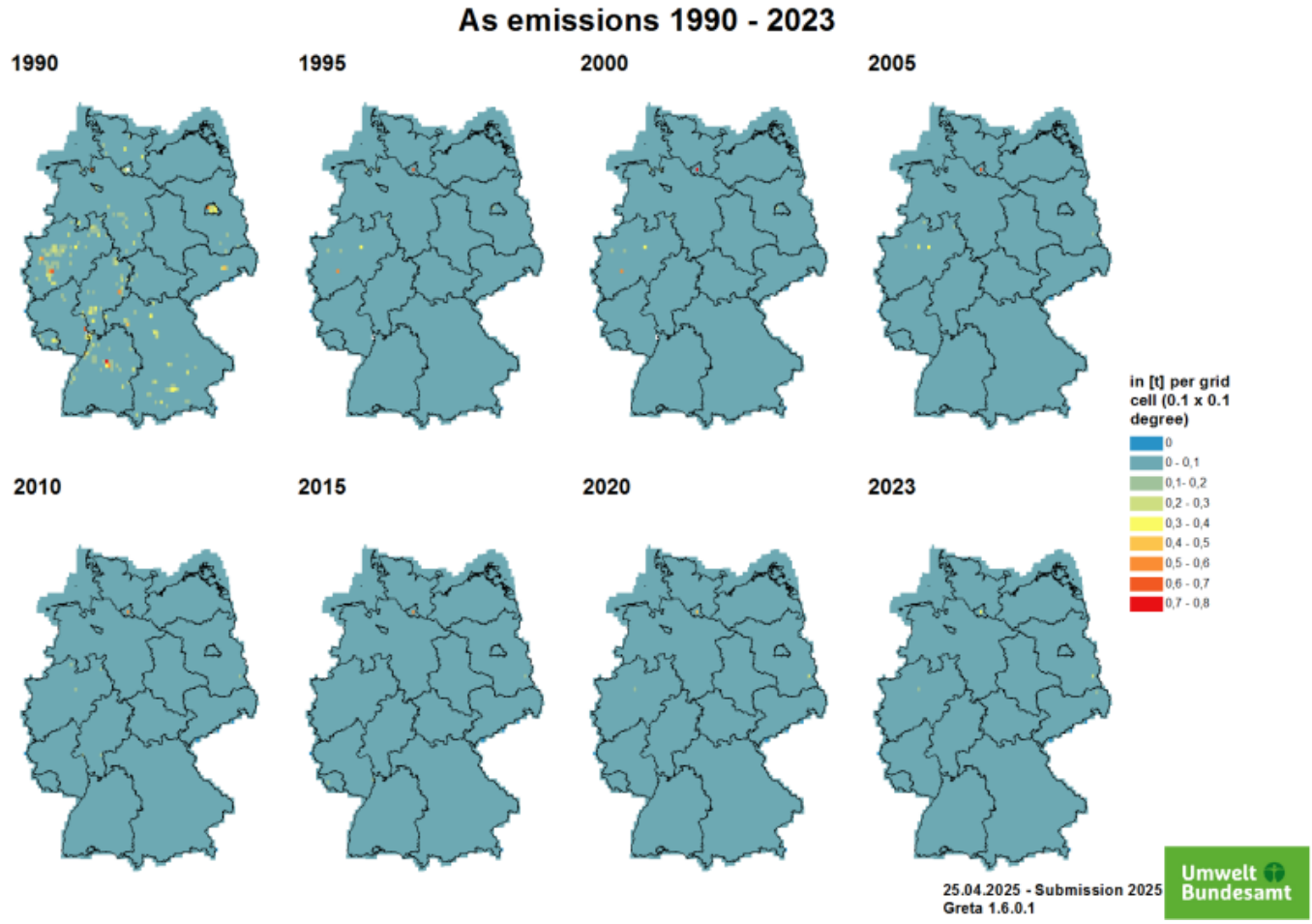
Nickel Emissions

Nickel (Ni) is a carcinogen and allergen. The main sources for Ni emissions in Germany are combustion processes of fossil fuels and the production of Ni containing alloys. The spatial distribution of Ni emissions from energy production and industrial activity is conducted as described above.



Arsenic Emissions

Arsenic (As) is a highly toxic and carcinogenic metalliod. In the environment, two oxidation states are most common, +3 and +5, were the first one has the highest toxic potential. Analogous to other anthropogenic metal emissions in Germany, As is released mostly during energy production from fossil fuels, especially coal, and during metal-producing processes. The spatial distribution of As emissions from energy production and industrial activity is conducted as described above.

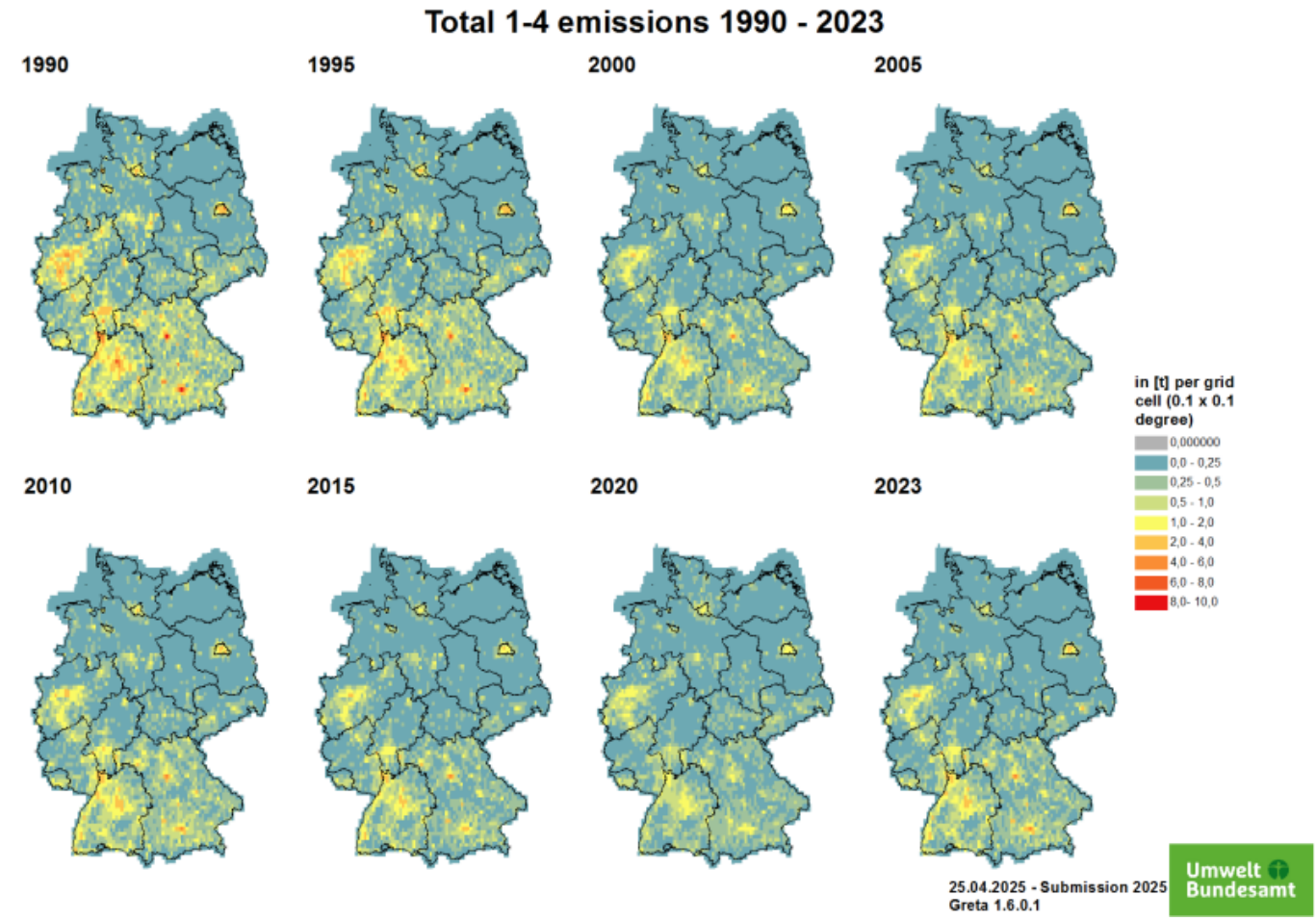


Emissions of persistent organic pollutants (POP)

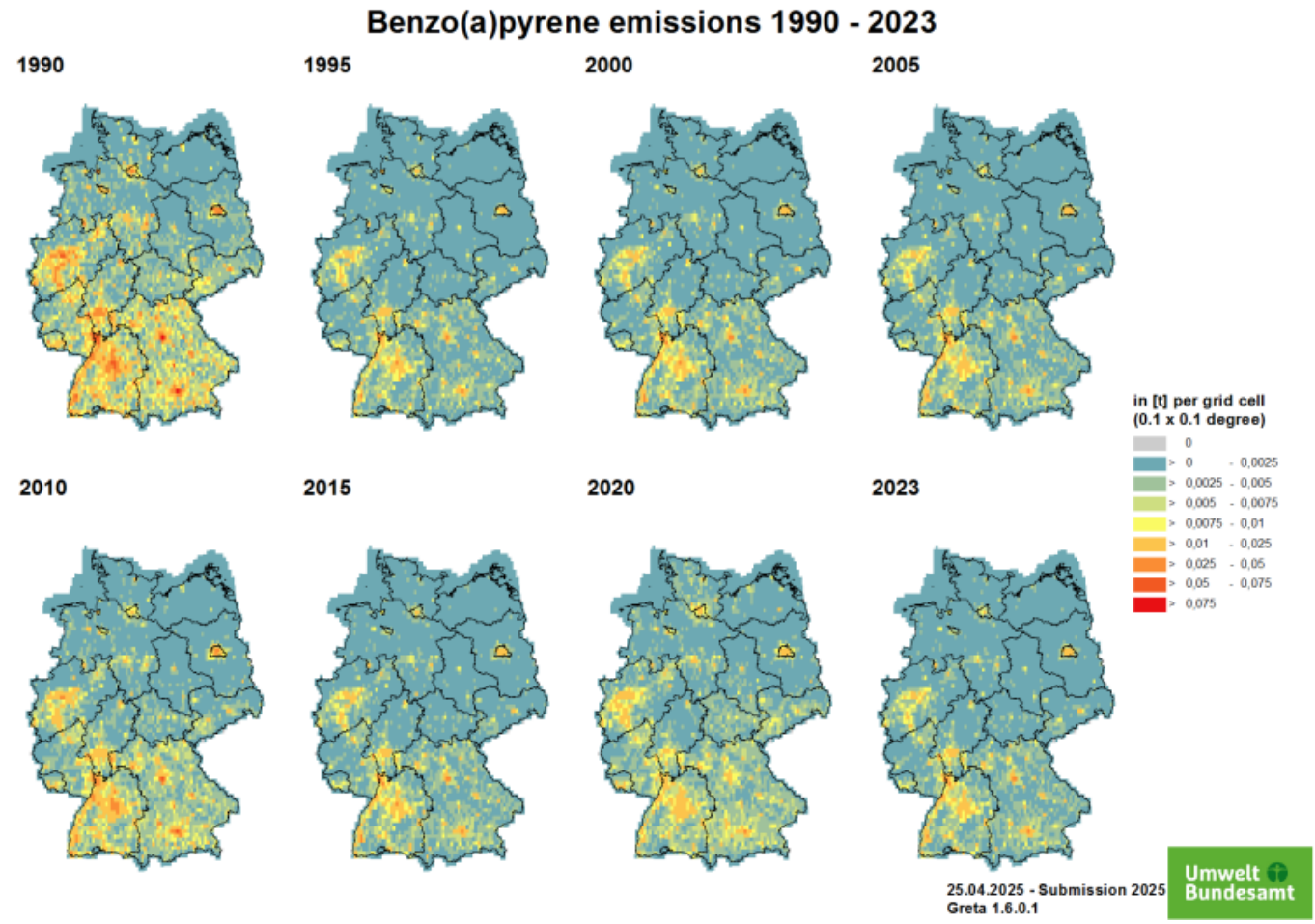
Data on POP emissions have a higher uncertainty compared to air pollutants such as SO_2, CO or NO_x. Therefore, the following maps should only be considered as estimates. It should be noted that the emission amounts are significantly different in magnitude from those of the air pollutants mentioned above.

Polycyclic aromatic Hydrocarbons and Benzo(a)pyrene

PAHs are formed during the incomplete combustion of organic material (e.g. coal, heating oil, fuel, wood, tobacco, forest fires). The dominant sources of PAHs in the environment are thus from human activity: wood-burning and combustion of other biofuels. The dominating source is the residential sector - Stationary. The spatial distribution is therefore mainly covered by distribution according to energy carriers (national).

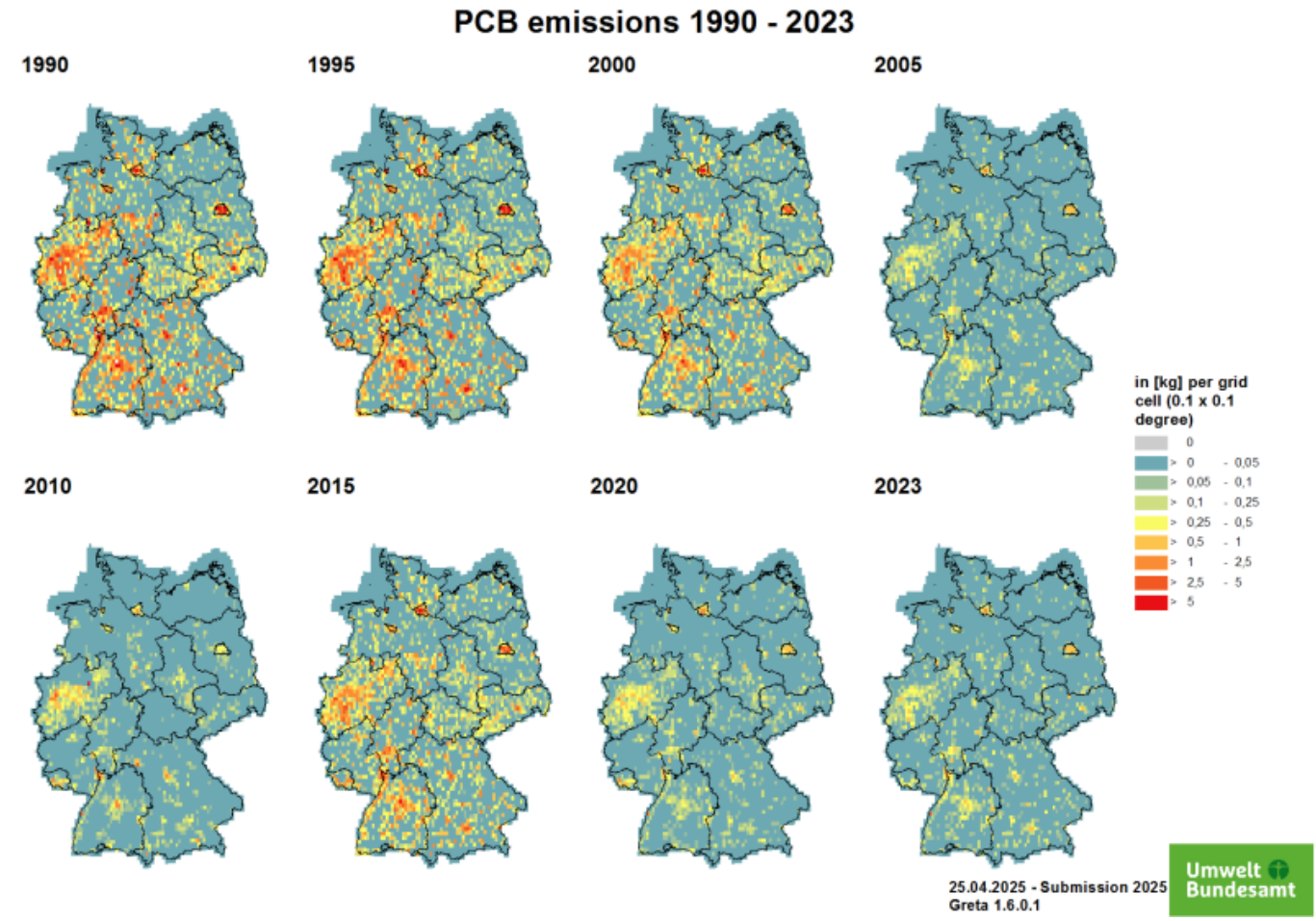


Benzo(a)pyrene is considered an indicator substance of polycyclic aromatic hydrocarbons. For this reason, more measurement data and further information are available than for other POPs. In the determination of environmental pollution by this group of substances, benzo[a]pyrene is usually used as a reference.



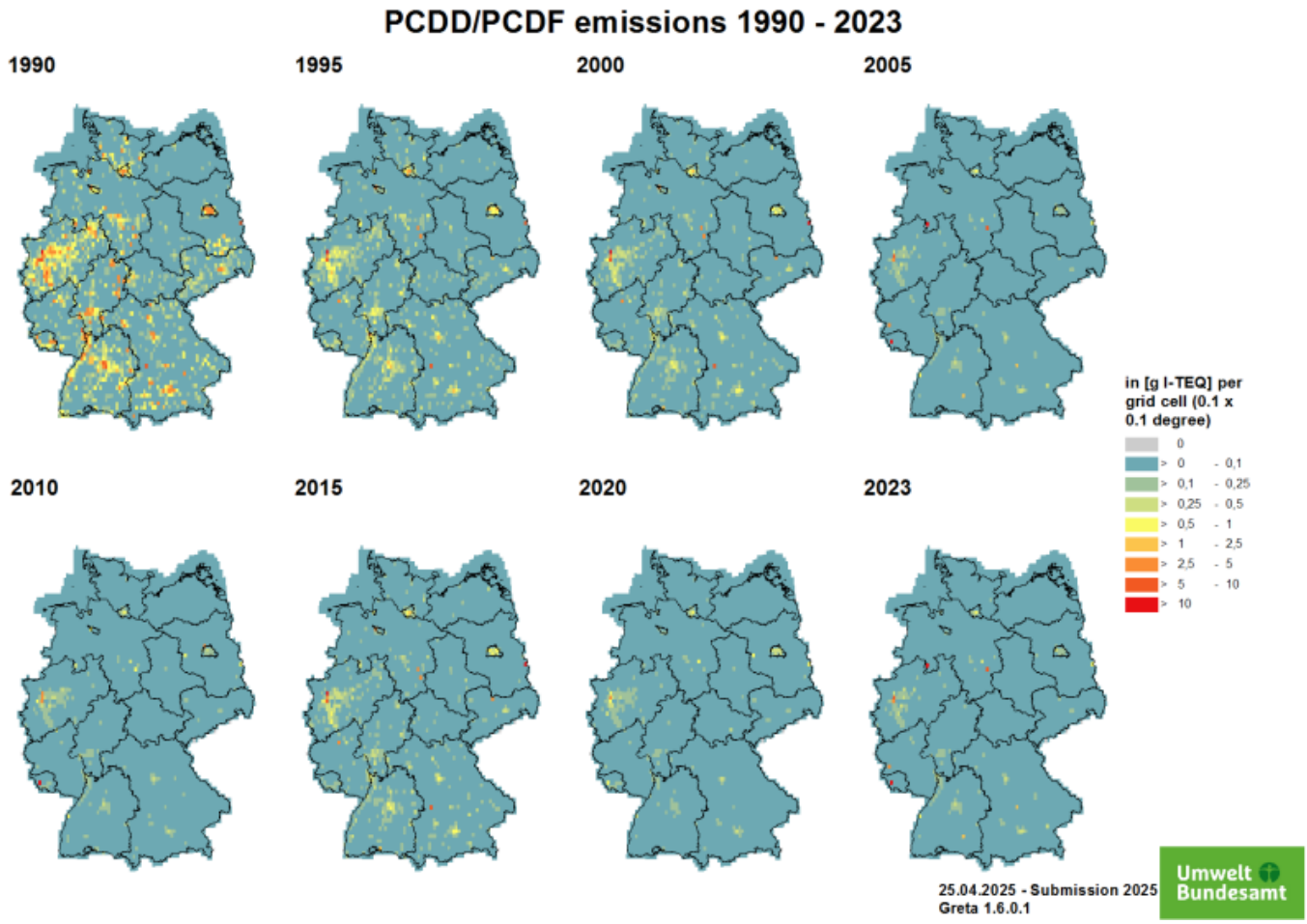
Polychlorinated biphenyls (PCB)

PCBs are classified as industrial chemicals and were used in various applications in pure form or as additives until the restrictions and bans came into force. Due to their properties (thermal stability, low water absorption and non-flammability), they were used in insulating oils in transformers, capacitors, additive to joint sealants and anti-corrosion coatings.The maps show the magnitude of HCB emissions in kilograms. The key sources are the sectors Public Power, Iron & Steel, and Residential - Stationary. The spatial distribution is therefore mainly covered by PRTR Point Sources (PS).



PCDD/PCDF

Emissions of dioxins and furans are formed as by-products in a variety of thermal processes, in the production of organochlorine chemicals, or in any oxidation reactions of hydrocarbon compounds in the presence of chlorine compounds. The magnitude of dioxins emissions is presented in the g I-TEQ range (toxic equivalence, TEQ) in the maps. The major key sources are the Residential - stationary combustion (1.A.4.b i), Other Waste: Building and Car Fires (5.E.2), and Metal Industrie - Iron and Steel (2.C.1). The spatial distribution is partially covered by information of PRTR point sources and for the residential sector according to energy carriers.

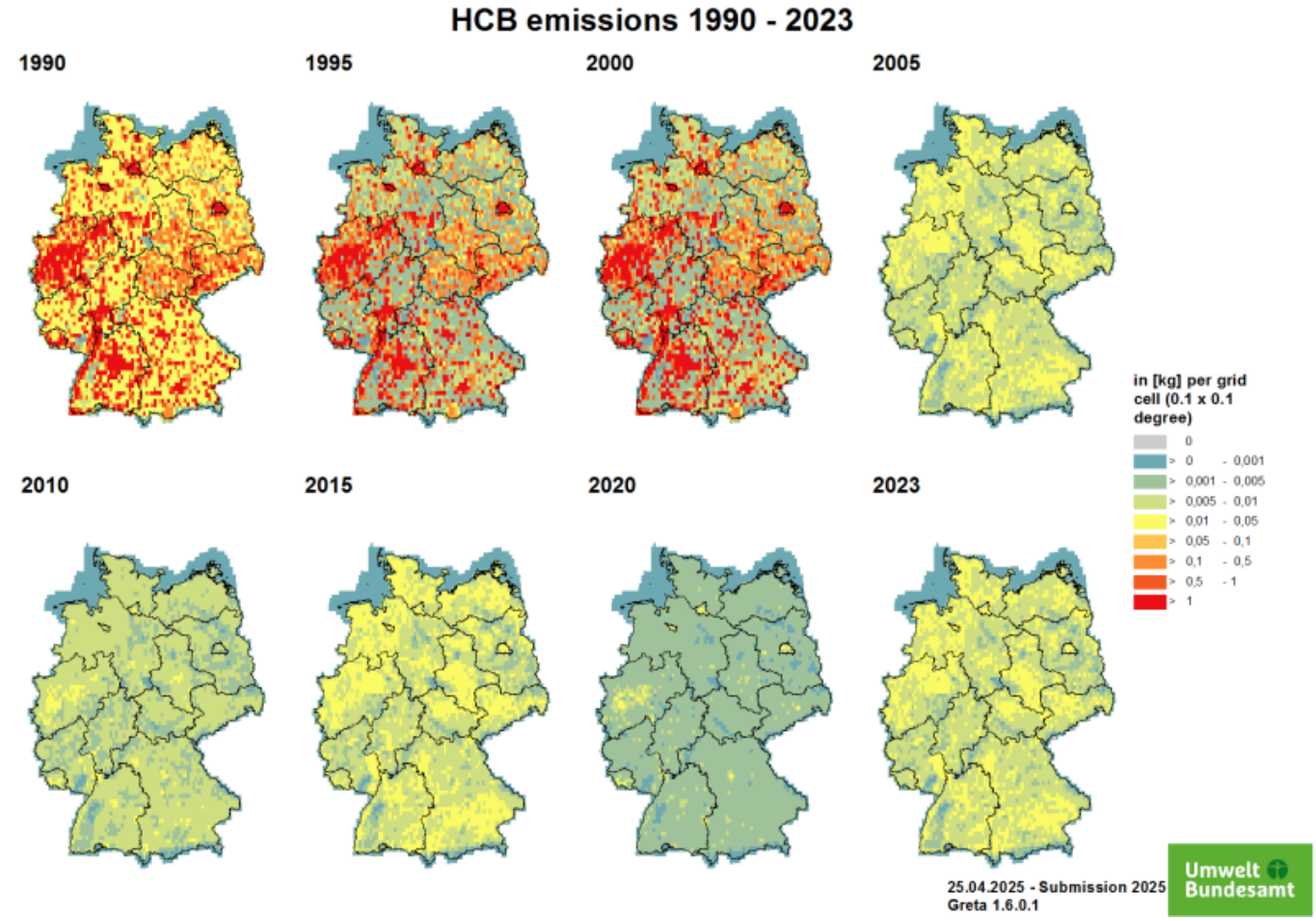


Hexachlorobenzene Emissions

Hexachlorobenzene (HCB) is a chemical substance that can also be formed as a by-product in the manufacture of chlorine compounds. It can also be released through incomplete combustion processes and leaching from landfills. The maps show the magnitude of HCB emissions in kilograms.

In the maps, the two main emission sources - production of secondary aluminium and application of pesticides in agriculture - as well as the emission trend are clearly visible. Degassing operations in refining plants of secondary aluminium production can produce HCB. The use of hexachloroethane has been prohibited by law in Germany since 2002, which eliminates the source of HCB. The emission distribution is partly covered by reports from the PRTR, the remaining emissions are calculated using number of employees per district in metal production and processing. More information is described under 2.C.3 - Aluminium Production.

In agriculture, HCB has not been used as a pure substance for a long time, as it has been banned since 1977. However, some pesticides that are still approved contain impurities that can arise during the manufacturing process. These agents are used to combat fungal infestations, particularly in cereal crops. Emissions from this sector are distributed over the agricultural area. However, this distribution is subject to great uncertainties, as the application is carried out depending on the mould infestation and the need for action. More information is described under 3.D.f - Agriculture other including use of pesticides.



[1)] Schneider et al. (2016): Schneider, Chr., Pelzer, M., Toenges-Schuller, N., Nacken, M., and Niederau, A.: ArcGIS basierte Lösung zur detaillierten, deutschlandweiten Verteilung (Gridding) nationaler Emissionsjahreswerte auf Basis des Inventars zur Emissionsberichterstattung. UBA Texte 71/2016, p.224; https://www.umweltbundesamt.de/sites/default/files/medien/1968/publikationen/2016-11-09_griddingtool_greta_langfassung_final.pdf; ISSN 1862-4804; AVISO GmbH on order of the Umweltbundesamt; Dessau-Roßlau, November 2016

[2)] Pelzer et al. (2018): Michael Pelzer, M., Schneider, Chr., Gallus, E. and Toenges-Schuller, N.: Gridding Emission Tool for ArcGIS (GRETA): Weiterentwicklungen und Erweiterung des Stoffspektrums - documentation regarding GRETA-AddIn version 1.1.2.2: https://iir.umweltbundesamt.de/2025/_media/general/gridded_data/2019_01_14_doku_greta_erweiterung2018_190114.pdf, AVISO GmbH on order of the Umweltbundesamt, October 2018, Aachen

[3)] Pelzer et al. (2021): Michael Pelzer, M., Schneider, Chr., Gallus, E. and Toenges-Schuller, N.: Gridding Emission Tool for ArcGIS (GRETA): WeiterentwicklungeAVn - GRETA-AddIn Version: 1.1.4.2; ArcGIS 10.8: https://iir.umweltbundesamt.de/2025/_media/general/gridded_data/2021_05_17_doku_greta_erweiterung_210517.pdf; AVISO GmbH on order of the Umweltbundesamt, May 2021, Aachen

[4)] Pelzer et al. (2024): Michael Pelzer, M., Toenges-Schuller, N. and Schneider, Chr.: Weiterentwicklungen 2023/2024: documentation as of 20.6.2024, GRETA-AddIn Version: 1.5.4.3; ArcGIS 10.8.2; https://iir.umweltbundesamt.de/2025/_media/general/gridded_data/2024_06_20_doku_greta_weiterentwicklung_2023_2024.pdf; AVISO GmbH on order of the Umweltbundesamt, June 2024, Aachen

CHAPTER 12: Adjustments and Emissions Reduction Commitments

For its 2025 submission, Germany fulfils its obligations regarding emission mitigation for all regulated pollutants and does not need to employ any adjustments.

The last adjustment applications date back to Germany's 2021 NEC submission. For more informtion, please refer to the information provided in the corresponding chapter of the 2021 IRR: https://iir.umweltbundesamt.de/2021/general/adjustments/start

Appendices to the German Informative Inventory Report

Appendix 1 - Key Category Analysis (KCA)
Appendix 2 - Detailed Methodological Descriptions
Appendix 2.1 - Reporting of PM emissions
Appendix 2.2 - Road Transport
Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources
Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources
Appendix 3 - Further Elaboration of Completeness
Appendix 4 - The National Energy Balance (NEB)
Appendix 5 - Additional Information

Appendix 1 - Key Category Analysis



All information is given in Chapter 1.5 - Key Sources.

Appendix 2 - Detailed Methodological Descriptions

The following sub-chapters of Appendix 2 provide additional methodological descriptions for individual source categories (where relevant and not provided in the related NFR sub-chapter) as well as for the entire inventory.

So far, appendix 2 provides additional methodological information on:

Appendix 2.1 - Reporting of PM emissions
Appendix 2.2 - Road Transport
Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources
Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources
to be continued...

Appendix 2.1 - Reporting of PM emissions

The condensable fraction of particulate matter ($PM_{2.5}$) is documented for all activities in the emissions database. A documentation entry has been created for each time series, indicating the following options for condensable particulate matter:

- Yes (measured/determined), the condensable fraction of $PM_{2.5}$ was measured and is included in the emission values
- No, the condensable fraction has not been determined and is not included in the emission values
- NA (no condensable $PM_{2.5}$ is generated in the process)
- Unknown, the condensable fraction for $PM_{2.5}$ is unknown and could be zero

Below is an excerpt from the database, showing the aforementioned documentation entries by source category.



NFR categories with no reported activity or $PM_{2.5}$ emissions are excluded here.

NFR Source Category		Yes	Not Applicable	No	Unknown	Number of document entries
		(measured/determined)	(no condensable $PM_{2.5}$ are generated in the process)	(potentially possible)		
NFR 1 Energy						
1A1ai	Electricity Generation	-	-	111	-	-
1A1aiii	Heat Plants	-	-	38	-	-
1A1b	Petroleum Refining	-	-	31	-	-
1A1ci	Manufacture of Solid Fuels	-	-	34	-	-
1A1ciii	Other Energy Industries	-	-	3	-	-
1A1civ	Other Manufacture of Solid Fuels and Other Energy Industries	-	-	13	-	-
1A2a	Iron and Steel	-	-	21	-	-
1A2gvii	Off-road Vehicles and Other Machinery	4	-	-	-	-
1A2gviii	Other	-	-	103	-	-
1A3ai(i)	International Aviation LTO (civil)	-	-	-	2	-
1A3ai(ii)	International Aviation Cruise (civil)	-	-	-	2	-
1A3aii(i)	Domestic Aviation LTO (civil)	-	-	-	2	-
1A3aii(ii)	Domestic Aviation Cruise (civil)	-	-	-	2	-
1A3bi	Road Transport: Passenger Cars	154	-	-	-	-
1A3bii	Road Transport: Light duty vehicles	138	-	-	-	-
1A3biii	Road Transport: Heavy duty vehicles and buses	136	-	-	-	-
1A3biv	Road Transport: Mopeds and Motorcycles	56	-	-	-	-
1A3bvi	Road Transport: Automobile tyre and brake wear	-	12	-	-	-
1A3bvii	Road Transport: Automobile road abrasion	-	6	-	-	-
1A3c	Rail Transport	11	-	1	-	-
1A3di(i)	International Maritime Navigation	-	-	-	3	-
1A3dii	National Navigation (shipping)	8	-	1	1	-
1A3ei	Pipeline Transport	-	-	3	-	-
1A4ai	Commercial/Institutional: Stationary	-	-	29	-	-
1A4aii	Commercial/Institutional: Mobile	3	-	-	-	-

NFR Source Category		Yes	Not Applicable	No	Unknown	Number of document entries
1A4bi	Residential: Stationary	-	-	15	-	-
1A4bii	Residential: Household and Gardening (mobile)	-	-	4	4	-
1A4ci	Agriculture/Forestry/Fishing: Stationary	-	-	16	-	-
1A4cii	Agriculture/Forestry/Fishing: Off-road Vehicles and other Machinery	6	-	-	-	-
1A4ciii	Agriculture/Forestry/Fishing: National Fishing	-	-	-	4	-
1A5a	Other Stationary (including military)	-	-	10	-	-
1A5b	Other Mobile (including military, land based and recreational boats)	-	-	9	1	-
1B1a2i	Mining Activities	-	1	-	-	-
1B1b	Solid Fuel Transformation	-	6	2	-	-
1B2c2ii	Gas	-	-	1	-	-
NFR 2 - IPPU						
2A1	Cement Production	-	-	1	-	-
2A2	Lime Production	-	-	-	2	-
2A3	Glass Production	6	-	-	-	-
2A4a	Ceramics	-	-	-	15	-
2A5a	Quarrying and Mining of Minerals other than Coal	-	4	-	-	-
2A5b	Construction and Demolition	-	5	-	-	-
2B5b	Calcium Carbide	-	-	-	1	-
2B8f	Carbon Black	-	-	-	1	-
2B10a	Chemical Industry: Other	-	-	-	1	-
2C1a	Steel	-	-	-	4	-
2C1b	Pig Iron	-	-	-	1	-
2C1d	Sinter	-	-	-	1	-
2C1f	Other Iron and Steel Production	-	-	-	1	-
2C2	Ferroalloys Production	-	-	-	1	-
2C3a	By-Product Emissions	-	-	-	2	-
2C5	Lead Production	-	-	-	2	-
2C6	Zinc Production	-	-	-	2	-
2C7a	Copper Production	-	-	-	2	-
2C7c	Other Metal Production	-	-	-	1	-
2D3b	Road Paving with Asphalt	-	-	-	1	-
2G4	Further Product Manufacture and Use	3	-	-	1	-
2H1	Pulp and Paper Industry	-	-	2	-	-
2H2	Food and Beverages Industry	-	-	-	2	-
2I	Wood Processing	-	1	-	-	-
2L	Handling of Bulk Products	-	1	-	89	-
NFR 3 - Agriculture						
3B1a	Dairy Cattle	-	1	-	-	-
3B1b	Non-dairy Cattle	-	6	-	-	-
3B2	Sheep	-	1	-	-	-
3B3	Swine	-	4	-	-	-
3B4c	Deer	-	1	-	-	-
3B4d	Goats	-	1	-	-	-
3B4e	Horses	-	1	-	-	-
3B4gi	Laying Hens	-	1	-	-	-
3B4gii	Broilers	-	1	-	-	-
3B4giii	Turkeys	-	1	-	-	-
3B4giv	Other Poultry	-	3	-	-	-

NFR Source Category		Yes	Not Applicable	No	Unknown	Number of document entries
3B4h	Other Animals	-	3	-	-	-
3D3	Farm-level Agricultural Operations incl. Storage, Handling and Transport of Agri. Products	-	1	-	-	-
NFR 5 - Waste						
5A1	Managed Waste Disposal Sites	-	1	-	-	-
5C1aii5	Other Waste	-	-	1	-	-
5C2aii	Other Biogenic Waste	-	-	-	1	-
5E	Other Waste	-	-	-	6	-
NFR 11 - Natural Sources						
11B	Forest Fires	-	-	-	1	-
SUM		**525**	**62**	**449**	**159**	**1.195**

Appendix 2.2 - Additional information: Emissions from road transport

Derivation of activity data

Cross-check with Energy Balance

The Energy Balance is also used to model transport-quantity structures in TREMOD. For example, the German Economic Institute (DIW) carries out a fuel-consumption calculation in order to derive total mileage travelled (DIW, 2002). Some of the results of the calculation, for automobile transports, are entered into TREMOD. The DIW uses a fuel-consumption calculation in order to determine total domestic mileage; TREMOD uses some other sources and assumptions to estimate total domestic mileage – especially for goods transports (cf. the detailed description in (Knörr, W., Höpfner, U., & Lambrecht, U. (2002)) [1)]. This estimate also takes the basic figures of the Energy Balance into account.

On the other hand, due to the many dependencies and uncertainties in the model, and to the basic data that must be taken into account, no feasible means is available for comparing mileage and energy consumption, for each year and each vehicle layer, in such a manner that the results yield the Energy Balance sum and the mileage and average energy consumption figures in the time series are plausible. For this reason, the TREMOD results for the fuel consumption are corrected, at the end of the process, in such a manner that the total for each reference year corresponds to the relevant figure in the Energy Balance.

Since TREMOD calculates fuel consumption in tonnes, the results first have to be converted into terajoule [TJ]. For this purpose the net calorific values of the Working Group on Energy Balances (AGEB) are used.

Table 1: Net calorific values for gasoline and diesel oil, in kJ/kg

	GASOLINE	DIESEL
1990-2000	43,543	42,959
2005	43,543	42,959
2006	43,543	42,961
2007	43,543	42,960
2008	43,543	42,960
2009	43,542	42,961
2010	43,543	42,961
2011	43,544	42,960
2012	43,543	42,961
2013	43,543	42,960
2014	43,542	42,649
2015	42,281	42,694
as of 2016	42,281	42,648

Source: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen)

The correction factors are derived in TREMOD separately for the various vehicle categories, as follows:

- Firstly, a correction factor for gasoline is derived from the calculated petrol consumption for all vehicle categories and from petrol sales pursuant to the Energy Balance.
- The correction factor for gasoline is then also used to bring fuel consumption of vehicles with diesel engines, among automobiles and other vehicles ≤ 3.5 t (light duty vehicles (LDV), and of motor homes and motorcycles (MC)), in line with the Energy Balance.
- The difference between the corrected diesel-fuel consumption of automobiles and of other vehicles ≤ 3.5 t and the Energy Balance is then allocated to heavy duty vehicles and busses.
- The correction factor for heavy duty vehicles and busses is then calculated from their energy consumption, as calculated in accordance with the domestic principle, and the pertinent difference, as calculated for this group, from the Energy Balance.

Table 2: Correction factors for adjustment of TREMOD estimates to the National Energy Balance

	GASOLINE FUELS	DIESEL FUELS	
	PC, LDV, M2W	PC, LDV	HDV, Bus
1990	1.086	1.086	0.983
1995	1.046	1.046	0.931
2000	0.995	0.995	0.957
2005	0.928	0.928	0.724
2010	0.860	0.860	0.869
2011	0.870	0.870	0.846
2012	0.846	0.846	0.913
2013	0.874	0.874	0.899
2014	0.849	0.849	0.902
2015	0.923	0.923	0.820
2016	0.925	0.925	0.811
2017	0.910	0.910	0.840
2018	0.880	0.880	0.900
2019	0.882	0.882	0.863
2020	0.887	0.887	0.939
2021	0.885	0.885	0.851
2022	0.924	0.924	0.828
2023	0.926	0.926	0.823

Source: TREMOD (Knörr, W. et al. (2024a)) [2)]

Allocation of biofuels, petroleum and LPG to the structural elements

The Energy Balance lists data for biofuels, petroleum and LPG for the transport sector. For purposes of importing into the CSE, the results for these fuels are derived as follows:

- Biodiesel is allocated to all structural elements with diesel engines, in keeping with their percentage shares of consumption of conventional diesel fuel.
- Bioethanol is allocated to all structural elements with gasoline engines, in keeping with their percentage shares of consumption of conventional gasoline.
- Petroleum is allocated to busses on roads outside of municipalities – and, thus, to the structural elements SV - BUS - KOAO and SV - BUS - MTAO – in keeping with their percentage shares of consumption of conventional diesel fuel.
- LPG is allocated to conventional automobiles, with petrol engines, on municipal roads (CSE nomenclature: SV - PKWO - KOIO).

Activity data for evaporation

The activity data for evaporation emissions is set as total gasoline consumption, on municipal roads, pursuant to TREMOD; the corresponding figure for mopeds is the total consumption. The values corrected for the Energy Balance are used.

Motor-vehicle-fleet data

For western Germany from 1990 through 1993, and for Germany as a whole as of 1994, car ownership was calculated on the basis of the officially published ownership and new registration statistics of the Federal Motor Transport Authority (KBA). The car ownership analysis for East Germany in 1990 was based on a detailed analysis of the Adlershof caremissions-testing agency in 1992 and the time series in the statistical annuals of the GDR. For the period between 1991 and 1993, it was necessary to estimate the figures with the aid of numerous assumptions.

Fleet data for the TREMOD model, for the reference years 2001 through 2003, are obtained from the database of the Federal Motor Transport Authority (KBA). The supplied data include vehicle fleets for each reference year, broken down as required for emissions calculation, i.e. in accordance with the following characteristics: type of engine (petrol, diesel, other), size class, vehicle age and emissions standard. For each reference year, the mid-year fleet is assumed to be representative of the fleet's composition for the year. The fleet figures for the years 2004 through 2007 were calculated with the help of a fleet-shifting module in TREMOD that extrapolates past fleet-growth trends.

Mileage

Mileage data were updated on the basis of the “2002 mileage survey” (“Fahrleistungserhebung 2002”; Institute of Applied Transport and Tourism Research (IVT, 2004 [3)]), the “2005 road-transport census” “Straßenverkehrszählungen 2005”; Federal Highway Research Institute (BASt), 2007 [4)]) and data on growth of transports on federal highways (BASt, 2008).

Shifting of fuel purchases to other countries

Because fuel prices in Germany are higher – significantly, in some cases – than in almost all of Germany's neighbours (Denmark is the only exception), for some time the fuels used in Germany have included fuels purchased in other countries and brought into the country as “grey” imports.

At present, no precise data are available on this phenomenon, which is significant for Germany's border regions and which is referred to as “refuelling tourism” (“Tanktourismus”). Although several detailed studies have been carried out, no reliable overall picture of the situation is yet available (cf. Lenk et al., 2004 [5)]). The sources that have documented shifting of consumers' fuel purchases to other countries (along with the resulting negative impacts on neighbouring countries' own emissions inventories) have included a study published by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW, 2005 [6)]).

Emission factors

All emission factors are listed in the “Handbook Emission Factors for Road Transport” versions 4.1 (Keller et al., (2019) [7)]) and 4.2 (Notter et al., (2022) [8)]).

This reference work is prepared via co-operation, between the environmental protection agencies of Germany, Switzerland and Austria also supported by Sweden, Norway, France as well as the JRC (European Research Center of the European Commission), in derivation of emission factors for road traffic.

The emission factors in this manual originate predominantly from the measurement programmes of TÜV Rheinland (TÜV, Technical Control Association) and RWTÜV. Those programmes have included fundamental surveys for the reference years 1989/1990. In those surveys, a new method was used, for both passenger cars and heavy duty vehicles, whereby emission factors were derived according to driving habits and the traffic situation. Within the context of field monitoring data, the passenger-car emission factors were updated for cars produced up to 1994. Version 3.4 of the “Emission-factor Manual for Road Transports” (“Handbuch der Emissionsfaktoren des Straßenverkehrs”: HBEFA), which is used for the current emissions calculations, draws on findings of the EU working group COST 346 and the ARTEMIS research programme. The emission factors are derived from the development of the various vehicle layers and from the data provided by the HBEFA. The emissions reduction achieved via the introduction of sulphur-free fuels was estimated by the German Environment Agency.

Derivation of emission factors

Emission factors from TREMOD

In the CSE, emission factors for the “engines” (“Antrieb”) category are listed in [kg/TJ], while those for the “Evaporation” category are given in [kg/t]. For gasoline, diesel oil, LPG and CNG, these values can be derived from TREMOD for all structural elements. To this end, emissions (in tonnes [t]) and energy consumption (in terajoules [TJ]; converted from the results “energy consumption in t”, using the net calorific values) are derived from the TREMOD results and allocated to the relevant structural elements. The emission factor for each structural element then results as the quotient resulting from emissions, in tonnes per structural element, divided by the energy consumption, per structural element, in terajoule.

A similar procedure is used to obtain the emission factors for fugitive emissions, in [kg/consumption on municipal roads], in tonnes [t]). For purposes of this derivation, TREMOD results without correction to the Energy Balance are used, since such correction is already contained in the activity data for the CSE. Use of the corrected values (emissions and energy consumption) leads to the same results, however, since the correction factor cancels out in calculation of mean emission factors (emissions corrected / energy corrected = emissions uncorrected / energy uncorrected).

Emission factors for biodiesel, bioethanol, petroleum, Liquefied Petroleum Gas (LPG), and Compressed Natural Gas (CNG)

The emission factors for biodiesel and petroleum are set at the same values as those for conventional diesel fuel. The emission factors for bioethanol are set at the same values as those for conventional gasoline.

Exception: * The SO_2 emission factor for petroleum is set to 24 kg/TJ for those years in which diesel fuel has a higher value. In all other years, the lower value for diesel fuel is used.

[1)] Knörr et al. (2002): Knörr, W., Höpfner, U., & Lambrecht, U. (2002): Aktualisierung des “Daten- und Rechenmodells”: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1980-2020 : Endbericht / Wolfram Knörr (Projektleiter): Heidelberg [u.a.] 2002.
[2)] Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg & Berlin, 2024.
[3)] IVT, 2004: Institut für angewandte Verkehrs- und tourismusforschung e.V.: Fahrleistungserhebung 2002, Teil: Begleitung und Auswertung. Untersuchung im Auftrag der Bundesanstalt für Straßenwesen, Projektnummer FE 82.201/2001. Heilbronn/Mannheim.
[4)] BASt, 2007: Federal Highway Research Institute (Bundesanstalt für Straßenwesen, BASt): Unterreihe Verkehrstechnik; V 164: “Straßenverkehrszählung 2005: Ergebnisse”, Thorsten Kathmann, Hartmut Ziegler, Bernd Thomas; 62 Seiten; Bergisch Gladbach, 2007.
[5)] Lenk et. al (2004): Lenk, T., Vogelbusch, F., & Falken, C.: Auswirkungen des Tanktourismus auf das deutsche Steueraufkommen – eine finanzwissenschaftliche Bestandsaufnahme. Paper presented at the UNITI Bundesverband mittelständischer Mineralölunternehmen e. V. - Mitgliederversammlung 2004, München.
[6)] BMLFUW, 2005: Federal Ministry for Agriculture, Forestry, Environment and Water Management (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft): Abschätzung der Auswirkungen des Tanktourismus auf den Treibstoffverbrauch und die Entwicklung der CO,,2,,-Emissionen in Österreich.; Wien, 2005.
[7)] Keller et al. (2019): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8_HBEFA41_Development_Report.pdf - Dokumentation, Bern, 2019.
[8)] Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf - Dokumentation, Bern, 2022.

Appendix 2.3 - Heavy Metal Exhaust Emissions From Mobile Sources

Road Transport

For heavy-metal exhaust emissions (other then lead from leaded gasoline), tier1 values have been derived from tier1 default values provided in the 2019 EMEP/EEA Guidebook.

Table 1: Tier1 default emisison factors applied to road vehicles, in g/TJ

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Diesel oil	0.012	0.001	0.123	0.002	0.198	0.133	0.005	0.002	0.419
Biodiesel[1]	0.013	0.001	0.142	0.003	0.228	0.153	0.005	0.003	0.483
Gasoline fuels	0.051	2.10	0.196	0.007	8.96	357	14.7	2.09	208
CNG	NE	NE	NE	NE	NE	NE	NE	NE	NE
LPG	NE	NE	NE	NE	NE	NE	NE	NE	NE
Biogas	NE	NE	NE	NE	NE	NE	NE	NE	NE

[1] values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel

The 2019 GB provides separate values for Hm from fuel combustion (icluding engine wear) and the unintended co-incineration of lube oil. The latter are reported in NFR 2.D as emissions from product use. (*Note: This country-specific approach has been discussed and accepted at both the 2018 TFEIP meeting and the 2018 NEC review.*)

Table 3-78: Heavy metal emission factors for all vehicle categories in ppm/wt fuel

Category	Pb	Cd	Cu	Cr	Ni	Se	Zn	Hg	As
Passenger cars, petrol	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003
Passenger cars, diesel	0.0005	5 E-05	0.0057	0.0085	0.0002	0.0001	0.018	0.0053	0.0001
LCVs, petrol	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003
LCVs, diesel	0.0005	5 E-05	0.0057	0.0085	0.0002	0.0001	0.018	0.0053	0.0001
HDVs, petrol	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003
HDVs, diesel	0.0005	5 E-05	0.0057	0.0085	0.0002	0.0001	0.018	0.0053	0.0001
L-category	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003

Table 3-79: Heavy metal emission factors for all vehicle categories in ppm/wt lubricant

Category	Pb	Cd	Cu	Cr	Ni	Se	Zn	Hg	As
Passenger cars, petrol	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
Passenger cars, diesel	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
LCVs, petrol	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
LCVs, diesel	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
HDVs, petrol	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
HDVs, diesel	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0
L-category	0.0332	4.56	778	19.2	31.89	4.54	450.2	0	0

Non-road Mobile Machinery in 1.A.2.g vii, 1.A.4.a.ii,1.A.4.b.i, 1.A.4.c.ii

and 1.A.5.b i

Without country-specific information, tier1 values are applied.

However, instead of using the emission factors provided in (EMEP/EEA, 2019) [1)], Table 3-1 Tier 1 emission factors for off-road machinery, EF for exhaust HMs from GB chapter 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv, page 93 ff are applied here too to allow for the separate reporting of emissions from fuel and enigine wear and the unintended co-incineration of lube oil. Here, separate tier1 default EFs are provided there in tables 3.77 and 3.78 of the GB chapter for road transport.

Heavy-metal emissions from lubricants (as far as not used in 2-stroke mix) are reported under NFR 2.G as emissions from product use.

(Note: Until submission 2017, the EMEP/EEA default EFs provided for NRMM were used in the German inventory. As these EFs do not differentiate between fuel combustion and lubricant co-incineration, the inventory compiler decided to apply the more specific EFs from road transport to NRMM in 1.A.2.g vii, 1.A.4.a ii, b ii and c ii and 1.A.5.b, too. This country-specific approach has been discussed and accepted at both the 2018 TFEIP meeting and the 2018 NEC review.)

Table 2: Tier1 default emission factors applied to NRMM, in g/TJ

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Diesel oil	0.012	0.001	0.123	0.002	0.198	0.133	0.005	0.002	0.419
Biodiesel[1]	0.013	0.001	0.142	0.003	0.228	0.153	0.005	0.003	0.483
Gasoline fuels - 4-stroke	0.037	0.005	0.200	0.007	0.145	0.103	0.053	0.005	0.758
Gasoline fuels - 2-stroke[2]	0.051	2.10	0.196	0.007	8.96	357	14.7	2.09	208
LPG (1.A.4.a ii only)	NE	NE	NE	NE	NE	NE	NE	NE	NE

[1] values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel
[2] including the HM of 1:50 lube oil mixed to the gasoline

Railways

Table 3: Tier1 default emission factors applied to railway vehicles, in g/TJ

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Diesel oil	1.21[2]	0.23[1]	0.12[1]	0.002[2]	1.16[2]	39.57[2]	1.63[2]	0.23[2]	23.28[2]
Biodiesel[3]	0.01	0.001	0.14	0.003	0.23	0.15	0.01	0.003	0.48
Lignite Briquettes	NE								
Raw Lignite	NE								
Hard Coal	NE								
Hard Coal Coke	NE								

[1] tier1 default from [2)], chapter: 1.A.3.b i-iv - Road transport: exhaust emissions: tier1 value for diesel vehicles
[2] tier1 default from [3)], chapter: 1.A.3.c - Railways
[3] values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel
(*NOTE: Assuming that biodiesel contains far less HMs than fossil diesel oil, similar values are applied to all mobile sources using this biogenic fuel.*)

As the EMEP/EEA GB 2019 does not provide specific defaults for **Pb, Hg and As**, the EF applied here has been derived from chapter: 1.A.3.b i-iv - Road transport: exhaust emissions: tier1 value for diesel vehicles.

Besides these emissions from fuel combustion and engine wear, the German inventory also covers **abrasive emissions from brakes, wheels on rail and contact line**. Here, a country-specific approach is applied with emissions of (i) chromium and nickel being estimated as part of the particle emissions from brake wear whereas emissions of copper (ii) copper are estimated as part of the PM emissions from the contact line.

Table 4: Country-specific emission factors for abrasive emissions, in g/km

	$PM_{2.5}$	PM_{10}	TSP	BC	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Contact line [1]	0.00016	0.00032	0.00032	NA	NA	NA	NA	NA	NA	0.00033	NA	NA	NA

	$PM_{2.5}$	PM_{10}	TSP	BC	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Tyres on rails [2]	0.009	0.018	0.018	NA	NA								
Braking system [3]	0.004	0.008	0.008	NA	NA	NA	NA	NA	0.00008	NA	0.00016	NA	NA
Current collector [4]	NE	NE	NE	NE	NA								

[1] assumption: 100 per cent copper
[2] assumption: 100 per cent steel
[3] assumption: steel alloy containing Chromium and Nickel
[4] typically: aluminium alloy + coal contacts; no particulate matter emissions calculated yet

Inland Vessels and Ships in 1.A.3.d ii

Table 5: Tier1 default emission factors applied to inland ships and vessels, in g/TJ

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Diesel oil	1.21	0.233	0.123	0.002	1.16	39.6	1.63	0.233	23.3
Biodiesel[1]	0.013	0.001	0.142	0.003	0.23	0.15	0.005	0.003	0.48

[1] similar EF for biodiesel applied for all mobile sources

Maritime Vessels and Ships in 1.A.3.d i, 1.A.3.d ii, 1.A.4.c iii and 1.A.5.b iii

The following table provides the tier1 EF applied for HMs from ships and vessels in both civil and military operation in NFR categories 1.A.3.d i -International Maritime Navigation, 1.A.3.d ii - National Navigation (Shipping), 1.A.4.c iii -Fisheryand 1.A.5.b iii - Other: Military Navigation.

Table 6: Tier1 default emission factors applied to maritime ships and vessels in g/TJ

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Heavy Fuel oil[1]	4.46	0.50	0.50	16.9	17.8	31.0	793	5.20	29.7
Diesel oil[2]	3.03	0.23	0.70	0.93	1.16	20.5	23.3	2.33	27.9
Biodiesel[3]	0.013	0.0013	0.142	0.003	0.23	0.15	0.005	0.003	0.48

[1] tier1 defaults from [4)], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Table 3-1
[2] tier1 defaults from [5)], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Table 3-2
[3] similar EF for biodiesel applied for all mobile sources (*NOTE: Assuming that biodiesel contains far less HMs than fossil diesel oil, similar values are applied to all mobile sources using this biogenic fuel.*)

Aircraft in 1.A.3.a and 1.A.5.b ii

The EMEP/EEA GB 2019 does not provide specific defaults for HM emissions from the combustion of jet kerosene and aviation gasoline, stating that for for aviation gasoline these emissions are *not estimated* (NE):

Therefore, the inventory compiler decided to apply the tier1 EF from gasoline fuel used in non-road mobile machinery here, too. Although the Party assumes that HM emissions are also likely to occur from the combustion of jet kerosene, no gap-filling is carried out for this fuel. Instead, all HM emission from jet kerosene are reported as *not estimated* (NE).

Table 7: Tier1 default emisison factors applied to aircraft, in g/TJ

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Kerosene	NE								
Aviation gasoline	9,481[1]	0.005	0.200	0.007	0.145	0.103	0.053	0.005	0.758

[1] estimated from average lead content of AvGas 100 LL (see also: 1.A.3.a ii (i) and FAQs) of 0.56 g Pb/liter

[1), 2), 3), 4), 5)] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook 2019; Chapter 1.A - Combustion; URL: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion, Copenhagen, 2019.

Appendix 2.4 - POP emissions from mobile combustion sources

Road Transport

For PAH exhaust-emissions, default emission factors from the 2019 version of EMEP Guidebook (EMEP/EEA, 2019) [1)] have been applied. Regarding PCDD/F, a tier1 EF from (Rentz et al., 2008) [2)] is used instead.

Table 1: Tier1 default emisison factors applied to road vehicles

	B[a]P	B[b]F	B[k]F	I[...]P	PAHs 1-4	PCDD/F
	[mg/TJ]					[µg/km]
Diesel oil	368	386	203	368	1,324	
Biodiesel[1]	368	386	203	368	1,324	
Gasoline fuels	96	140	69	158	464	
CNG	NE	NE	NE	NE	NE	
LPG	4.35	0.00	4.35	4.35	13.2	
Biogas	NE	NE	NE	NE	NE	
all fuels						0.0000056

[1] values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel

Here, the tier1 values for PAH exhaust emissions have been derived from the following tier1 default values provided in the July 2017 version of the 2016 EMEP/EEA Guidebook:

Non-road Mobile Machinery in 1.A.2.g vii, 1.A.4.a.ii,1.A.4.b.i, 1.A.4.c.ii and 1.A.5.b i

Table 3: Tier1 default emisison factors applied to NRMM

	B[a]P	B[b]F	B[k]F	I[...]P	PAH 1-4	PCDD/F
	[mg/TJ]					[µg/TJ]
Diesel oil	698	1.164	801	184	2,847	1.62[3]
Biodiesel[1]	806	1.343	924	212	3,284	1.87
Gasoline fuels - 4-stroke	919	919	90	204	2,131	2.76[3]
Gasoline fuels - 2-stroke[2]	919	919	90	204	2,131	57.5[3]
LPG (1.A.4.a ii only)	4.35	0.00	4.35	4.35	13.04	NE

[1] values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel
[2] no separate values available for 2-stroke-mix including 1:50 lube oil.
[3] tier1 values derived from [3)]

Railways

Table 3: Tier1 default emission factors applied to railway vehicles

	B[a]P	B[b]F	B[k]F	I[...]p	PAH 1-4[3]	PCDD/F
	[mg/TJ]					[µg/TJ]
Diesel oil	698[2]	1,164[2]	801[1]	184[1]	2,847[3]	2.09
Biodiesel	806	1,343	924	212	3,284	2.41
Lignite Briquettes	34,500	NE	NE	NE	90,000	29.80
Raw Lignite	NE					NE

Hard Coal	NE	NE
Hard Coal Coke	NE	NE

[1] tier1 default from [4)], chapter: 1.A.3.b i-iv - Road transport: exhaust emissions: tier1 value for diesel vehicles
[2] tier1 default from [5)], chapter: 1.A.3.c - Railways
[3] sum of tier1 default value applied for B[a]P, B[b]F, B[k]F, and I[…]P

As the EMEP/EEA GB 2019 does not provide a tier1 value for **PCDD/F**, the EF applied here has been derived from a study carried out by Rentz et al. (2008) [6)] for the German Federal Environment Agency. Furthermore, both **HCB** and **PCBs** emissions are stated as *not applicable* in [7)], chapter 1.A.3.c Railways, Table 3-1 Tier 1 emission factors for railways.

Inland Vessels and Ships in 1.A.3.d ii

Table 4: Tier1 default emission factors applied to inland ships and vessels

	B[a]P	**B[b]F**	**B[k]F**	**I[…]p**	**PAH 1-4**[2]	**HCB**	**PCBs**	**PCDD/F**
	[mg/TJ]							[µg/TJ]
Diesel oil	698[4]	1,164[4]	801[5]	184[5]	2,847	1.86[3]	0.88[3]	93.0[7]
Biodiesel[1]	806	1,343	924	212	3,284	1.02	2.15	107

[1] similar EF for biodiesel applied for all mobile sources; due to lack of better information EF values are derived from conventional diesel oil but taking into account the specific NCV of biodiesel
[2] sum of tier1 default values applied for B[a]P, B[b]F, B[k]F, and I[1,2,3-c,d]P
[3] tier1 defaults from [8)], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Tables 3-1 and 3-2
[4] tier1 defaults from [9)], Chapter: 1.A.3.c Railways: Diesel, Table 3-1
[5] tier1 defaults from [10)], Chapter: 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv - Road transport, Table 3-8: HDV, Diesel

Maritime Vessels and Ships in 1.A.3.d i, 1.A.3.d ii, 1.A.4.c iii and 1.A.5.b iii

The following table provides the tier1 EF applied for POPs from ships and vessels in both civil and military operation in NFR categories 1.A.3.d i -International Maritime Navigation, 1.A.3.d ii - National Navigation (Shipping), 1.A.4.c iii -Fisheryand 1.A.5.b iii - Other: Military Navigation.

Table 4: Tier1 default emission factors applied to maritime ships and vessels

	B[a]P	**B[b]F**	**B[k]F**	**I[…]p**	**PAH 1-4**[2]	**HCB**	**PCBs**	**PCDD/F**
	[mg/TJ]							[µg/TJ]
Diesel oil	698[4]	1,164[4]	801[5]	184[5]	2,847	1.86[3]	0.88[3]	93.0[7]
Biodiesel[1]	806	1,343	924	212	3,284	2.15	1.02	107
Heavy Fuel oil[6]	741	1,235	849	195	3,020	3.46	14.1	98.7

[1] similar EF for biodiesel applied for all mobile sources; due to lack of better information EF values are derived from conventional diesel oil but taking into account the specific NCV of biodiesel
[2] sum of tier1 default values applied for B[a]P, B[b]F, B[k]F, and I[1,2,3-c,d]P
[3] tier1 defaults from [11)], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Tables 3-1 and 3-2
[4] tier1 defaults from [12)], Chapter: 1.A.3.c Railways: Diesel, Table 3-1
[5] tier1 defaults from [13)], Chapter: 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv - Road transport, Table 3-8: HDV, Diesel
[6] derived from default for fossil diesel oil, but adapted to specific NCV of heavy fuel oil
[7] tier1 value derived from [14)]

Aircraft in 1.A.3.a and 1.A.5.b ii

The EMEP/EEA GB 2016 (July 2017) does not provide specific defaults for POP emissions from the combustion of jet kerosene and aviation gasoline, stating that for for aviation gasoline these emissions are *not estimated* (NE):

Therefore, the inventory compiler decided to apply the tier1 EF for **PAHs** from gasoline fuel used in non-road mobile

machinery here, too. Furthermore, both **HCB** and **PCBs** emissions are stated as *not applicable* in [15], chapter 1.A.3.a, 1.A.5.b Aviation, Table 3.3 Tier 1 emission factors for NFR 1.A.3.a.ii.(i): Civil aviation (domestic, LTO).

As the Party assumes that POP emissions from the combustion of jet kerosene are unlikely to occur, these emission are reported as *not applicable* (NA).

Table 5: Tier1 default emisison factors applied to aircraft, in mg/TJ

	B[a]P	B[b]F	B[k]F	I[...]p	PAH 1-4	PCDD/F
Kerosene	NA	NA	NA	NA	NA	NA
Aviation gasoline	126	182	90	205	602	NE

[1], [4], [5], [7], [8], [9], [10], [11], [12], [13], [15] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, Copenhagen, 2019.
[2], [3], [6], [14] Rentz et al., 2008: Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, January 2008 - URL: https://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer

Appendix 3

Appendix 3 provides a further elaboration of completeness, uses of NE & IE and (potential) sources of air pollutant emissions excluded (where relevant).

Appendix 4 - The Energy Balance for the Federal Republic of Germany

The basis for determination of energy-related emissions is the Energy Balance of the Federal Republic of Germany, which is prepared by the Working Group on Energy Balances (AG Energiebilanzen – AGEB) under commission to the Federal Ministry for Economic Affairs and Climate Action (BMWK). The most important data source for the Energy Balance is the Federal Statistical Office (Statistisches Bundesamt). The surveys of the Federal Statistical Office that were used are listed in Table 477: Zur Erstellung der Energiebilanzen für die Bundesrepublik Deutschland verwendeten Erhebungen des . Data on renewable energy sources are obtained by the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), working under the leadership of the German Environment Agency (UBA), and transferred directly to the Working Group on Energy Balances (AGEB), for purposes of the Energy Balances. The data involved include provisional data on renewable energy sources, which enter into the estimated Energy Balance and the evaluation tables. Additional data, supplementing those provided by the aformentioned data sources, are provided by associations of the German energy industry, and by German research institutes. The final Energy Balance includes data from the following associations: Nuclear Technology Germany (KernD); the Federal German association of lignite-producing companies and their affiliated organisations (DEBRIV); the Federal German association of the energy and water-resources industries (bdew); the Gesamtverband Steinkohle association of the German hard-coal-mining industry (GVSt); and the Fuels and Energy industry association (en2x). In the Federal Republic of Germany, energy statistics are published by numerous other agencies, and their statistics can differ in terms of their presentation, scope, methods and aggregation.

The complete Energy Balances for the years since 1990 are available on the Internet at (AGEB, 2025) [1)].

The AGEB's website presents a foreword for the Energy Balances (AGEB, 2015) that describes the structure of the Energy Balance. The overall responsibility for preparation of Energy Balances lies with the AGEB.

In recent years, German experts on energy statistics have expended considerable efforts on the task of minimizing the differences between the provisional and final Energy Balances. In 2020, the Federal Statistical Office obtained the EU grant “improvement of timeliness of energy statistics” from EUROSTAT. In the framework of a dedicated project, this funding is expected to enable the Federal Statistical Office to provide data for year x-1, to the AGEB, as early as August of the relevant year. The pertinent project was launched in 2020, and it includes the statistical offices of the Länder, which are responsible for the concrete surveys involved. Key surveys for the preparation of the Energy Balance and the emissions inventories have been given temporal priority. As a result, the Federal Statistical Office, working on the basis of the data collected by the reference date, and using imputation procedures, was able – in July 2020 – to extrapolate a complete data set for the year 2019. In July 2021, the so-developed methods were used in routine operations for the first time.

In October 2021, quality assurance for the methods was carried out by comparing the extrapolated results with the final 2020 survey data. In the 2022 survey year, the resulting methodological improvements made it possible to prepare a considerably improved provisional Energy Balance, now based, for the first time, on extrapolations – the 2021 provisional Energy Balance. The participating institutions coordinated their scheduling for the relevent data flow so carefully that a number of process steps were carried out in the shortest possible time, and the relevant data were made available for inventory preparation in reporting year 2023.

Structure of the Energy Balances

Via a matrix structure, each Energy Balance presents an overview of production, transformation and use of energy sources / fuels throughout a defined period. In the Energy Balance of the Federal Republic of Germany, energy flows are shown for a total of 30 energy sources / fuels (groups). The production balance shows

- domestic production,
- imports,
- removals from stocks,
- exports,
- international marine bunkers, and
- additions to stocks,

of energy resources, and it summarises them under primary energy consumption. The primary Energy Balance provides the basis for calculations under the IPCC reference procedure (Plinke & Schonert, 2000). The usage balance provides a key basis for preparation of emissions inventories. The usage balance can also be used for determination of primary energy consumption. It comprises:

- the transformation balance
- flaring and line losses
- non-energy-related consumption, and
- final energy consumption.

Data on non-energy-related consumption, broken down by industrial sectors, are regularly provided to the Federal Environment Agency (UBA) in the framework of an additional table included with the Energy Balance for Germany.

Differences between the production and usage balances are compensated for in the position “Statistical differences”.

The transformation balance, part of the usage balance, shows what energy resources are transformed into other, “secondary” resources. The transformation production shows the results of such transformation. Energy transformation can involve conversions of substances – such as conversion of crude oil (conversion input) into petroleum products (conversion output) – or conversions of energy – such as combustion of hard coal (conversion input) – in power stations, for production of electrical energy (conversion output). The energy consumption in the transformation sector shows how much energy was needed for operation of transformation systems (the transformation sector's own consumption). The transformation balance is divided into a total of 12 different sectors.

Non-energy-related consumption, as a component of the consumption balance, is shown as a total, without allocation to industrial sectors. Data on non-energy-related consumption, broken down by industrial sectors, are regularly provided to the Federal Environment Agency (UBA) in the framework of an additional table included with the Energy Balance for Germany. It describes which energy resources are used as raw materials (e.g. in the chemicals industry, transformation of energy resources into plastics).

The description of final energy consumption (by energy sources / fuels) shows the potential scope of energy consumption in the final consumption sectors. (The energy that is ultimately required (for applications such as work, lighting, space heat and process heat) has to be differentiated from final energy consumption. It is not listed in the EB (AGEB, 2019).) The breakdown covers the areas of industry – sub-divided into 14 sectors – transport, households, commercial use, trade, services and other consumers (including agriculture). The energy flow in the Energy Balances is depicted for 30 energy sources / fuels. These energy resources can be allocated to the following main groups:

- hard coal,
- lignite,
- petroleum (including LPG and refinery gas),
- gases (coke-oven and blast furnace gas, natural gas and firedamp, and excluding landfill gas and the gases in the previous category),
- renewable energies (including renewable waste and, as of 2013, sewage sludge),

electrical power and other energy sources / fuels (non-renewable waste, waste heat). Detailed information about the transformation balance, non-energy-related consumption, final energy consumption and the energy sources / fuels groups is provided in the NIR (2023). In this regard, we call attention to the brochure “Energie in Zahlen – Arbeit und Leistungen der AG Energiebilanzen” (“Energy in numbers – the work and services of the AG Energiebilanzen”) (AGEB, 2019), which presents further details and background information about the German Energy Balance.

Energy Balances for Germany as a whole are available for the years as of 1990 (AGEB, 2003). As of the year 2000, the energy-resource structure in the area of renewable energies / waste was changed: hydroelectric and windpower systems, and photovoltaic systems, were combined, and waste/biomass was divided into renewable and non-renewable fractions. Since 2003, non-renewable waste and waste heat are also listed under final-energy consumption within the Energy Balance.

In the Energy Balance, fuels / energy sources are listed in natural units, including tonnes (t) for solid and liquid fuels, cubic metres (m^3) for gases (except for natural gas), kilowatt hours (kWh) for electrical power and natural gas, and joules (J) for waste, renewable energy sources, nuclear power and district heating. In order to render the data comparable, and to allow them to be added up, all values are converted into joules (J), via suitable conversion factors. With respect to gases, the Energy Balance differs from gas statistics in that it views all gases in terms of their net calorific value Hi – and not of their gross calorific value, Hs.

To meet the need for emissions reporting to be as up to date as possible, the following procedure will be carried out on an annual basis as of 2022 for purposes of inventory preparation: at the end of August, the Working Group on Energy Balances (AGEB) will provide the German Environment Agency (UBA) with a complete provisional Energy Balance, based on extrapolated statistics of the Federal Statistical Office, for the year x-1. The AGEB will then deliver the final Energy Balance to UBA in the following February (at that point, the EB will be for the year x-2). Publication will then take place in about the following April.

Methodological issues: Energy-related activity rates

Essentially, the inventories for air pollutants and greenhouse gases prepared by the German Environment Agency are based on the Energy Balances for Germany prepared by the Working Group on Energy Balances (AGEB). The data required for emissions calculation can be read directly from Energy Balance lines 11, 12, 15, 16, 40, 60, 65 and 68. For natural gas and light heating oil, EB line 14 is also used in calculation.

In a few cases, the special requirements pertaining to emissions calculation, and the need to assure the completeness of data, necessitate a departure from the above-described system, and additional data have to be added:

- The emissions-relevant fuel inputs for lignite drying have to be calculated out of EB line 10. A precise description of category 1.A.1.c is provided in Chapter 3.2.6.2.
- Natural gas inputs in compressors, for the years 1995-2002, were taken directly from the Energy Balance (EB line 33). For the years 1990-1994, and for the period as of 2003, the values have to be calculated outside of the Energy Balance. The method is described in the NIR 2022's Chapter for category 1.A.3.e.
- For systematic reasons, and for reasons having to do with a focus on energy production, the Energy Balance does not list incinerated waste quantities completely for all relevant years. In this area as well, therefore, the lacking data have to be added from waste statistics. Relevant explanations are provided in Chapter for category 1.A.1.a and in the Chapter for category 1.A.2.g Other (stationary).
- Firewood use in the categories commercial and institutional is not listed in the Energy Balances through 2012; it has to be added. The method is described in Chapter for category 1.A.4.

In the Energy Balance, inputs of reducing agents, in pig-iron production, are listed in part as energy-related consumption, in EB line 54, and in part as transformation inputs, in EB line 17 (top-gas equivalent). Use, for energy production, of the blast-furnace gas produced in pig-iron production is listed in the relevant Energy Balance lines, 11, 12, 15, 33 and 54. To prevent double counting, the reducing-agent inputs from blast furnaces, as listed in EB line 54, and the relevant top-gas equivalent, are not reported.

Uncertainties, time-series consistency and quality assurance in the Energy Balance

While the Act on Energy Statistics (which entered into force in 2003) improved the relevant basic data foundations for the Energy Balance somewhat, the dynamic development of the energy sector soon necessitated an amendment of that Act. The currently valid amendment of the Act on Energy Statistics of 6 March 2017 (Federal Law Gazette (BGBl) I p. 392) introduces improvements in statistical coverage, updates the survey groups involved and adds a number of new aspects to be surveyed. In addition, the survey periodicity has changed – in part, in favour of monthly surveys. The first survey covered survey year 2018.

The data structures of the Energy Balance are adjusted on an ongoing basis, in order to ensure that the best-possible data are provided. These changes are made at relatively large intervals and are documented by the Working Group on Energy Balances (AGEB) in each case:

- Explanations relative to revision of the Energy Balances 2003 – 2006
- Remarks regarding changes in the Energy Balances 2003 through 2007
- Revision of the Energy Balances 2003 through 2009
- Methodological changes in the 2012 Energy Balance
- Explanations relative to the Energy Balances (updated as of November 2015)

In October 2021, the AGEB prepared a report, in compliance with its contract, on "Germany's Energy Balance – required revisions" ("Revisionsbedarf in der Energiebilanz Deutschland") resulting in a fundamental revision of the time series in 2023 and for the 2024 emission reporting (see NID and IIR 2024) [2)].

Quality report of the Working Group on Energy Balances (AGEB) regarding preparation of Energy Balances for the Federal Republic of Germany

Since 2012, the Working Group on Energy Balances (AGEB) has regularly submitted joint quality reports, to the German Environment Agency (UBA), that document its quality-assurance measures in preparation of Energy Balances. As of 2020, in the framework of the contract for the Energy Balances, and in the interest of quality assurance, the Energy Balances are being prepared and provided in a time-series format. This facilitates detection of time-series jumps during compilation of the data.

The following section presents the content of the current report, in its original wording (marked with a different typeface).

Background

In the framework of greenhouse-gas reporting, the National Co-ordinating Committee for the National System of Emissions Inventories has established minimum requirements pertaining to quality control and quality assurance (QC/QA). Those requirements are to be fulfilled on all levels of inventory preparation. One of the most important data sets for determination of greenhouse-gas emissions consists of the Energy Balances for the Federal Republic of Germany, which the Working Group on Energy Balances (AGEB) has been commissioned to prepare. The German Institute for Economic Research (DIW Berlin), the EEFA research institute (Münster) and the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW; Stuttgart) support the AGEB in its work, as sub-contractors. In the current Energy Balance cycle, the German Institute for Economic Research is participating for the last time in preparation of an Energy Balance for Germany. All persons working on Energy Balances are required to comply with minimum requirements pertaining to QC/QA, in areas such as transparency, consistency, comparability, completeness and accuracy.

To document its data sources and quality-assurance measures in preparation of Energy Balances, the Working Group on Energy Balances (AGEB) herewith submits its current quality report to the Federal Environment Agency (UBA). It focuses especially on the 2021 Energy Balance.

Work-sharing in preparation of Energy Balances

The basic working method for preparation of Energy Balances has changed, partly for the reason that revisions of Balance data are pending. Now, the Energy Balances for Germany are now being centrally generated, via a database (which is stored at the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW). The basic responsibilities for the various energy sources / fuels (Energy Environment Forecast and Analysis (EEFA) institute: hard coal, lignite, coking gas, blast furnace gas, basic oxygen furnace gas and mine gas; ZSW: petroleum and petroleum products, natural gas, petroleum gas, and other fuels; office of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat): renewable energies) have not been affected by the change. Also, in connection with its Energy Balance work, the DIW Berlin has coordinated the quarterly estimates of primary energy consumption for the Federal Republic of Germany, and prepared estimates for the energy area “Other.” In this framework, the EEFA research institute is responsible for the fuel “hard coal.” Figures on renewable energies are calculated and published on the basis of the relevant data, in consultation with the office of the Working Group on Renewable Energy Statistics (GS AGEE-Stat).

In February of 2022, EEFA/ZSW prepared an “early-estimate” version of the 2021 Energy Balance (with data available as of 15 February 2022). The 2021 provisional Energy Balance was then submitted in May 2022. In September of the same year, a further 2021 provisional, “early-estimate” Energy Balance was prepared, along with the pertinent evaluation tables. That Balance included data and estimates of the Federal Statistical Office, including data and estimates on development of final energy consumption by industry. In the normal process, data from official Mineral Oil Statistics (AMS) of the Federal Office of Economics and Export Control (BAFA) [3)] are integrated within the petroleum section of the Energy Balance. Those data, covering the previous year, are usually in April.

In February or spring of any given year, important official data sources, such as surveys relative to energy consumption of industrial sectors, are normally not yet available. Consequently, the pertinent data gaps have to be closed with the help of estimates. Understandably, an estimated Energy Balance (or an early-estimate version of the Balance) cannot fulfill the strict data-quality requirements met by the final Energy Balance, which is a work published with a time lag of about one year.

Quality of the data sources used

The following data of the Federal Statistical Office (StaBuA) are used in the preparation of the Energy Balances for the Federal Republic of Germany:

- Annual survey (No. 060) of energy use by manufacturing, mining and quarrying companies,
- Monthly survey (No. 061E) of coal imports,
- Annual survey (No. 062) of heat and electricity generation from geothermal energy,
- Annual survey (No. 063) of production of biofuels,
- Annual survey (No. 064) of generation and use of heat and of heating-network operations,
- Monthly survey (No. 066K) of electricity and heat generation for the public supply,
- Annual survey (No 067) of electricity and heat generation by manufacturing, mining and quarrying companies,

- Monthly survey (No. 068) of the gas supply,
- Annual survey (No. 070) of electricity feed-in, and electricity demand, as recorded by electricity grid operators,
- Annual survey (No. 073) of production, use and supply of sewage gas,
- Annual survey (No. 075) of supply of LP gas,
- Annual survey (No. 082) of gas sales and income in the gas-supply sector,
- Energiesteuerstatistik (energy taxation statistics), Fachserie 14, Reihe 9.3).

The data of the Federal Statistical Office (StaBuA) are subject to official quality requirements. The quality reports of the Federal Statistical Office are available online at (Destatis, 2025) [4)].

In addition, data from the Official Mineral Oil Statistics (AMS) of the Federal Office of Economics and Export Control (BAFA) are applied (BAFA, 2024) [5)].

The AMS, which are published monthly and annually, are a closed, consistent system covering all petroleum production and consumption in Germany. The statistical basis for the AMS consists of the Integrated Mineral Oil Report (Integrierte Mineralölbericht – IM), which is prepared monthly, on the basis of the Act on mineral oil data (Mineralöldatengesetz), with input from companies operating in Germany's petroleum market. The Federal Office of Economics and Export Control (BAFA) reports the pertinent production and consumption data, together with the relevant data of the Federal Statistical Office, to IEA and Eurostat, which publish internationally comparable energy balances. The calorific values for crude oil inputs, and the petroleum products, that are covered by these reports are cross-checked against the national Energy Balance. For the Energy Balance's section on petroleum, both AMS data and data of the Federal Statistical Office are used.

In addition to the available official data, association data are also used. Among the statistics provided by associations, the Statistik der Kohlenwirtschaft (coal-industry statistics; since 2020, available only for lignite) play a special role. The data used for the Energy Balance include the following:

- Data on extraction, production of lignite products, producers' own consumption and sales (form 5), and information from production reports,
- Data on domestic sales / use, broken down by Länder and consumer groups,

The coal-statistics data available in Germany have a semi-official status, and they are very precise and reliable. For more than 60 years, the Statistik der Kohlenwirtschaft coal-sector-statistics association has served as a liaison between coal-sector companies and official producers of statistics. Official coal statistics in this area are based on surveys carried out by the Statistik der Kohlenwirtschaft association. A large portion of the coal data is made publicly accessible on the website http://www.kohlenstatistik.de. The transparency this provides also attests to the reliability and accuracy of these data sources. The Act on Energy Statistics (Energiestatistikgesetz) has no separate paragraph relative to surveys on the domestic coal sector; its refers instead explicitly to the functioning system of coal statistics.

A considerable portion of the data used for preparation of the overall natural-gas balance (Erdgasbilanz) comes from official statistics. In some areas, the data and information provided by official statistics have gaps that have to be closed. This is accomplished with the help of additional association data, as well as of model calculations. For natural gas, associated gas:

- Data on flaring losses are obtained using the implied net calorific value given by the Federal association of the natural gas, oil and geothermal energy industry (BVEG, the former WEG oil and gas industry association). The 2019 Statistical Report (Statistischer Bericht 2019) (page 22) introduced a change in the breakdown of flaring losses into the categores of “routine,” “safety-relevant” and “non-routine.”
- In early Balance years, data on natural gas consumption in the transport sector were derived by Zukunft Erdgas (formerly Erdgas mobil), from data provided by the German Association of Energy and Water Industries (BDEW). Energy tax statistics also yield data for this sector.
- As a result of the change in the statistical report of the Federal association of the natural gas, oil and geothermal energy industry (BVEG), own consumption is now listed as process-related own consumption, i.e. including processing losses, measuring differences and flaring losses. For purposes of preparation of Energy Balances, the BVEG has provided actual-own-consumption figures for the years 2018 through 2020.
- The following additional sources are also used:
- In the framework of monitoring under the CHP act (Kraft-Wärme-Kopplungsgesetz), the Öko-Institut e.V. Institute for Applied Ecology estimates inputs of natural gas, and light fuel oil, for electricity and heat generation in compact gas-/oil- fired CHP systems that are not covered by official statistics.
- Detailed information on how the various data sources are used in preparation of the Energy Balance is provided by the “cookbook” (“Kochbuch”; it contains source information for specific entries in the Balance).

In addition to quality, the important aspects of the available data, relative to preparation of Energy Balances, include their multi-year availability and their standardised, consistent presentations of time series. Such aspects play a critically important role in ensuring that the procedures and methods used for preparation of Energy Balances generate data that can be consistently integrated, without structural discontinuities, in the basic scheme for the Balances. Both the relevant official

sources and the coal statistics data have a long tradition. Where breaks in time series cannot be avoided, as a result of reviews or changes in statistical foundations (for example in the Act on Energy Statistics), such breaks are documented in the sources used for preparation of Energy Balances. This ensures that methods are always properly adjusted.

Transparency of methods and procedures

The Act on Energy Statistics (Energiestatistikgesetz – (EnStatG) entered into force on 1 January 2003. That act consolidates official energy statistics, from different legal frameworks, and adapts them to users' changed information requirements. Since the act's entry into force, the Federal Statistical Office has also collected and provided data for the areas heat market, combined heat / power generation (CHP) and renewable energy sources. As a result of the restructuring, the Federal Statistical Office, in addition to providing data on electricity and heat generation from combined heat / power generation (CHP), also provides data on all fuel inputs for CHP, for both the general public supply and industry (broken down by energy sources).

Such changes in the available statistics have made it necessary to adjust the methods used for the Energy Balances – especially for their descriptions of industrial final energy consumption. As a consequence of the described expansion in the data supply, separate data on fuel inputs as of 2003 for industrial electricity generation – i.e. for electricity-only generation – are now available.

The Federal Statistical Office does not collect data on breakdowns of fuel inputs by “electricity” and “heat” in industrial and public-supply combined heat / power generation (CHP) systems; such statistics are collected by the Working Group on Energy Balances (AGEB) and estimated by institutes it commissions. The “Finnish” method used for such purposes is based on Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004. That method is precisely defined, mathematically, and it is explained in the forewords to the Energy Balances. Currently, it is also explained in the brochure “Energie in Zahlen – Arbeit und Leistungen der AG Energiebilanzen” (“Energy in figures – the work and services of the Working Group on Energy Balances”), p. 10, 11 f.

With regard to quality assurance, the Finnish method makes calculations relative to power/heat production for the public supply and for industry logical and transparent. The necessary pertinent assumptions, such as the reference efficiencies of non-CHP generation as provided in the documentation for the Energy Balances, are stated in the process. In sum, although Energy Balance preparation is a process that makes use of frequently complex transformational methods, its results can still be highly transparent and unambiguous. As a result, all Energy Balance entry fields can always be traced back to their primary statistical foundations. Primary data provided by official or association sources – regardless of its quality – can seldom simply be “plugged into” the Energy Balance without undergoing the statistical processing normally used to prepare the Energy Balances. Description of relevant complex energy flows, using matrices that conform to the formal parameters and methodological specifications for the Energy Balances, and on the basis of statistical raw data, requires numerous transformation steps, recalculations and reallocations. What is more, in some (few) areas of the Energy Balance primary statistics are no longer available, and thus data gaps have to be closed through use of formal estimation methods, applied in accordance with the requirements of each relevant individual case.

Checking and verification of results

Measures for quality assurance and control cover the following areas:

- Assurance of data quality / transparency of methods and procedures,
- Mechanisms for checking and critically reviewing the Energy Balances, measures that assure the Balances' correctness, completeness and consistency,
- Measures for documentation and archiving, designed to ensure the Balances' clarity and reproducibility,
- Expert responsibility for preparation of Energy Balances.

Critical discussion, verification and checking of results take place on various levels: * The involved experts mutually check their work and review it, on the basis of control figures (such as changes emerging year-to-year comparisons, implied calorific values, utilisation levels), for plausibility.

- The time-series consistency is regularly verified. Where a time series shows implausible jumps that cannot be attributed to transfer or calculation errors, and that must be tied to developments in the underlying primary statistics, the problem is discussed constructively with the relevant data-supplying institution (such as the Federal Statistical Office). In preparation of the 2018 Energy Balance, for example, it was seen in the Statistik 064 statistics, with respect to the fuels natural gas, petroleum gas, and light fuel oil, that plants' case numbers had increased, while their fuel inputs had remained at about the same level. This was due to a change of perspective from companies to plants (cf. Table 1 in this regard).

- The Energy Balances are cross-checked against the data provided to IEA/Eurostat.
- In addition, the AGEB member associations carry out supporting checks.
- Furthermore, at early stages data and results are exchanged and discussed with responsible experts of the Federal Environment Agency (UBA), also in consultation with AGEE-Stat.
- Statistical questions pertaining to the Energy Balance are also discussed by the “Working Group on methods” (“Arbeitskreis Methodi”“ – AKM) sited within the Federal Ministry for Economic Affairs and Climate Action (BMWK).

Only when the completed Energy Balance has successfully passed through all controlling bodies is it published on the AGEB's website and are provisional Energy Balance data provided to the Federal Environment Agency for further processing within the system for the national greenhouse-gas inventory. With a view to effective prevention of errors in data calculation and estimation for the Energy Balances, the annual balances are prepared via standardised procedures. To that end, a broad range of instruments has been developed that automate proven estimation procedures, and formal calculation methods, within the context of Energy Balance preparation. This approach, which often permits simple entry of statistical raw data into the suitable calculation tools, largely eliminates calculation and transformation errors. What is more, its use of consistent, standardised methods plays an important role in assuring time-series consistency.

Documentation and archiving

The EEFA research institute, the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) and the German Institute for Economic Research (DIW Berlin) keep detailed, written documentation relative to the annual Energy Balances. The documentation covers every Energy Balance entry, lists the statistical sources and surveys used and precisely describes the calculation methods and procedures used. The purpose of the documentation is to ensure that all steps can be retraced, both by the organisations themselves and by the Federal Ministry for Economic Affairs and Climate Action (BMWK) and the German Environment Agency (UBA). Furthermore, regular updating of the documentation contributes to data quality and helps to assure consistency in time series and methods.

All statistical data, calculation methods and estimation procedures used in preparation of Energy Balances for the Federal Republic of Germany are archived. The electronic data are stored on servers of the ZSW (AGEB database). For archiving of electronic content, the EEFA institute uses a range of computers and removable disk drives, as well as network-base server and cloud-computing solutions. Data back-ups are carried out both automatically and manually (at regular intervals).

Qualified staff

For execution of the service project “Preparation of Energy Balances for the Federal Republic of Germany” (“Erstellen von Energiebilanzen für die Bundesrepublik Deutschland”), the EEFA research institute, ZSW and DIW Berlin rely on experienced staff with solid backgrounds in the areas of statistics, economics and the energy sector.

Explanations regarding the currentness and availability of data for preparation of Energy Balances

Official statistics Since 2022, and in the framework of national inventory preparation, every August the Federal Statistical Office has collected/calculated additional data that enter into the Energy Balance of the previous year (in 2022, therefore, into the 2021 Energy Balance) and the Joint Annual Questionnaire. As a result, official data now become available much earlier than was previously the case. The “cookbook” for the Energy Balance shows, on a specific-cell level, what statistics provided by the Federal Statistical Office, and by BAFA, etc., are used.

Association statistics In the final Energy Balance, gaps in the available official data are closed, at various points, with data provided by associations (see above). Also, thanks to the quarterly estimates that the Working Group on Energy Balances carries out in cooperation with energy industry associations, current data and forecasts are available, on an ongoing basis, relative to the development of primary energy consumption in Germany.

The BDEW provides important provisional data, dated as of May and August, that are also of relevance to final energy consumption as recorded in the estimate Balance. Every summer, that organisation publishes data under the heading “The German energy market – facts and figures on the gas, electricity and district-heating sectors” (“Energiemarkt Deutschland – Zahlen und Fakten zur Gas-, Strom- und Fernwärmeversorgung”). In addition, the estimated Energy Balance incorporates BDEW data on gross electricity generation, data of Statistik der Kohlenwirtschaft coal-industry statistics, and data of the Fuels&Energy industry association (Wirtschaftsverband Fuels&Energie – en2x, formerly Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry).

Ongoing early estimate of the German Energy Balance, beginning in February of the following year

The fact that the early estimate of the complete German Energy Balance for the previous year now becomes available as of 15 February of each year must be seen as a significant improvement, schedule-wise, in the availability of complete energy data. The early estimate of the Energy Balance is not based solely on the energy data that are available at the time it is produced; extensive portions of the early Balance (such as those covering final energy consumption) are also based on formal forecasting procedures (models).

Details on the approach used in preparing the early estimate of the German Energy Balance are provided in the UBA study “Pilotprojekt zur Frühschätzung der Energiebilanz 2020 und Vergleich zu späteren definierten Datenständen” (“Pilot project on the early estimate of the 2020 Energy Balance, and comparison with later defined data inventories”) from Buttermann & Nieder (2023) [6)].

The most-current early estimate of the Energy Balance for the 2022 reporting year will be provided to the Federal Ministry for Economic Affairs and Climate Action (BMWK) on 15 February 2023.

Other data

All renewable-energies-trends data that are used in Energy Balance preparation are obtained from calculations of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat).

Figures for electricity generation and fuel inputs in small CHP systems fired with natural gas and HEL (< 1 MW) were calculated with data the BHKW (compact combined heat-and-power (CHP) generating systems) database of the Öko-Institut e.V. Institute for Applied Ecology. The same data are used for reporting in the IEA/Eurostat context. Data on use of petroleum coke in metallurgical coking plants are provided for the Federal balance by the relevant German Länder, on the basis of an agreement between the Working Group on Energy Balances (AGEB) and the Länder working group on Energy Balances (Länderarbeitskreis Energiebilanzen).

[1)] AGEB (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-1990-bis-2030/?wpv-jahresbereich-bilanz=2021-2030, Köln & Berlin, 2025

[2)] AGEB (2021): Germany's Energy Balance – required revisions (Revisionsbedarf in der Energiebilanz Deutschland): special report of the Working Group on Energy Balances (AGEB), https://ag-energiebilanzen.de/wp-content/uploads/2023/11/AGEB_InfoAusgabe-3-2023.pdf; 2021

[3), 5)] BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Infothek zu den Amtlichen Mineralöldaten für die Bundesrepublik Deutschland; URL: https://www.bafa.de/SiteGlobals/Forms/Suche/Infothek/Infothek_Sucheinstieg_Rechtsgrundlagen_Formular.html?nn=1468600&sortOrder=dateOfIssue_dt+desc, Eschborn, 2024.

[4)] Destatis (2025): Federal Statsitical Office (Statistisches Bundesamt - Destatis):Quality Reports (Qualitätsberichte: https://www.destatis.de/DE/Methoden/Qualitaet/Qualitaetsberichte/Energie/einfuehrung.html, Wiesbaden, 2025

[6)] Buttermann, H.-G. & Nieder, Th. (2023): Pilot project on the early estimate of the 2020 Energy Balance, and comparison with later defined data inventories (Pilotprojekt zur Frühschätzung der Energiebilanz 2020 - Berechnung einer vorläufigen Version der Energiebilanz zum Berichtsjahr 2020 und Vergleich zu späteren definierten Datenständen); https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/texte_18-2023_pilotprojekt_zur_fruehschaetzung_der_energiebilanz_2020.pdf; UBA-Texte 18/2023 on order of the Umweltbundesamt, Dessau-Roßlau, Januar 2023

Appendix 5 - Verification with Independent Data

5.1 Introduction

Four independent datasets were used for the verification work for the German Informative Inventory Report (IIR). The selection of these verification data were carried out on the basis of broadly accepted, independent data similar to the good guidelines for verification in the 2019 refinements of the IPCC guidelines for verification (Romano et al., 2019)[1)].

The first recommended dataset is the air-pollution (AP) dataset of the Emission Database for Global Atmospheric Research (EDGAR) of the JRC (Crippa et al., 2023)[2)], which is a worldwide gold standard source of data for global and local air-quality modelling. It contains standard air-pollutants, such as NO_2 or NMVOC. Data for several heavy metals species are, however, missing in this dataset. The second source of data is the mass median data for the German data from the European moss survey (Schröder and Nickel, 2019)[3)], which is also part of the monitoring carried out at the Umweltbundesamt in Germany. Here the median of the mass fraction in moss for each heavy metal species is compared to the reported inventory data. The third dataset used is the Pollution Release and Transfer Register (PRTR) (Umweltbundesamt, 2025)[4)]. Details for the PRTR data, as well as the database may be found under: https://thru.de/thrude/. Here analysis has been split into two parts, first the heavy metal air-pollutants and secondly the ordinary air-pollutants, due to their different mass in the reporting tables.

The most important, modern dataset used in the verification work is available via the Copernicus Atmospheric Monitoring Service, Atmospheric Datastore (CAMS-ADS), which are the CAMS global reanalysis (EAC4) monthly averaged field (ECMWF, 2024)[5)]. Details of these dataset are detailed in (Inness et al., 2019)[6)]. These data provide monthly averaged fields for standard air-pollutants such as NO_2, or particulate matter. Data for more insight into the distribution of heavy metal species are, however, missing.

Time series data from all the four datasets are compared to the reported national inventory data time series on the basis of the national totals for Germany. This is done in a visual-quantitative way using plots of the time series data of the national totals, as well as scatter plots between the reported national totals and each of the four sets of data. In addition a quantitative analysis in form of correlation is carried out using standard mathematical similarity operators such as the Pearson and Spearman-Rank correlations, which are widely used to compute similarity between two mathematical vectors. The overall goal is to offer a semi-quantitative and qualitative comparison between the reported national totals of air pollution species and the independent datasets using time-series data. A direct sector-based comparison has not been considered, yet, as only EDGAR and PRTR data would offer a sectoral disaggregation of the national total data.

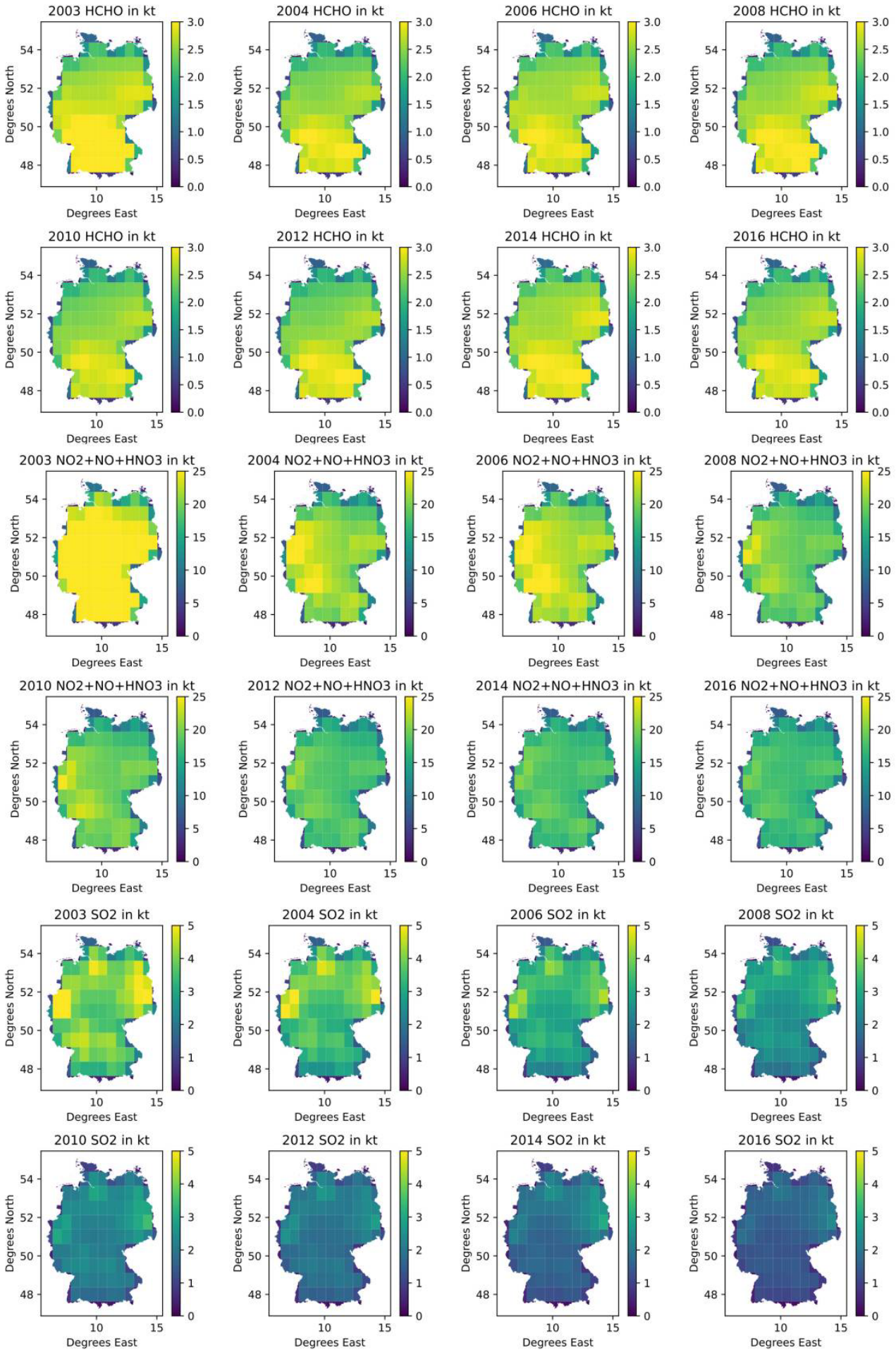

2003 HCHO in kt
2004 HCHO in kt
2006 HCHO in kt
2008 HCHO in kt
2010 HCHO in kt
2012 HCHO in kt
2014 HCHO in kt
2016 HCHO in kt
2003 NO2+NO+HNO3 in kt
2004 NO2+NO+HNO3 in kt
2006 NO2+NO+HNO3 in kt
2008 NO2+NO+HNO3 in kt
2010 NO2+NO+HNO3 in kt
2012 NO2+NO+HNO3 in kt
2014 NO2+NO+HNO3 in kt
2016 NO2+NO+HNO3 in kt
2003 SO2 in kt
2004 SO2 in kt
2006 SO2 in kt
2008 SO2 in kt
2010 SO2 in kt
2012 SO2 in kt
2014 SO2 in kt
2016 SO2 in kt
Degrees North
Degrees East

Figure 4: This is an example of the CAMS-EAC4 monthly data provided by ECMWF atmospheric datastore aggregated to the respective years shown in the figure.

5.2 Methods and Materials

Each of the four datasets require separate analysis using specialized python scripts, that have been developed for this verification work. The EDGAR spreadsheet data was used for the extraction of the EDGAR-AP national totals for Germany (Crippa et al., 2023)[7)]. PRTR data were used in form of an sql-database file, which offers all the national reported data on large point sources (Umweltbundesamt, 2025)[8)]. CAMS data from the European Centre for Medium-Range Weather Forecasts (ECMWF) were used, which are available in monthly slices in netcdf-Format (Inness et al., 2019)[9)]. Data from the German part of the European moss survey (Schröder et al., 2019))[10)] was kindly provided by Gudrun Schütze from the Umweltbundesamt.

5.2.1 The EDGAR AP Inventory

EDGAR Inventory Data and its database (Crippa et al., 2023)[11)] are available from the Joint Research Center (JRC) of the European Commission. We used the version 8.1 air-pollution database, which offers annual totals of major air pollutants, as well as gridded emissions, for air pollution modelling. National totals of air-pollutants (AP) were extracted from the EDGAR spreadsheets for verification. The air-pollutants offered in the database are NO_2, PM_{10}, $PM_{2.5}$, SO_2, CO, NMVOC and NH_3. The current EDGAR timeseries (Crippa et al., 2023)[12)] covers the time period from 1970 until 2023. The EDGAR AP inventory is frequently update on a longer product cycle.

5.2.2 The CAMS EAC4 data

The CAMS global reanalysis data products are available from the ECMWF Atmospheric Composition Reanalysis (EAC4) process. They are available as either daily or monthly (ECMWF, 2024)[13)] data products in either single, or multi-level variants. More detail on the data products and their generation can be found in (Inness et al., 2019)[14)].

For the verification work presented here the 0.75°x0.75° monthly averaged fields data product was used, which is available for the time-period from 2003 till 2022. Therefore, we used the time-period from 2005 until 2022 for comparison to the German inventory data. The update frequency of this monthly dataset is every six months, carried out by the ECMWF. The CAMS monthly dataset offers total column values for the following major air-pollutants (NO_2, PM_{10}, $PM_{2.5}$, SO_2 and several species of NMVOC such as HCHO), which were used in the following for a comparison to the national total values for Germany. An example of the monthly data aggregated to the respective year can be seen in figure 1.

5.2.3 The Pollution Release and Transfer Register

The PRTR database is an SQL-Database file, which is available for download at the domain thru.de. The data is compiled and curated by the Umweltbundesamt in Germany. It compiles data, which are reported for the large emission sources in Germany, which are e.g.: power plants, smelters, or plants from the chemical industry. The European Union Regulation No 166/2006 on the establishment of a PRTR register governs the process of PRTR data compilation.

A modified Python script was used, to extract data from the PRTR database. The tool is based on the PRTR reporting tool of (Hausmann, Zagorski and Mielke, 2021)[15)]. Figure 2 shows the data of PRTR point sources extracted from the PRTR database file for visualization. We used the PRTR data from 2007 till 2018 for our verification work for the air pollutants: CO, NO_2, SO_2, NMVOC, PM_{10} and NH_3. Data from the heavy-metals species: Cd, Ni, Zn, As, Hg, Cr, Cu and Pb were also used for the here presented verification work of the national totals of Germany.

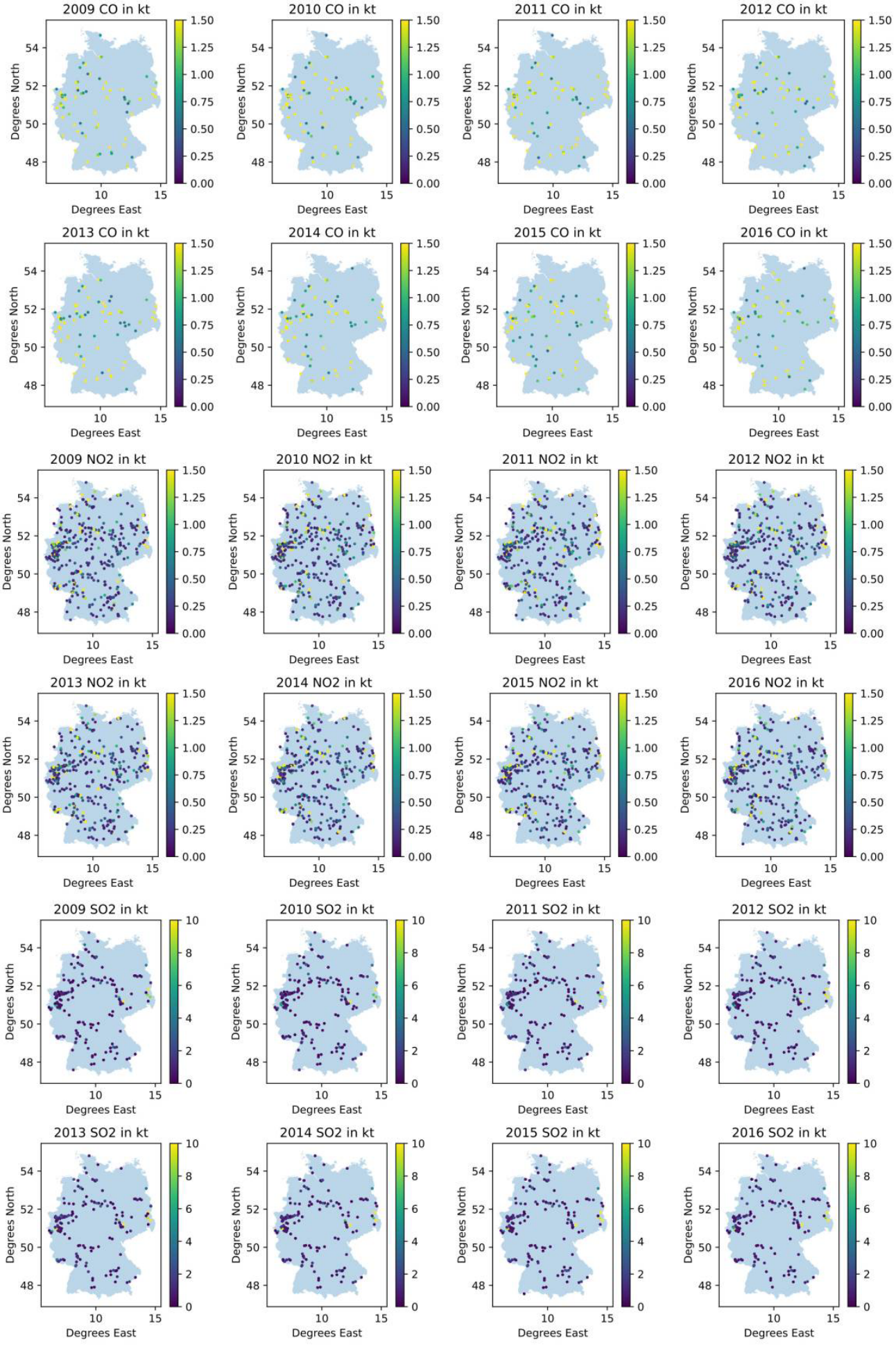

2009 CO in kt
2010 CO in kt
2011 CO in kt
2012 CO in kt
2013 CO in kt
2014 CO in kt
2015 CO in kt
2016 CO in kt
2009 NO2 in kt
2010 NO2 in kt
2011 NO2 in kt
2012 NO2 in kt
2013 NO2 in kt
2014 NO2 in kt
2015 NO2 in kt
2016 NO2 in kt
2009 SO2 in kt
2010 SO2 in kt
2011 SO2 in kt
2012 SO2 in kt
2013 SO2 in kt
2014 SO2 in kt
2015 SO2 in kt
2016 SO2 in kt
Degrees North
Degrees East

Figure 5: This is an example of the PRTR data extracted from the PRTR database for the years and substances shown.

5.2.4 The German Moss Survey Data

Data from the German Moss survey, which is carried out within the larger context of the European moss survey (Frontasyeva et al. 2020)[16]; (Schröder et al., 2019)[17] is also used for verification of the temporal trend of heavy metals in the German inventory. This survey is carried out every 5 years. It has been conducted since 1990. The time series for Germany currently covers 1990, 1995, 2000, 2005 and 2015. The data is sampled in a specified grid following a specific methodology detailed in (Schröder and Nickel, 2019)[18] and (Schröder et al., 2019)[19].

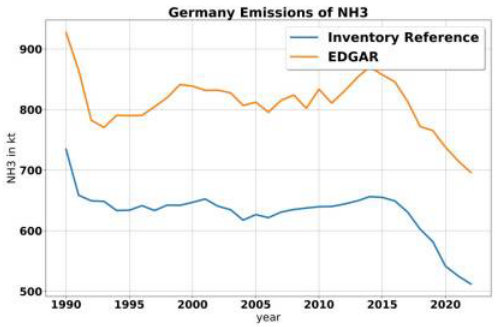
5.3 Analysis

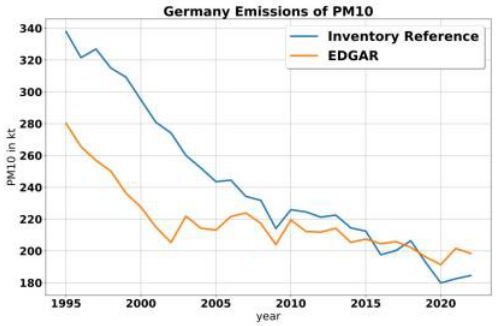
The analysis of the data for the national totals is carried out on the available time-series/air-pollutant species data, as offered by the four datasets. Therefore, the temporal resolution and series length is dependant on the verification data offered. Only those timestamps matching, with the reported national totals for Germany could be compared. Figure 1 and figure 2 are visual examples of the CAMS and PRTR data of Germany, to illustrate the spatial distribution of the data. Pearson and the spearman-rank correlation were computed for each, individual time-series pair (verification data and reported national total). These standard similarity measures were computed, to quantify the similarity between the temporal trends of the individual air-pollutant dataset.

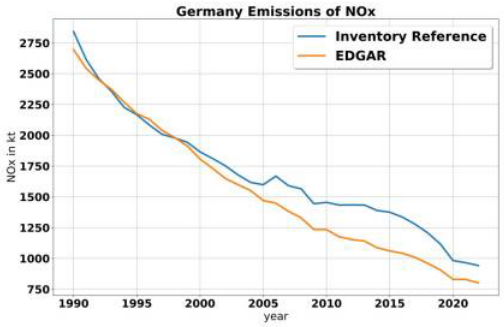
5.3.1 The EDGAR AP Inventory

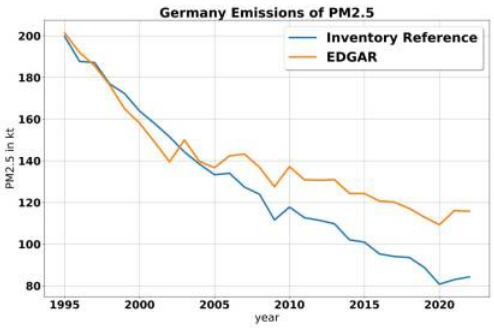
EDGAR data was extracted from the national totals spread-sheets, offered as download from the JRC (Crippa et al., 2023)[20] using python scripts. The national totals for Germany were extracted as individual time series for the respective air pollutants (NO_2, PM_{10}, $PM_{2.5}$, SO_2, CO, BC, NMVOC, and NH_3).

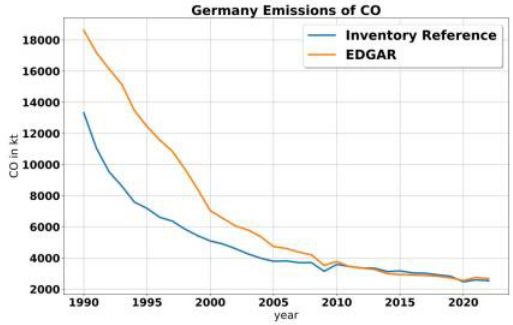
The EDGAR data for the eight AP species and a scatter plot are shown in figure 3. The orange line depicts the time series from the EDGAR national total, whilst the blue line illustrates the national total from the German inventory, together with a scatterplot of all eight individual AP species.

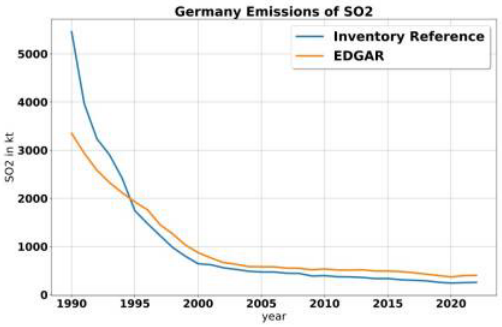

Germany Emissions of NH3
Inventory Reference
EDGAR
NH3 in kt
year

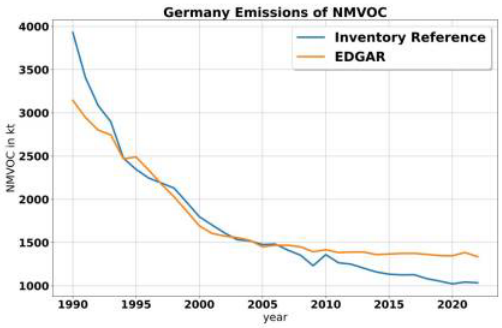

Germany Emissions of PM10
Inventory Reference
EDGAR
PM10 in kt
year


Germany Emissions of NOx
Inventory Reference
EDGAR
NOx in kt
year


Germany Emissions of PM2.5
Inventory Reference
EDGAR
PM2.5 in kt
year


Germany Emissions of CO
Inventory Reference
EDGAR
CO in kt
year


Germany Emissions of SO2
Inventory Reference
EDGAR
SO2 in kt
year


Germany Emissions of NMVOC
Inventory Reference
EDGAR
NMVOC in kt
year

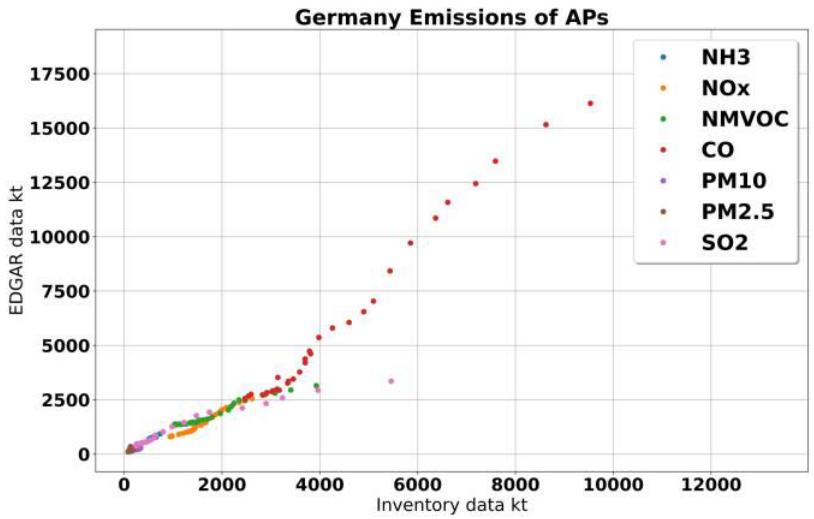
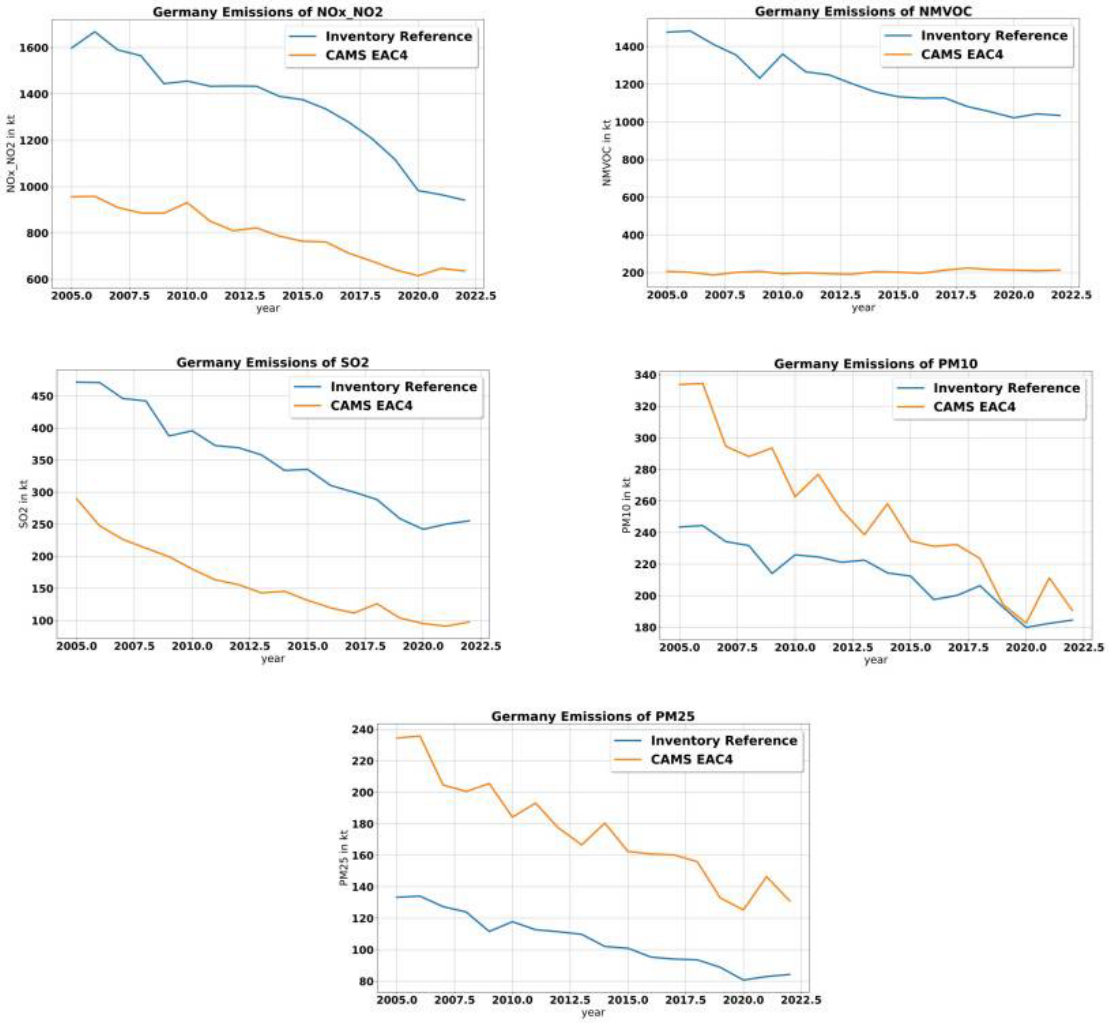

Germany Emissions of APs
NH3
NOx
NMVOC
CO
PM10
PM2.5
SO2
EDGAR data kt
Inventory data kt

Figure 6: The upper images show EDGAR time series data plotted versus the reported inventory data of Germany. The lowermost image illustrates the correlation between each of the reported time-series with the respective EDGAR data.

5.3.2 The CAMS EAC4 Data

The monthly averaged CAMS EAC4 data has been aggregated to the spatial scale of Germany with the help of a spatial vector data file, which symbolizes the country area of Germany (Patterson and Kelso, 2022)[21)]. It has been intersected with the CAMS EAC4 data, enabling the cropping of the data pixels to the shape of Germany. The equal earth projection of (Šavrič, Patterson and Jenny, 2019)[22)] was used after this procedure to calculate the area of each cell in-order to convert the CAMS EAC4 field data to mass per pixel and month. These monthly time slices were summed up for all twelve months to retrieve the national total for the respective AP species of each year. The data is shown in figure 4.



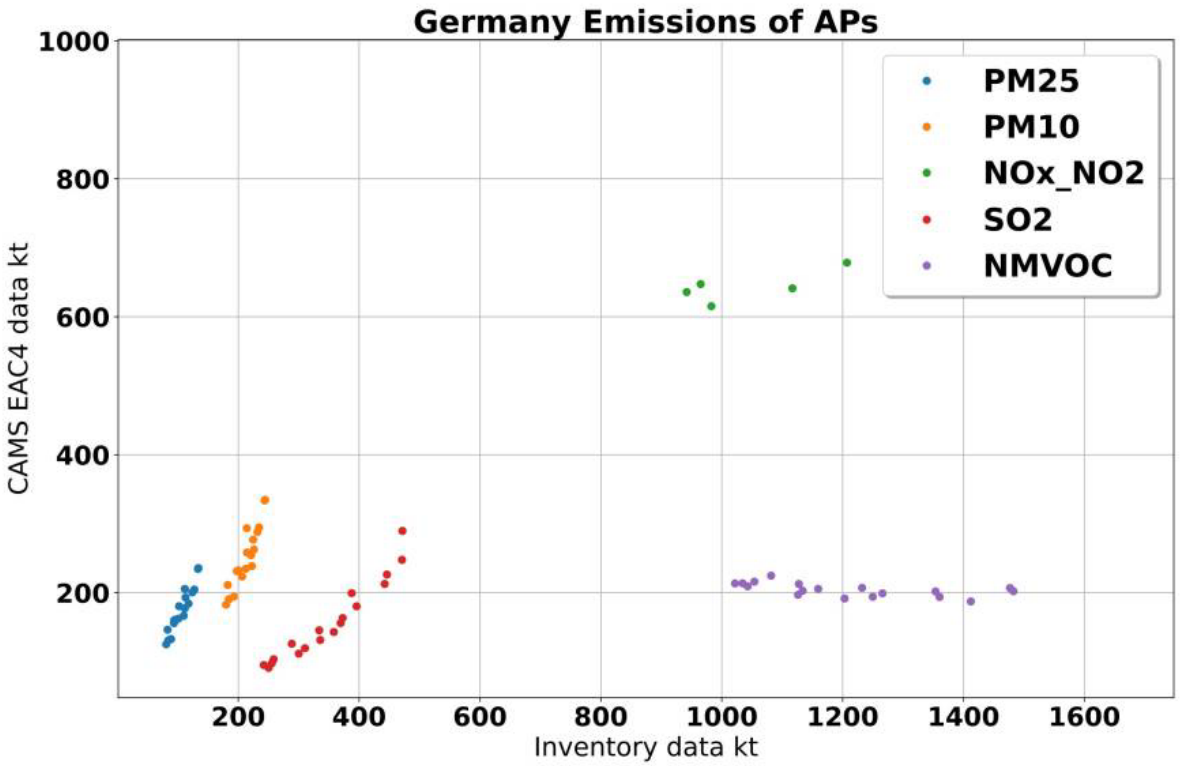
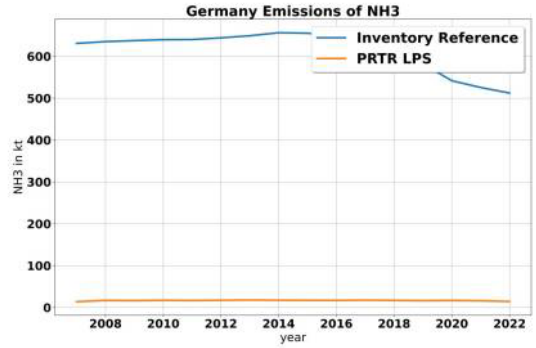


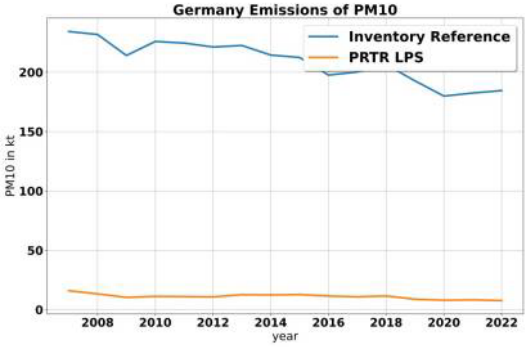
Figure 7: The upper images show yearly aggregated CAMS time series data plotted versus the reported inventory data of Germany. The lowermost image illustrates the correlation between each of the reported time-series with the respective

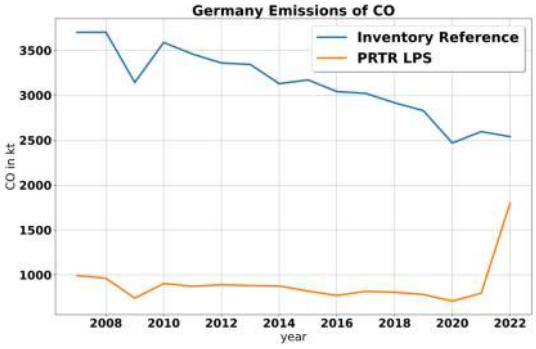
CAMS data.

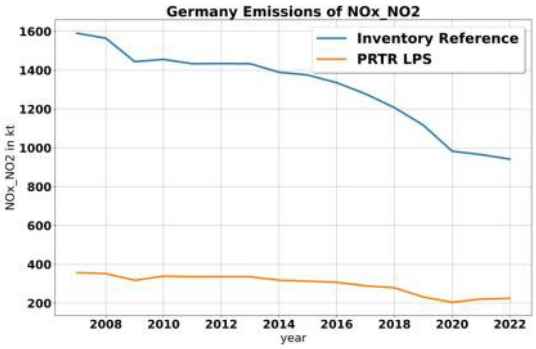
5.3.3 The Pollution Release and Transfer Register

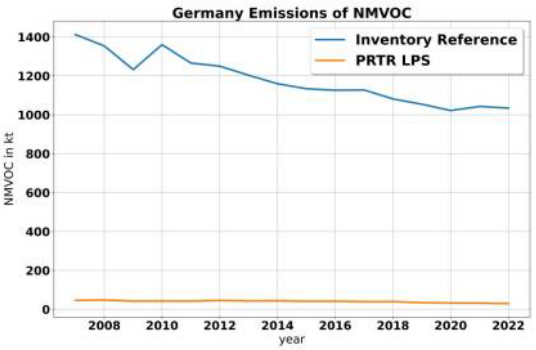
The PRTR database is an SQL-Database file, which is available for download at the domain thru.de. The data is compiled and curated by the Umweltbundesamt in Germany. It compiles data, which are reported for the large emission sources in Germany, which are e.g.: power plants, smelters, or plants from the chemical industry. The European Union Regulation No 166/2006 on the establishment of a PRTR register governs the process of PRTR data compilation. A modified Python script was used, to extract data from the PRTR database. The tool is based on the PRTR reporting tool of (Hausmann, Zagorski and Mielke, 2021)[23)]. Figure 2 shows the data of PRTR point sources extracted from the PRTR database file for visualization. We used the PRTR data from 2007 till 2022 for our verification work for the air pollutants: CO, NO_2, SO_2, NMVOC, PM_{10} and NH_3. Data from the heavy-metals species: Cd, Ni, Zn, As, Hg, Cr, Cu and Pb were also used for the here presented verification work of the national totals of Germany.

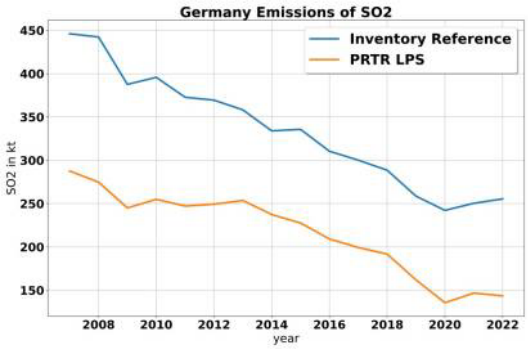

Germany Emissions of NH3
Inventory Reference
PRTR LPS
NH3 in kt
year


Germany Emissions of PM10
Inventory Reference
PRTR LPS
PM10 in kt
year


Germany Emissions of CO
Inventory Reference
PRTR LPS
CO in kt
year


Germany Emissions of NOx_NO2
Inventory Reference
PRTR LPS
NOx_NO2 in kt
year


Germany Emissions of NMVOC
Inventory Reference
PRTR LPS
NMVOC in kt
year


Germany Emissions of SO2
Inventory Reference
PRTR LPS
SO2 in kt
year

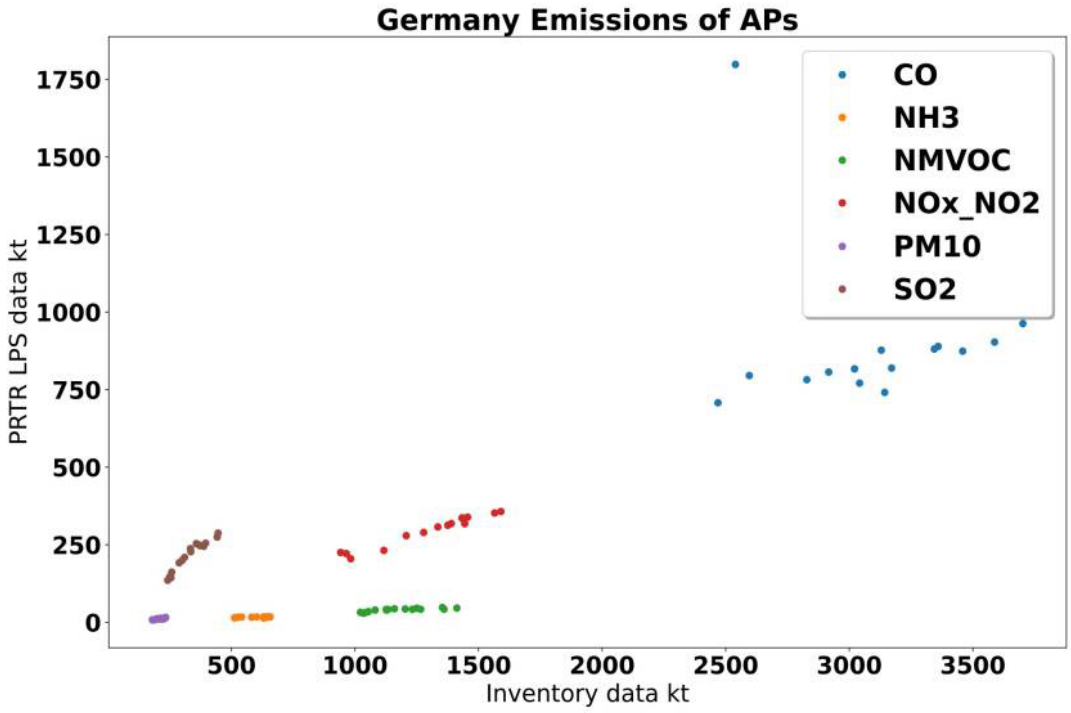
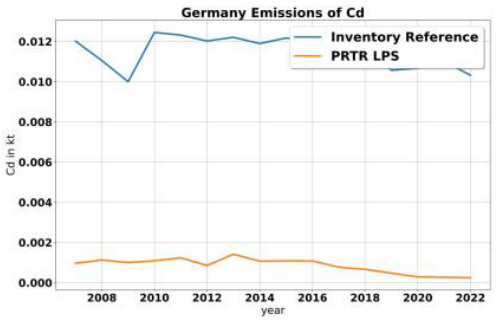
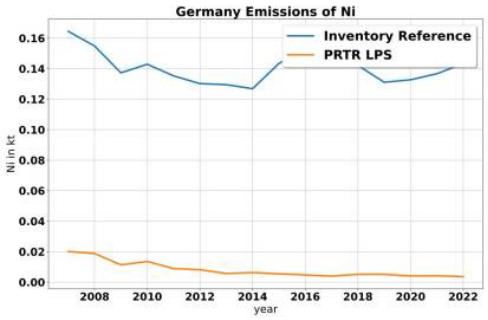
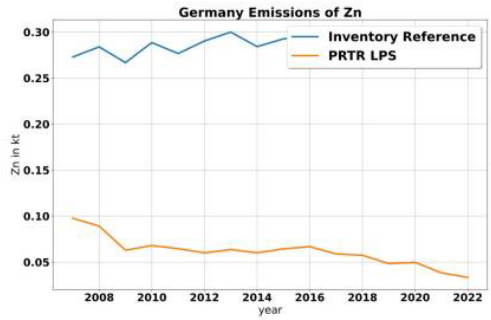
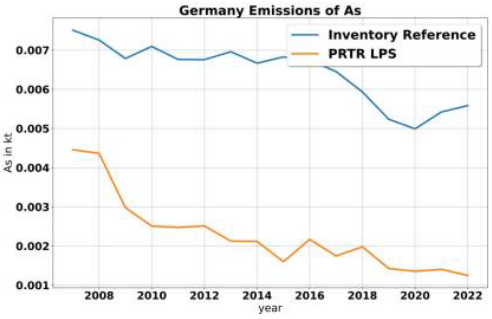

Germany Emissions of APs
CO
NH3
NMVOC
NOx_NO2
PM10
SO2
PRTR LPS data kt
Inventory data kt

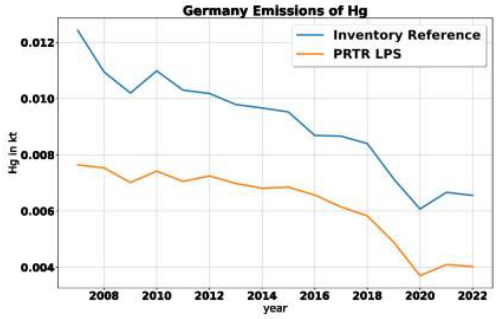
Figure 8: The upper images show yearly time series data for air-pollutants extracted from the PRTR database plotted versus the reported inventory data of Germany. The lowermost image illustrates the correlation between each of the reported time-series with the respective AP species from the PRTR data.

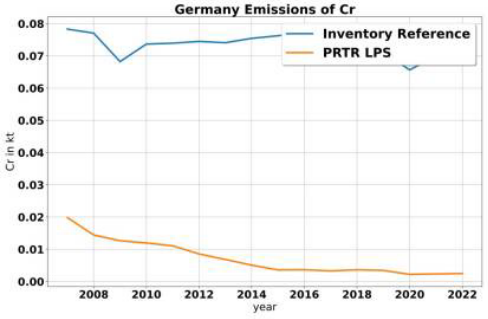

Germany Emissions of Cd
Inventory Reference
PRTR LPS
Cd in kt
year

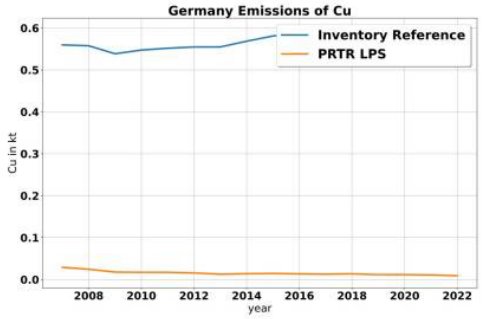

Germany Emissions of Ni
Inventory Reference
PRTR LPS
Ni in kt
year

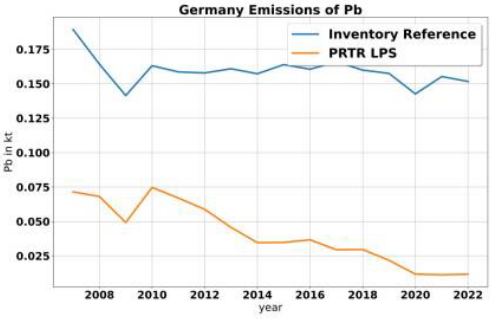

Germany Emissions of Zn
Inventory Reference
PRTR LPS
Zn in kt
year


Germany Emissions of As
Inventory Reference
PRTR LPS
As in kt
year


Germany Emissions of Hg
Inventory Reference
PRTR LPS
Hg in kt
year


Germany Emissions of Cr
Inventory Reference
PRTR LPS
Cr in kt
year


Germany Emissions of Cu
Inventory Reference
PRTR LPS
Cu in kt
year


Germany Emissions of Pb
Inventory Reference
PRTR LPS
Pb in kt
year

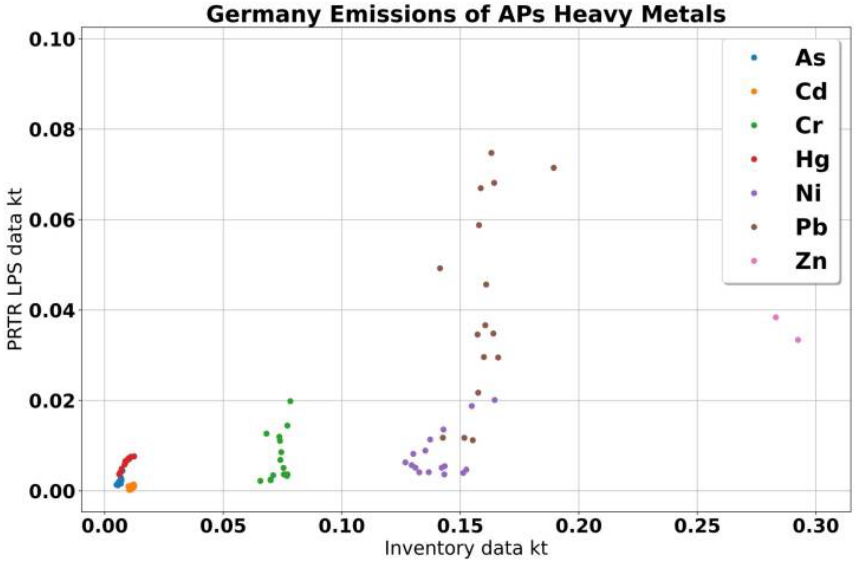

Germany Emissions of APs Heavy Metals
As
Cd
Cr
Hg
Ni
Pb
Zn
PRTR LPS data kt
Inventory data kt

Figure 9: The upper images show yearly time series data for heavy metals extracted from the PRTR database plotted versus the reported inventory data of Germany. The lowermost image illustrates the correlation between each of the reported time-series with the respective HM species from the PRTR data.

5.3.4 The German Moss Survey Data

Data from the German Moss survey, which is carried out within the larger context of the European moss survey (Frontasyeva et al. 2020; Schröder et al., 2019) is also used for verification of the temporal trend of heavy metals in the German inventory. This survey is carried out every 5 years. It has been conducted since 1990. The time series for Germany currently covers 1990, 1995, 2000, 2005 and 2015. The data is sampled in a specified grid following a specific methodology detailed in (Schröder and Nickel, 2019)[24] and (Schröder et al., 2019)[25]. Here the median for each heavy metal species per year was calcluated and compared to the reported heavy metal emission value of that year as shown below in figure 7.

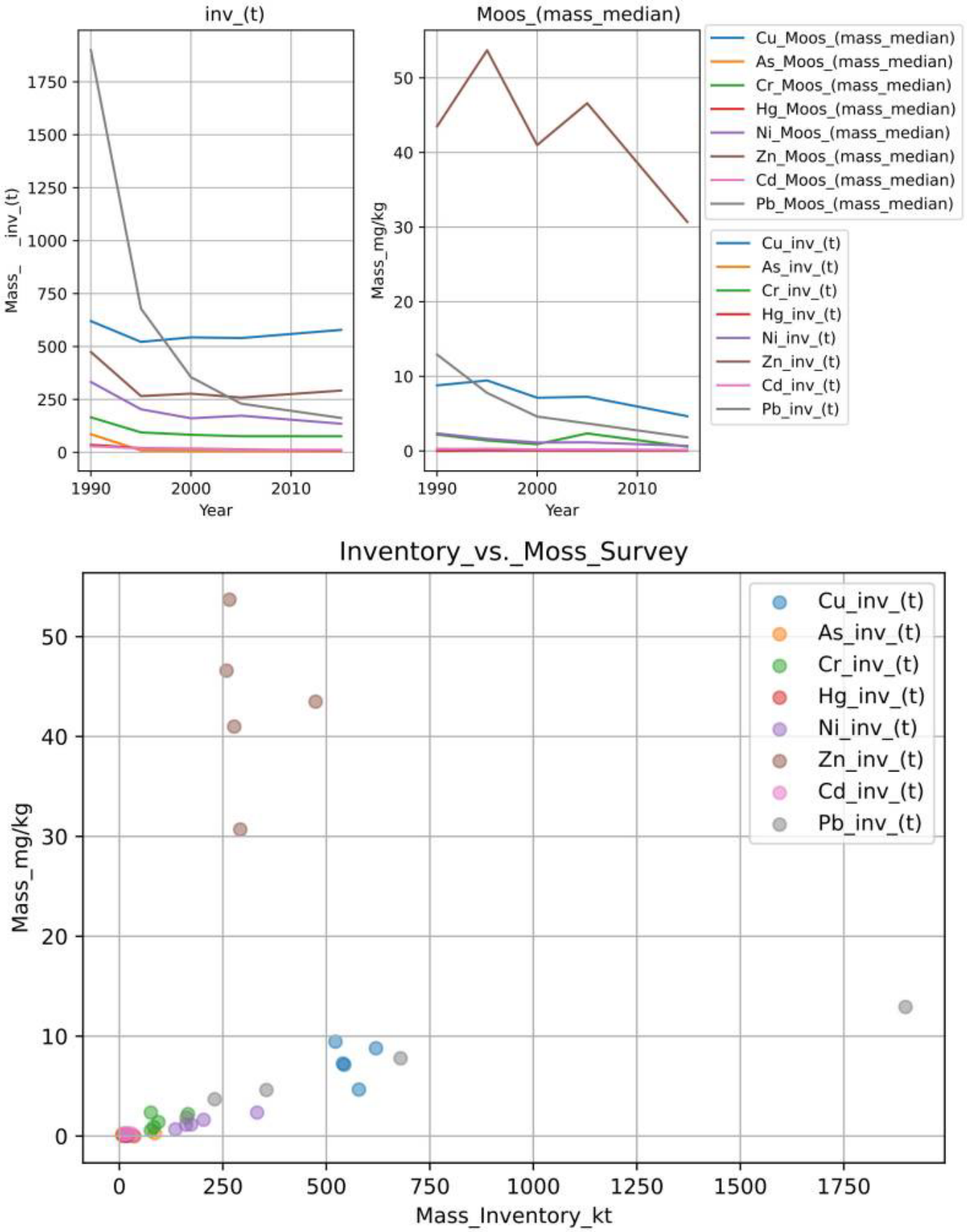


Figure 10: The upper images show yearly time series data for heavy metals extracted from the German moss survey plotted versus the reported inventory data of Germany. The lowermost image illustrates the correlation between each of the reported time-series with the respective HM species from the heavy metal moss data.

5.4 Results and Discussion

The trend data in figures 3-7 show an overall good agreement of the national totals from the verification data with the national inventory data in the time series, as well as scatter plots. Individual differences in the four datasets for specific air-pollutants are discussed below.

EDGAR	substance	pearson	spearman	MOSS	substance	pearson
NH3	NH3	0.8922	0.74098	Cu	Cu	-0.135
NOx	NOx	0.9873	0.9977	As	As	0.747
NMVOC	NMVOC	0.981	0.98162	Cr	Cr	0.491
CO	CO	0.9785	0.995	Hg	Hg	-0.798
PM10	PM10	0.2651	0.66644	Ni	Ni	0.97
PM2.5	PM2.5	0.375	0.7721	Zn	Zn	-0.0949
SO2	SO2	0.974	0.9987	Cd	Cd	0.617
PRTR	substance	pearson	spearman	Pb	Pb	0.969
As	As	0.7634	0.8265	CAMS	substance	pearson
CO	CO	-0.1364	0.56471	PM25	PM25	0.949
Cd	Cd	0.6262	0.67353	PM10	PM10	0.923
Cr	Cr	0.333	0.3912	Nox_NO2	Nox_NO2	0.945
Cu	Cu	-0.11934	-0.10882	SO2	SO2	0.96
Hg	Hg	0.9594	0.9853	HCHO	HCHO	-0.58
NH3	NH3	0.50757	0.6588			
NMVOC	NMVOC	0.82589	0.8912			
NOx_NO2	NOx_NO2	0.981	0.95588			
Ni	Ni	0.54549	0.0882			
PM10	PM10	0.83589	0.7294			
Pb	Pb	0.5	0.526471			
SO2	SO2	0.96571	0.96471			
Zn	Zn	-0.2274	-0.2			

Figure 11: Here the tabulated results for the correlation analysis between the individual datasets and the respective reported emissions time series are shown as individual blocks.

5.4.1 The EDGAR Inventory

The EDGAR inventory usually is in good agreement with the national inventory data as shown in figure figure 3. Close, almost perfect matches of the EDGAR national totals with the reported inventory data can be found in case of SO_2, NMVOC, NO_2, $PM_{2.5}$ and PM_{10}. Slight deviations with a convergence around 2015 exist for CO. Ammonia data from EDGAR are considerably higher than the reported national totals (~200 kt difference). This needs to be further investigated in future disaggregated, detailed analysis, which is not offered in this report, yet. The scatterplot shows similar exceptional correlations between the EDGAR data and the reported national totals of Germany as shown in the lowermost figure of figure 3. The correlation values for the individual time series of the EDGAR data towards the inventory data can be found in figure 8. Here correlation values are relatively high above 0.8-0.9 with the already discussed exception of the ammonia data, as shown in figure 3.

5.4.2 The CAMS EAC4 Data

The CAMS EAC4 data shows very high correlation values to the reported national totals as shown in figure 8., all correlation values are above 0.9 with the exception of formaldehyde (HCHO). The low values here for formaldehyde are compared to the much higher national total values for NMVOC. This shows that formaldehyde is anticorelated with NMVOC in case of Germany.

$PM_{2.5}$ and PM_{10} values of the EAC4 data show a good agreement to the trend of the national totals of Germany as shown in figure figure 4, however, both species show an offset.

5.4.3 The Pollution Release and Transfer Register

Data for PM_{10}, NO_2 and SO_2 are well correlated with the reported emissions with correlation values above 0.9 as shown in figure 8. This is also shown in the scatterplots and trend diagrams of figure 5. NMVOC and CO show moderate correlation values above 0.5. For the heavy metals As and Hg correlation values above 0.8 are shown in figure 8, whilst only moderate correlation values exist for Pb and Ni (around 0.5), whilst Cu, Cr, Zn show almost no correlation, which is also visible in the scatter plot of figure 6.

5.4.4 The German Moss Survey Data

The moss survey data shows exceptional high correlation values (above 0.97) for As, Ni and Pb, as illustrated in figure 8, whilst data for Cd shows only values around 0.87. All other correlation values are considerably lower. Figure 7 shows the similar picture in the accompanying scatterplot.

References

[26] [27] (Accessed: 27 February 2022).)] [28] [29] [30] [31] [32] [33] [34] [35] [36]

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[1], [31] Romano, D. et al. (2019) 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories — IPCC General Guidance and Reporting. General Guidance and Reporting Volume 1. IPCC. Available at: https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/ (Accessed: 8 January 2022).
[2], [7], [11], [12], [20], [26] Crippa, M. et al. (2023) 'EDGAR v8.1 Global Air Pollutant Emissions'. Available at: https://edgar.jrc.ec.europa.eu/index.php/dataset_ap81 (Accessed: 27 February 2025).
[3], [18], [24], [34] Schröder, W. and Nickel, S. (2019) 'Spatial structures of heavy metals and nitrogen accumulation in moss specimens sampled between 1990 and 2015 throughout Germany', Environmental Sciences Europe, 31(1), p. 33. doi:10.1186/s12302-019-0216-y.
[4], [8], [35] Umweltbundesamt (2025) Thru.de, Pollution Release and Transfer Register (PRTR). Available at: https://thru.de/wp-content/uploads/2024/06/PRTR_20231120_de.zip (Accessed: 24 Jamuary 2025).
[5], [13], [27] CAMS global reanalysis (EAC4) monthly averaged fields, Copernicus ADS. Available at: https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4-monthly?tab=overview
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[15], [23], [28] Hausmann, K., Zagorski, A. and Mielke, C. (2021) Convert ePRTR data to CLRTAP LPS submission. Umweltbundesamt (EPA Germany), V1.6 - Emission situation. Available at: https://gitlab.opencode.de/uba-emsit/reporting/eprtr2lps (Accessed: 24 September 2024).
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[21], [30] Patterson, T. and Kelso, V. (2022) Natural Earth - Free vector and raster map data at 1:10m, 1:50m, and 1:110m scales. Available at: https://www.naturalearthdata.com/ (Accessed: 8 January 2022).
[22], [32] Šavrič, B., Patterson, T. and Jenny, B. (2019) 'The Equal Earth map projection', International Journal of Geographical Information Science, 33(3), pp. 454–465. doi:10.1080/13658816.2018.1504949.

DOWNLOADS & LINKS

Additional information availabke from this site include **previous Submissions** (NFR Tables, IIRs, Adjustment Apllications), **Review Reports** (UNECE Stage 3, NEC, Adjustments) and pollutant-specific **uncertainty spreadsheets** (for current submission).

As time allows, further additional and background information will be included here to improve transparency not only for the annual review activities.

INVENTORY SUBMISSIONS

	NFR TABLES	IIR		ADJUSTMENTS	
		pdf	link	Application	Additional Info
Submission 2025	NFR 2025 @ CDR	IIR 2025	IIR 2025	*No adjustments applied.*	
Submission 2024	NFR 2024 @ CDR	IIR 2024	IIR 2024	*No adjustments applied.*	
Submission 2023	NFR 2023 @ CDR	IIR 2023	IIR 2023	*No adjustments applied.*	
Submission 2022	NFR 2022 @ CDR	IIR 2022	IIR 2022	*No adjustments applied.*	
Submission 2021	NFR 2021 @ CDR	IIR 2021	IIR 2021	Approval	
Submission 2020	NFR 2020 @ CDR	NA	IIR 2020	Approval	
Submission 2019	NFR 2019 @ CDR	NA	IIR 2019	Approval	
Submission 2018	NFR 2018 @ CDR	NA	IIR 2018	Approval	
Submission 2017	NFR 2017 @ CDR	NA	NA	Approval	
Submission 2016	NFR 2016 @ CDR	NA	NA		
Submission 2015	NFR 2015 @ CDR	NA	NA		
Submission 2014	NFR 2014 @ CDR	NA	NA		

REVIEW RESULTS

	CLRTAP	NEC	NEC Adjustments
Submission 2024	*ongoing*	*ongoing*	*No adjustments applied.*
Submission 2023	Stage 3 Report 2023	Review Report 2023	*No adjustments applied.*
Submission 2022	Stage 3 Report 2022	Review Report 2022	*No adjustments applied.*
Submission 2021	*No Stage 3 Review applied.*	Review Report 2021	NA
Submission 2020	*No Stage 3 Review applied.*	Review Report 2020	NA
Submission 2019	*No Stage 3 Review applied.*	Review Report 2019	NA
Submission 2018	*No Stage 3 Review applied.*	Review Report 2018	NA
Submission 2017	*No Stage 3 Review applied.*	Review Report 2017	NA
Submission 2016	*No Stage 3 Review applied.*	NA	Review Report
Submission 2015	*No Stage 3 Review applied.*	NA	Review Report
Submission 2014	Stage 3 Report 2014	NA	Review Report

POLLUTANT SPECIFIC UNCERTAINTY ANALYSIS

(for current submission only)



spreadsheet for nitrogen oxides
spreadsheet for sulphur oxides
spreadsheet for non-methane volatile organic compounds (NMVOC)
spreadsheet for ammonia
spreadsheet for PM2.5

GRIDDING (with GRETA, the GRidding Emission Tool for ArcGIS)



GRETA distribution parameters

doku on GRETA extension 2018

doku on GRETA extension 2021

doku on further development of GRETA 2024

TO BE CONTINUED…



As a test, original inventory data as processed and used in this IIR are provided as downloadable MS Excel files for NFR categories 1.A.3.a and 1.A.3.c



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