umweltbundesamt

ENVIRONMENT AGENCY AUSTRIA

Austria's Informative Inventory Report (IIR) 2024

Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants

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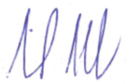
Date of submission 15.04.2024 Total Number of Pages 552 Pages	Responsible for the content of this report  DI Michael Anderl (Head of the inspection body)

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PREFACE

The report "Austria's Informative Inventory Report (IIR) 2024" provides a complete and comprehensive description of the methodologies used for the compilation of the Austrian Air Emission Inventory ("Österreichische Luftschadstoff-Inventur – OLI") as presented in Austria's 2024 submission under the Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE/LRTAP) and under the Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants (NEC Directive).

Austria is required to annually report data on emissions of air pollutants covered under the UNECE/LRTAP Convention and its Protocols as well as under the NEC Directive for the main pollutants NO_x, SO_2, NMVOC, NH_3 and CO, Particulate Matter (PM), Persistent Organic Pollutants (POPs) and Heavy Metals (HM).

To be able to meet these reporting requirements, Austria compiles an Air Emission Inventory („Österreichische Luftschadstoff-Inventur – OLI") which is updated annually.

This report follows the regulations under the UNECE/LRTAP Convention and its Protocols that define standards for national emission inventories. In 2008 the Executive Body adopted the Guidelines for Reporting Emission Data under the Convention on Long-Range Transboundary Air Pollution (LRTAP) (ECE/EB.AIR/97)[1]/[2] for estimating and reporting of emission data. They are necessary to ensure transparency, accuracy, consistency, comparability and completeness (TACCC) of the reported emissions. In 2023, the Reporting Guidelines were revised[3] and adopted for application in 2024 and subsequent years.

The emission data presented in this report were compiled according to these guidelines for estimating and reporting emission data, which also define the new format of reporting emission data (Nomenclature for Reporting – NFR (latest version of the templates 'NFR19'[4] dated 18.11.2019) as well as standards for providing supporting documentation which should ensure the transparency of the inventory.

The complete set of tables in the new NFR format, including sectoral reports, sectoral background tables and footnotes to the NFR tables, are submitted separately in digital form only. A summary of emission data is presented in the Appendix of this report.

The IIR 2024 at hand complements the reported emission data by providing background information. It follows the current template[5] of the "Informative Inventory Report – IIR" as elaborated by the LRTAP Convention's "Task Force on Emission Inventories and Projections – TFEIP". The structure of this report follows closely the structure of Austria's National Inventory Report (NIR) submitted annually under the United Nations Framework Convention on Climate Change (UNFCCC), which includes a complete and comprehensive description of methodologies used for compilation of Austria's greenhouse gas inventory (Umweltbundesamt, 2024).

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1 https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2009/rep_guidelines_ece_eb_air_97_e.pdf

2 At its twenty-sixth session (15–18 December 2008), the Executive Body approved the revised Guidelines (ECE/EB.AIR/2008/4) as amended at the session and requested the secretariat to circulate a final amended version.

3 https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2022/emissions_reporting_guidelines_2023_final.pdf

4 https://www.ceip.at/reporting-instructions

5 Annex II: https://www.ceip.at/reporting-instructions/annexes-to-the-2014-reporting-guidelines

Austria´s Informative Inventory Report (IIR) builds on the IIR submitted in 2023. It is based on AUT NFR tables submitted on 15 February 2024. The aim of this report is to document the methodology in order to facilitate understanding of the calculation of the Austrian air emission data. The more interested reader is kindly referred to the background literature cited in this document.

Michael Anderl in his function as head of the Expert Team *National Emission Inventories* of the Umweltbundesamt is responsible for the preparation of Austria's National Air Emission Inventory as well as for the preparation of the IIR.

Michael Anderl in his function as head of the *Inspection Body for Emission Inventories* is responsible for the content of this report and for the quality management system of the Austrian Air Emission Inventory. Katja Pazdernik acts as deputy head of the *Inspection Body for Emission Inventories*.Project leader for the preparation of the Austrian Air Emission Inventory is Stephan Poupa.

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- Fugitive emissions .... Marion Gangl ('Sector Coordinator')
- Industrial processes and Product Use......... Maria Purzner ('Sector Coordinator')
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- Key Category Analysis.................................. Andreas Zechmeister
- Uncertainty Analysis .... Andreas Zechmeister

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- Chapter 3 Energy.. Stephan Poupa, Günther Schmidt,
  .... Wolfgang Schieder
- Chapter 3 Transport...................................... Gudrun Stranner, Günther Schmidt
- Chapter 3 Fugitive emission.......................... Marion Gangl, Katja Pazdernik
- Chapter 4 Industrial Processes and
  Product Use..................................... .... Maria Purzner, Manuela Wieser, Jérôme Colson
- Chapter 5 Agriculture.................................... Michael Anderl, Simone Mayer, Lisa Makoschitz
- Chapter 6 Waste .... Katja Pazdernik, Michael Roll

  Chapter 7 Recalculations &
  Improvements.. .... Lisa Makoschitz, Simone Mayer
- Chapter 8 Projections .... Andreas Zechmeister

- Chapter 9 Reporting of gridded emissions and LPS................................. .... Christine Brendle, Günther Schmidt, ... Robert Wankmüller
- Appendix .... Lisa Makoschitz

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EXECUTIVE SUMMARY

ES.1 REPORTING OBLIGATIONS UNDER UNECE/LRTAP AND DIRECTIVE (EU) 2016/2284 (NEC DIRECTIVE)

Austria's Informative Inventory Report (IIR) and the complete set of NFR tables (the latter are submitted in digital format only) represent Austria's official submission under the United Nations Economic Commission for Europe (UNECE) Convention on Long-rage Transboundary Air Pollution (LRTAP) and under Directive (EU) 2016/2284 (NEC Directive). The Umweltbundesamt in its role as single national entity regarding emission inventories compiles Austria's annual delivery, and the Austrian Federal Ministry of 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' (BMK) submits it officially to the Executive Secretary of UNECE as well as to the European Commission.

As a party to the UNECE/LRTAP Convention and according to the reporting obligations of the NEC Directive Austria is required to annually report data on emissions of air pollutants covered in the Convention and its Protocols:

- main pollutants: nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), sulphur oxides (SO_x), ammonia (NH_3) and carbon monoxide (CO);
- particulate matter (PM): primary PM (fine particulate matter ($PM_{2.5}$) and coarse particulate matter (PM_{10}))[6];
- priority heavy metals (HMs): lead (Pb), cadmium (Cd) and mercury (Hg);
- persistent organic pollutants (POPs): polychlorinated dibenzodioxins/dibenzofurans (PCDD/Fs), polycyclic aromatic hydrocarbons (PAHs), hexachlorobenzene (HCB) and polychlorinated biphenyls (PCBs).

In order to fulfil these reporting requirements, Austria compiles an Air Emission Inventory ("Österreichische Luftschadstoff-Inventur – OLI"), which is updated annually. The IIR contains information on Austria's inventories of air pollutants for all years from 1990 to 2022 for the main pollutants, for POPs and HMs and for the years 1990, 1995 and from 2000 onwards for PM. In accordance with the NEC Directive (EU) 2016/2284, Table A (*Annual emission reporting requirements*) and Table C (*Reporting requirements on emissions and projections*), Austria does not report emissions of BC (notation key NR is used).

From submission 2020 onwards, Austria reports all pollutants in the NFR19 reporting format from 1990 to the latest inventory year. Emissions of the years before 1990 were last updated and published in submission 2014.[7]

In addition, the report includes both detailed descriptions of methods, data sources and uncertainties and information on quality assurance and quality control (QA/QC) activities as well as analyses of emission trends.

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[6] According to the CLRTAP Reporting GL the reporting of total suspended particules (TSPs) is not mandatory, but reported by Austria.

[7] Austria´s submission 2014 under the Convention on Long-range Transboundary Air Pollution covering the years 1980–2012: https://cdr.eionet.europa.eu/at/un/CLRTAP_AT/envuvyara/

The emission data presented in this report were compiled according to the 2023 Reporting Guidelines that were adopted by the Executive Body for the UNECE/LRTAP Convention at its 42^{nd} session.

The Austrian inventory is complete with regard to reported gases, reported years and reported emissions from all sources, and also complete in terms of geographic coverage.

ES.2 DIFFERENCES WITH OTHER REPORTING OBLIGATIONS

NEC Directive (EU) 2016/2284 sets out national emission reduction commitments for the pollutants SO_2, NO_x, VOC, NH_3 and $PM_{2.5}$. Emission reduction obligations will apply to anthropogenic emissions of these pollutants and also particulate matter ($PM_{2.5}$) covering the years from 2020 to 2029 and from 2030 onwards. While the target comparison for the years 2010 to 2019 was based on emissions without exports of fuels, Austria's total emissions calculated on the basis of the volume of fuel sold will now be taken into account for the current target period, as the emission reduction commitments from 2020 onwards have been derived from projections based on the amount of fuel sold.

The annual greenhouse gas reporting under the UNFCCC also requires the reporting of indirect GHGs (NO_x, CO, NMVOC) and SO_2 emissions based on *fuel sold*. In contrast to UNFCCC requirements, emissions from aviation under the NEC Directive and the LRTAP Convention include domestic LTO and cruise. Furthermore, international navigation of inland waterways is covered under NEC and CLRTAP.

ES.3 OVERVIEW OF EMISSION TRENDS

Main Pollutants

In 1990, national total SO_2 emissions amounted to 74 kt. Since then emissions have decreased quite steadily. In the year 2022, emissions were reduced by 85% compared to 1990 and amounted to 11 kt. This decline is mainly caused by a reduction of the sulphur content in mineral oil products and fuels (according to the Austrian Fuel Ordinance), the installation of desulphurisation units in plants (according to the Clean Air Act for boilers) and an increased use of low-sulphur fuels like natural gas. From 2021 to 2022, SO_2 emissions decreased by 0.9% (-0.1 kt) mainly because of other sectors (*1.A.4*, predominantly households). In the case of households (*1.A.4.b.1*), the reduction in the use of biomass (-20 %) and coal (-25 %) led to a significant decrease in emissions compared to the previous year. This is due to milder weather conditions and price changes on the energy market. This decline was partly offset by higher emissions from energy supply and increased production from industry, with only the paper industry showing a decline. SO_2 emissions from the paper industry (*1.A.2.d*) decreased by 20 % compared to 2021 due to lower production.

In 1990, national total NO_x emissions amounted to 216 kt. After an all-time high of emissions between 2003 and 2005 emissions are decreasing continuously mainly due to reductions in sector *1.A.3.b*. In 2022, NO_x emissions amounted to 114 kt and were about 47% lower than in 1990. From

2021 to 2022 emissions decreased by 7.1%. One of the main reasons for this was the renewal of the fleet with low-emission vehicles in passenger car and truck traffic (1.A.3.b), which reduced the level of emissions despite an increase in mileage. NO_x emissions from fuel combustion of other sectors (*1.A.4*, predominantly households) fell significantly by 3.0 kt (and 15 %) compared to the previous year. This was due to the lower use of biomass, gas and oil, the milder weather and price changes on the energy market.

In 1990, national total NMVOC emissions amounted to 329 kt. Emissions have decreased steadily since then and in the year 2022 emissions were reduced by 70% to 100 kt compared to 1990. From 2021 to 2022, NMVOC emissions decreased by 8.0 kt (-7.4%). The largest reductions since 1990 have been achieved in the road transport sector due to an increased use of catalytic converters and diesel cars. Currently the road transport sector (*1.A.3.b.*) accounts only for a small share (3.5%) of Austria's total NMVOC emissions. Compared to the previous year, the emission reduction was mainly due to the decline in the use of biomass (-20 %) from residential heating as a result of the milder weather and price changes on the energy market and lower emissions from industrial paint application. Reductions in the solvent sector (2.D.3) have been achieved due to the Solvent Ordinance and the VOC Installation Ordinance.

In 1990, national total NH_3 emissions amounted to 74 kt; emissions have decreased over the period from 1990 to 2022. In 2022, emissions were 8.2% under 1990 levels and amounted to 68 kt. NH_3 in Austria is almost exclusively emitted in the agricultural sector. The lower NH_3 emissions can be explained by decreasing cattle numbers, more efficient feeding and an increased application of low emission spreading techniques (e.g. band spreading, trailing shoe, rapid incorporation of manure). Compared to the previous year 2021, total emissions decreased by 1.2 kt (-1.7%). The main reason for this reduction were falling emissions from mineral fertilizer application as a result of lower sales volumes due to the significant increase in energy and raw material prices, which led to higher prices on the fertilizer market. Furthermore, ammonia emissions decreased due to reductions in manure spreading because of the increased use of band spreading techniques in Austria.

In 1990, national total CO emissions amounted to 1 248 kt. Emissions decreased considerably from 1990 to 2022. In 2022, emissions were 61% below 1990 levels and amounted to 481 kt. This reduction was mainly due to decreasing emissions from road transport (catalytic converters). The emissions decreased between 2021 and 2022 by 11%, mainly in the category *1.A.4.b.i Residential: stationary* as a consequence of the mild weather as well as changes in energy prices and the associated reduced use of biomass.

Particulate Matter

Particulate matter emissions in Austria mainly arise from 1*.A Fuel Combustion Activities* (*1.A.3 Road transport, 1.A.4 Other sectors* – residential heating), *2 Industrial Processes and Product Use* and *3 Agriculture*.

Particulate matter (PM) emissions show a decreasing trend over the period 1990 to 2022: TSP emissions decreased by 28%, PM_{10} emissions were about 37% below the level of 1990, and $PM_{2.5}$ emissions dropped by about 51%. In the transport sector PM emissions show a general decrease since several years as a result of improved technology. In the NFR sectors *1.A.4 Other* and *2 Industrial Processes*, PM emissions also fell since 1990. Between 2021 and 2022 TSP, PM_{10} and $PM_{2.5}$ emissions decreased by 6.6% (TSP), 6.8% (PM_{10}) and 9.6% ($PM_{2.5}$). The short-term decrease was largely influenced by sector residential heating (*1.A.4.b.i*) as a consequence of the mild weather as well as changes in energy prices and the associated reduced use of biomass. In sector *2.A.5 Mining, construction/demolition and handling of products* the PM emission levels have also decreased in 2022 due to less construction activities.

Heavy Metals

Emissions of all three priority heavy metals (Cd, Pb and Hg) have decreased since 1990.

The overall Cd emissions reduction of 49% from 1990 to 2022 is mainly due to a decline in the industrial processes and energy sector, which is due to reduced use of heavy fuel oil and lower process emissions from iron and steel production. The decrease in 2022 compared to the previous year was mainly due to lower emissions from residential heating *(1.A.4.b.i Residential: stationary)*.

The overall reduction of Hg of about 61% for the period 1990 to 2022 was due to to decreasing emissions from cement industries and the industrial processes sector as well as due to reduced use of coal for residential heating and public electricity and heat production. Several bans in different industrial sub-sectors led to the sharp fall of total Hg emission in Austria, where the largest reduction was achieved in the early 90ies. Due to abatement measures emissions dropped from 2006 onwards. Between 2021 and 2022 emissions decreased by 5.3 % because of falling emissions from NFR *1.A.4.b Residential.* As a result of the warmer weather and and price changes the biomass consumption dropped significantly compared to the previous year.

The overall reduction trend of Pb emissions was minus 94% for the period 1990 to 2022, which is mainly a result of the ban of lead in gasoline. However, abatement techniques and product substitutions also contributed to the emission reduction. Compared to the previous year total Pb emissions show a decrease of 0.7% mainly because of the lower consumption of biomass in *1.A.4.b.i Residential: stationary*.

Persistent Organic Pollutants (POPs)

Emissions of all POPs decreased remarkably from 1990 to 2022 (HCB -87%, PAH -69%, PCDD/F -74% and PCBs -92%), where the highest achievement was made until 1994. The significant increase of HCB emissions in the years 2012, 2013 and 2014 was due to unintentional releases of HCB by an Austrian cement plant.

In 2022 PCDD/F emissions decreased by 15 % compared to the previous year, HCB emissions decreased by 18% and PAH emissions by 21% in the same time. The reductions of HCB and PCDD/F emissions were mainly due to lower emissions from sectors *1.A.4.b Residential* and to a lesser extent *from 2.C Metal Production (2.C.1 Iron and Steel Production* and *2.C.3 Aluminium Production)*. PAH emissions fell because of lower emissions from *1.A.4.b Residential.* Decreasing HCB and PCDD/F emissions from *Iron and steel production* were due to changes in the production process and from *aluminium production* emissions followed production figures. In the residential sector emissions fell due to the lower heating demand because of the the warmer weather but also due to the higher prices on the energy market.

In 2022 PCB emissions decreased by 9.8% compared to the previous year 2021 due to lower emissions from 2*.C.1 Iron and Steel Production* as a result of changes in the production process and reduced hard coal consumption *in 1.A.2.d Pulp, Paper and Print*.

The most important source of PAH, PCDD/F and HCB emissions in Austria is residential heating. In the 1980s industry and waste incineration were still important sources regarding POP emissions.

Due to legal regulations concerning air quality emissions from industry and waste incineration decreased remarkably from 1990 to 1993. For PCB emissions the most important source category is *2.C Metal Production*.

ES.4 KEY CATEGORIES

To determine key categories, a trend and a level assessment have been carried out, which resulted in 44 identified key categories. It shows that the residential sector has been identified as the most important key category: all air pollutants except for NH_3 are found key in either the trend or the level assessment. In the following table the top 5 ranked key categories are listed.

Table 1: Most relevant key categories in Austria for air emissions 2022.

Name of key category	No of occurrences as key category
1.A.4.b.1 – Residential: stationary	26 times (SO_2, NO_x, NMVOC, CO, Cd, Pb, Hg, PAH, DIOX, HCB, PCB, TSP, PM_{10}, $PM_{2.5}$)
2.C.1 – Iron and Steel Production	13 times (Cd, Pb, Hg, PAH, DIOX, PCB, TSP, PM_{10}, $PM_{2.5}$)
1.A.1.a – Public Electricity and Heat Production	12 times (SO_2, NO_x, Cd, Pb, Hg, DIOX, HCB, PM_{10}, $PM_{2.5}$)
1.A.3.b.1 – R.T., Passenger cars	10 times (NO_x, NMVOC, CO, Pb, TSP, PM_{10}, $PM_{2.5}$)
1.A.2.d – Pulp, Paper and Print	8 times (SO_2 , NOX , Cd , Hg , TSP , PM_{10} , $PM_{2.5}$)

ES.5 MAIN DIFFERENCES IN THE INVENTORY SINCE THE LAST SUBMISSION

As a result of the continuous improvement process of Austria's Annual Air Emission Inventory, emissions for some sources have been recalculated, e.g. on the basis of updated activity data or revised methodologies. Thus emission data for the whole time series submitted this year differ from the data reported previously.

In NFR sector ***1 Energy***, changes are mainly due to revisions of the energy balance. Energy consumption for non-road mobile machinery in the industrial sector has been revised for 2021 due to an update of the industrial production index. Minor revisions of PM emissions from subcategories *1.A.1.a* and *1.A.2.f* were due to error corrections.

For 1990 to 2021, minor changes in of categories Commercial/Institutional *(1.A.4.a)* and Residential *(1.A.4.b)* occurred because of updated heating stock data and newly allocated shares of combustion technologies per energy carrier (updated energy demand model for space heating).

Activity data (gasoline) in *1.B.2.a.5 Distribution of oil products* had to be corrected by one data supplier for the year 2021, resulting in slightly revised NMVOC emissions for 2021. PM emissions of *1.B.1.a Storage of solid fuels* for 2021 were revised due to revised coal consumption activity data.

In NFR sector ***1.A.3 Transport***, the fuel consumption for PC and LDV PHEV has been revised. As the energy consumption in hybrid vehicles is highly uncertain, a more pessimistic charging behavior for PHEV vehicles has been assumed, which increased the real fuel consumption of PHEV cars (petrol) and LDV (petrol), especially in 2021. Furthermore, an update of of specific vehicle mileage per year was undertaken, leading to an increase for LDV and 2-wheelers for 2021. Confidential data (fuel consumption) became available from a survey for military off-road vehicles for the year 2021. This evaluation and a separate expert assessment improved the trend from 1990 to 2022 for *1.A.5 Military*.

In NFR sector ***2 Industrial Processes and Product Use*** several recalculations have been carried out on the one hand due to revisions of activity data and on the other hand as a result of methodological improvements (e.g. reallocation in *2.B.1*; elimination of a time series inconsistency in *2.B.10*; reassessment of POPs in *2.C.1*, corrections on the top down data in *2.D.3;* error corrections in *2.I*).

One of the main reasons for revised emissions in NFR sector ***3 Agriculture*** was the application of the new Tier 2 NH_3 EF for mineral fertilizers according to the EMEP/EEA Guidebook 2023. Additionally, updated activity data has been included: new figures for the protein and fat content of milk for the year 2021 as well as updated figures on biogas plants became available. Methodological improvements of Statistics Austria resulted in shifts of livestock numbers between the cattle < 1 year sub-categories in the years 2003–2021.

In NFR sector ***5 Waste****,* revisions of activity data were carried out in categories *Solid waste disposal on land (5.A.1)*, *Anaerobic digestion at biogas facilities* (*5.B.2*), *Open burning of waste (5.C.2)* and *Other waste (5.E)*: New data on landfill gas recovery from a national study *(5.A.1)*, updates of activity and nutrition data ($N_{excretion}$ of cattle, biogas plants) *(5.B.2)*, revised area of vineyards burnt from 2010 onwards *(5.C.2)* and updated statistical information on accidental building fires *(5.E)* were included.

For more detailed information see Chapter 7 – Recalculations and Improvements.

ES.6 IMPROVEMENT PROCESS

The Austrian Air Emission Inventory is subject to a continuous improvement programme resulting in annual recalculations (see Chapter ES.5 above). Furthermore, the regularly conducted reviews under the LRTAP Convention and the NEC Directive trigger improvements.

The last CLRTAP Stage 3 ("In-depth") review of the Austrian Inventory took place in 2017 (United Nations, 2017). The findings for Austria are summarized and commented in Table 339. In 2022, an In-depth review of all Parties (so called ad-hoc Review) took place with a special focus on the condensable component of PM for sectors Residential heating and Transport. The recommendations for Austria are presented in Table 340. In 2023, the ad-hoc Review focused on Agriculture (emission inventories and gridded data). The recommendations for Austria are presented in Table 341.

In addition to the CLRTAP Review, from 2017 onwards the national emission inventory data is also checked by the European Commission as set out in Article 10 of Directive 2016/2284. The inventories are checked annually in order to verify the transparency, accuracy, consistency, comparability and completeness of information submitted and to identify possible inconsistencies with the requirements set out under international law, in particular under the LRTAP Convention. Synergies are maximised with the 'Stage 3' reviews conducted by the LRTAP Convention. The findings under the NEC Review 2023 (EC, 2023a) and the National Air Pollution Projections Review 2023 (EC, 2023b) for Austria are summarized and commented in Table 342 and Table 343.

Recalculations and improvements are summarized in Chapter 7 – Recalculations and Improvements and described in detail in the sector-specific chapters of this report.

ES.7 CONDENSABLE COMPONENT OF PM_{10} AND $PM_{2.5}$

The Parties to the LRTAP Convention have been formally requested by the Executive Body at its thirty-eight session to provide information on the reporting of the condensable component of particulate matter (PM) in their Informative Inventory Reports. The purpose is the provision of transparent information for the modellers. As a consequence, Annex II (Recommended structure for the Informative Inventory Report (IIR)) of the CLRTAP Reporting GL has been updated accordingly. Austria included the following information in its IIR from 2019 on:

- appendix including a table summarising whether PM_{10} and $PM_{2.5}$ emission factors for each source sector include or exclude the condensable component (and references for their emission factors) (see chapter 12.3).
- indication in the methodology sections whether PM_{10} and $PM_{2.5}$ emission estimates include or exclude the condensable component (please refer to the methodological chapters 3-6).

1 INTRODUCTION

1.1 National inventory background

The Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) administrates Austria's reporting obligations to the

- Convention on Long-range Transboundary Air Pollution (LRTAP)[8] of the United Nations Economic Commission for Europe (UNECE)[9]
- United Nations Framework Convention on Climate Change (UNFCCC)[10]
- European Commission (EC)[11] and the
- European Environment Agency (EEA)[12]

The Environmental Control Act (Umweltkontrollgesetz, UKG)[13] that entered into force on the 1st of January 1999 regulates responsibilities of environmental control in Austria and lists the tasks of the Umweltbundesamt. The Umweltbundesamt is designated as single national entity with overall responsibility for inventory preparation.

Furthermore, the Environmental Control Act incorporates the Umweltbundesamt as a private limited company. To ensure that the Umweltbundesamt has the resources required to fulfil all listed tasks, the financing is set up as a fixed amount of money annually allocated to the Umweltbundesamt. The Umweltbundesamt is free to manage this so called "basic funding", provided that the tasks are fulfilled. Projects beyond the scope of the Environmental Control Act are financed on project basis by the contracting entity, which may be national or EC authorities as well as private entities.

One task is the preparation of technical expertise and the data basis for fulfilment of the obligations under the UNFCCC, UNECE and EC. Thus, the Umweltbundesamt prepares and annually updates the Austrian Air Emissions Inventory ("Österreichische Luftschadstoff-Inventur OLI"), which covers greenhouse gases and emissions of other air pollutants as stipulated in the reporting obligations further explained in Chapter 1.2.2.

For the Umweltbundesamt, a national air emission inventory that identifies and quantifies the sources of pollutants in a consistent manner is of a high priority. Such an inventory provides a common means for comparing the relative contribution of different emission sources and hence can serve as an important basis for policies to reduce emissions.

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8 https://unece.org/convention-and-its-achievements

9 https://unece.org/

10 https://unfccc.int/

11 https://commission.europa.eu/index_en

12 http://www.eea.europa.eu/

13 „Umweltkontrollgesetz" – Bundesgesetz über die Umweltkontrolle und die Einrichtung einer Umweltbundesamt Gesellschaft mit beschränkter Haftung; Federal Law Gazette I 152/1998

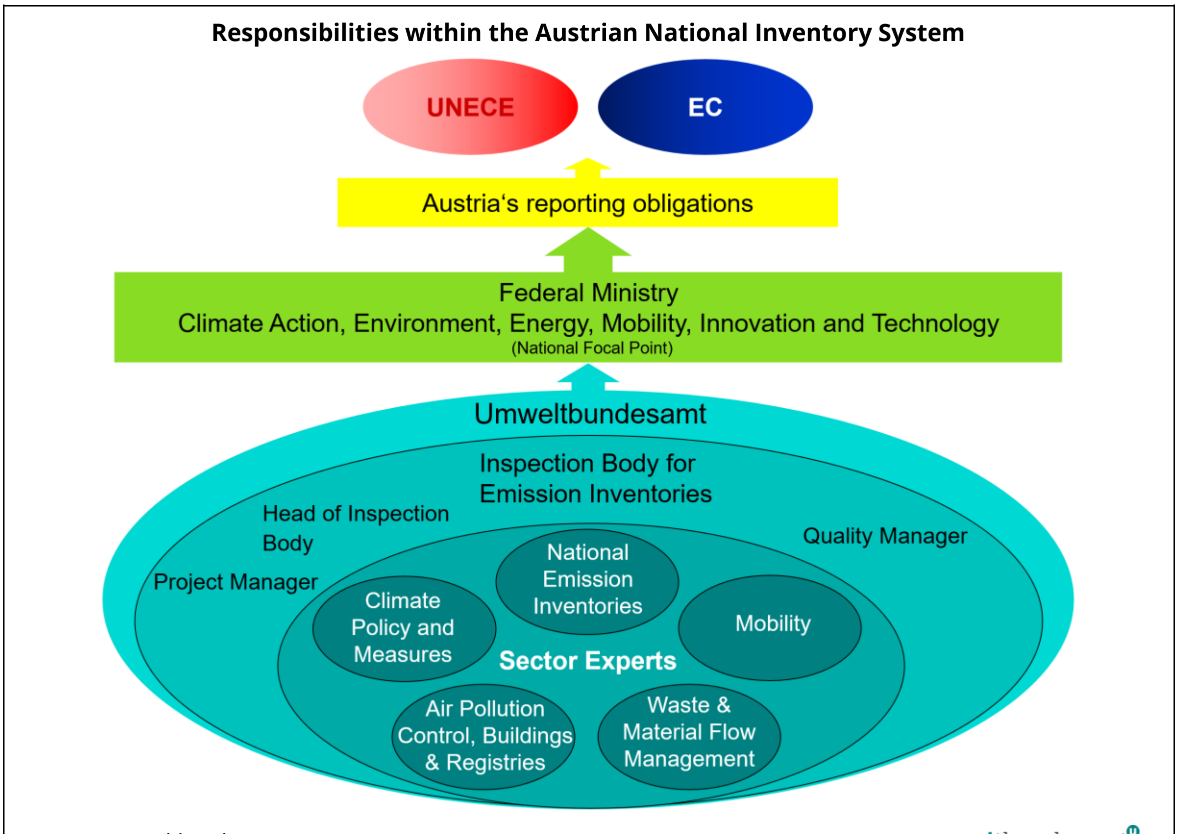
1.2 Institutional, legal and procedural arrangements

The Umweltbundesamt established an Inspection Body for Emission Inventories (IBE, hereinafter also referred to as inspection body) which is entrusted with the preparation of emission inventories as assigned to the Umweltbundesamt as described above (refer to Chapter 1.1). So, since 23 December 2005, the Umweltbundesamt has been accredited as Inspection Body for Emission Inventories, Type A (ID No. 0241), in accordance with EN ISO/IEC 17020 and the Austrian Accreditation Law (AkkG),[14] by decree of Accreditation Austria (first decree, No. BMWA-92.715/0036-I/12/2005, issued by Accreditation Austria / Federal Ministry of Economics and Labour on 19 January 2006).

The accreditation comprises the emission inventory for all GHGs and air pollutants as reported under the UNFCCC, the Regulation on the Governance of the Energy Union and Climate Action as well as the UNECE and NEC Directive.

The personnel of the IBE consists of staff from various organisational units of the Umweltbundesamt, who in the course of their inspection activity are assigned to the IBE and are in this context responsible to the head of the inspection body. They are free from any commercial, financial and other pressures that might influence their technical judgement. Technical instructions for the preparation of emission inventories may not be given from outside of the IBE (see Figure 1).

Figure 1: Responsibilities within the Austrian National Inventory System (Air Pollutants).



Source: Umweltbundesamt

[14] Federal Law Gazette I No 28/2012 (Akkreditierungsgesetz 2012)

The quality management system (QMS) is maintained and updated under the responsibility of a quality representative. The inventory work is coordinated by a project manager. For these functions as well as for the head of inspection body deputies are appointed. Regarding the inventory work, specific responsibilities for the different emission source/sink categories ('Sector Experts') are defined. There are 9 sectors defined (Energy, Buildings, Transport, Fugitive Emissions, Industrial Processes, Product Use, Agriculture, LULUCF[15] and Waste). At least two experts form a sector team with one of them acting as "Sector Coordinator". For more information on the QMS please refer to Chapter 1.6.

In addition, the Austrian emissions trading registry is managed by the Umweltbundesamt on behalf of the Federal Ministry 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' (BMK). This mandate was given to the Umweltbundesamt in the Registry Ordinance (Registerstellenverordnung) Federal Law Gazette II No 208/2012. The Umweltbundesamt is responsible for the operational management of the registry and serves as a contact point for national and international authorities.

The Austrian emissions trading registry has been operational since 2005 and serves both as registry for the EU Emissions Trading Scheme and as the national registry for Austria.

Besides the Environmental Control Act there are some other legal and institutional arrangements in place as the main basis for the national system:

- The Austrian Emissions Certificate Trading Act[16] that regulates monitoring and reporting in the context of the EU Emissions Trading Scheme (ETS) in Austria. The Umweltbundesamt takes the emission reports of the emissions trading scheme into account for the national greenhouse gas inventory in order to comply with requirements of the Regulation on the Governance of the Energy Union and Climate Action and the UNFCCC. This is not only important for emissions from combustion of fuels, for which more detailed information is available in the ETS reports than is provided in the national energy balance, but also for emissions from industrial processes. First data from the EU ETS were available for the year 2005. Since then ETS data have been considered in the submissions.
- The Austrian statistical office (Statistik Austria) is required by contract with the BMK to annually prepare the national energy balance (the contracts also cover some quality aspects). The energy balance is prepared in line with the methodology of the Organisation for Economic Co-operation and Development (OECD) and is submitted annually to the International Energy Agency (IEA) (IEA/EUROSTAT Joint Questionnaire (JQ) Submission). The national energy balance is the most important data basis for the Austrian Air Emissions Inventory.
- According to national legislation (Bundesstatistikgesetz 2000[17]), the Austrian statistical office has to prepare annual import/export statistics, production statistics and statistics on agricultural issues (livestock counts etc.), providing an important data basis for calculating emissions from the sectors *Industrial Processes, Product Use* and *Agriculture*.
- In order to comply with the reporting obligations, the Umweltbundesamt has the possibility to obtain confidential data from the national statistical institute (of course these data have

[15] Land Use, Land Use Change and Forestry (Only relevant for GHG emissions)

[16] *„Emissionszertifikate-Gesetz 2011"*; Federal Law Gazette I No 118/2011

[17] *„Bundesstatistikgesetz 2000"*; Federal Law Gazette I No 163/1999

to be treated confidentially). The legal basis for this data exchange is the Bundesstatistikgesetz 2000[17] (federal statistics law), which allows the national statistical office to provide confidential data to authorities that have a legal obligation for the processing of these data.

- According to paragraph 38 (1) of the EG-K 2013[18] each licensee of an operating boiler with a thermal capacity of more than two megawatts (MW) is obliged to report the emissions to the competent authority. The Umweltbundesamt can request copies of these emission declarations. This data is used to verify the data from the national energy balance for the *Energy* sector.
- According to the old Landfill Ordinance (Deponieverordnung 1996)[19] the operators of landfill sites had to report type and amount of waste deposited annually. These reports (collected in a central database run by Umweltbundesamt) still provide the main basis for calculating emissions from the sector *Waste* for the inventory years 1998–2007.
- Starting with the deposited waste of the year 2008 landfill operators have been – pursuant to the new Landfill Ordinance (Deponieverordnung 2008)[20] – obliged to submit their data annually and electronically via the portal http://edm.gv.at (Electronic Data Management – 'EDM'). The BMK is responsible for data collection and analysis. The necessary data is requested by the Umweltbundesamt for the purpose of inventory preparation.
- Since 2004 there has been a reporting obligation to the BMK under the Austrian Fluorinated Compounds (FC) Ordinance[21] for users of FCs for the following applications: refrigeration and air-conditioning, foam blowing, semiconductor manufacture, electrical equipment, fire extinguishers and aerosols. This data is notified via EDM and used for estimating emissions from the consumption of fluorinated compounds (IPCC sector *2.F*).

More information on the National Inventory System in Austria (NISA) is provided in the following Chapter 1.2.1.

1.2.1 National Inventory System Austria (NISA)

History of the National Inventory System Austria – NISA

Austria's National Inventory System (NISA) has had to be adapted to different obligations which have been subject to continuous development. A brief history of the development and the activities of NISA are provided below:

- Austria established estimates for SO_2 under EMEP in 1978 (Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe).[22]

[18] *„Emissionsschutzgesetz für Kesselanlagen 2013"*; Federal Law Gazette I No 127/2013

[19] *„Deponieverordnung"*; Federal Law Gazette No 164/1996

[20] *„Deponieverordnung 2008"*; Federal Law Gazette II No 39/2008

[21] *„Industriegas-Verordnung (HFKW-FKW-SF6-VO)"*; Federal Law Gazette II No. 447/2002

[22] http://www.emep.int/

- As an EFTA[23] country, Austria participated in CORINAIR 90,[24/25] an air emission inventory for Europe. It was part of the CORINE (Coordination d'Information Environmentale) work plan set up by the European Council of Ministers in 1985. The aim of CORINAIR 90 was to produce a complete, consistent and transparent emission inventory for the following pollutants: SO_x as SO_2, NO_x as NO_2, NMVOC, CH_4, CO, CO_2, N_2O and NH_3.
- Austria signed the UNFCCC on June 8, 1992 and subsequently submitted its instrument of ratification on February 28, 1994.[26] The Convention i.a. includes the commitment to prepare an emission inventory for GHG on a regular basis.
- In 1994, the first so-called Austrian Air Emission Inventory (Österreichische Luftschadstoff-Inventur, OLI) was prepared.
- In 1997, a consistent time series for the emission data from 1980 to 1995 was reported for the first time.
- In 1998, also emissions of heavy metals (HM), persistent organic pollutants (POP) and fluorinated compounds (FC) were included in the inventory.
- Austria signed the KYOTO PROTOCOL on April 4, 1998 and subsequently submitted its instrument of ratification on May 31, 2002.
- Inventory data for particulate matter (PM) were included in the inventory in 2001.
- Austria signed the Paris Agreement on April 16, 2016 and subsequently submitted its instrument of ratification on October 5, 2016.
- The accreditation as *Inspection Body for Emission Inventories* according to ISO/IEC 17020 was awarded for the first time in 2005 and was renewed in 2011, 2016 and 2020 so far.

Organisation of the National Inventory System Austria – NISA

Regulations under the UNECE/LRTAP Convention and its protocols define and continuously improve standards for the preparation of and reporting on national emission inventories. In 2002, the Executive Body adopted new guidelines for estimating and reporting emission data to ensure that the transparency, consistency, comparability, completeness and accuracy of reported emissions are adequate for current LRTAP Conventions needs (EB.AIR/GE.1/2002/7[27] and its supporting addendum).

The submission is in accordance with the revised Guidelines for Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution (ECE/EB:AIR/125).

As illustrated in Figure 2, the Austrian Air Emission Inventory (OLI), comprising all air pollutants stipulated by various national and international obligations, represents the core of NISA. The national system as required already under the Kyoto Protocol and the Quality Management System (ISO/IEC 17020) are incorporated into NISA as complementary sections.

The Austrian Air Emission Inventory (OLI) covers all pollutants, i.e. air pollutants reported to UNECE/EC and greenhouse gases (GHG) as reported to the UNFCCC. This is to streamline efforts

[23] EFTA: European Free Trade Association; http://www.efta.int/

[24] The CORINAIR system has been integrated into the work programme of the European Environment Agency (EEA) and the work is continuing through the Agency's European Topic Centre on Air Emissions (ETC/AE).

[25] http://www.eea.europa.eu/publications/topic_report_1996_21

[26] https://unfccc.int/process-and-meetings/the-convention/status-of-ratification-of-the-convention

[27] http://www.unece.org/fileadmin/DAM/env/documents/2002/eb/ge1/eb.air.ge.1.2002.7.e.pdf

and benefit from a common approach to inventory preparation in one single National Inventory System for Austria (NISA).

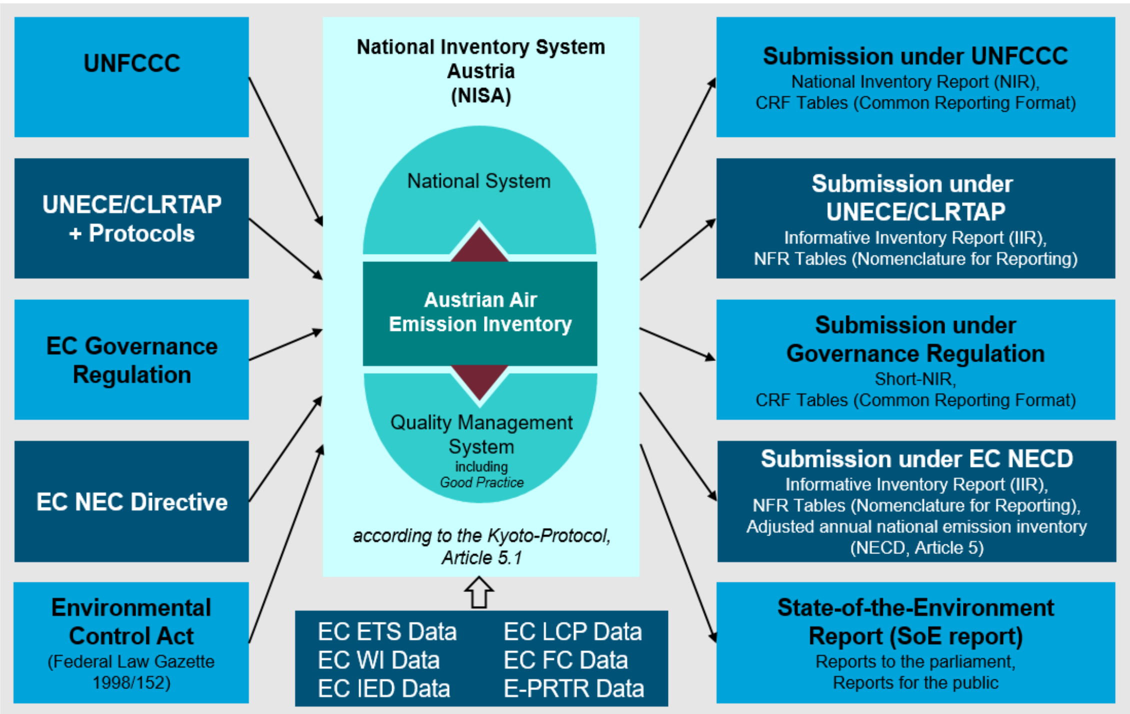
It is designed to comply with the standards for national emission inventories under the UNFCCC and also meets all the requirements of the LRTAP Convention and the reporting obligations of the European Union (EC Governance Regulation, EU NEC Directive) as presented in Chapter 1.2.2.1.

The "National Inventory System Austria" (NISA) includes all institutional, legal and procedural arrangements made for the preparation of emission inventories and for reporting and archiving inventory information. It should ensure the quality of the inventory: transparency, accuracy, consistency, comparability and completeness (TACCC) and timeliness.

As there are many different obligations which are subject to continuous development, Austria's National Inventory System (NISA) has to be adapted continually to these changes. The present structure is illustrated in Figure 2.

Figure 2: Structure of the National Emission Inventory System Austria (NISA).

Structure of the National Emission Inventory System Austria (NISA)



Source: Umweltbundesamt

1.2.2 Austria's Obligations

Austria has to comply with the following air emission related obligations:

- UNECE Convention on Long-range Transboundary Air Pollution (LRTAP) and its protocols comprising the annual reporting of national emission data on SO_2, NO_x, NMVOCs, NH_3, CO, TSP, PM_{10}, and $PM_{2.5}$ as well as on the heavy metals Pb, Cd and Hg and persistent organic hydrocarbons (PAHs), dioxins and furans (PCDD/F), hexachlorobenzene (HCB) and Polychlorinated biphenyls (PCBs). Austria signed the convention in 1979; since its entry into force in 1983, the Convention has been extended by eight protocols which identify specific obligations or measures to be taken by Parties. These obligations as well as information regarding the status of ratification are listed in Table 2.
- Directive (EU) 2016/2284[28] on the reduction of national emissions of certain atmospheric pollutants (NEC Directive) of the European Parliament and of the Council of 14.12.2016, amending Directive 2003/35/EC and repealing Directive 2001/81/EC. The national air emissions act[29] transposes the NEC Directive into Austrian national legislation.
- „United Nations Framework Convention on Climate Change" (UNFCCC) (1992)[30]
- Regulation (EU) 2018/1999 of the European Parliamentand of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council; ("*Governance Regulation*"[31]). The purpose of this regulation is to monitor anthropogenic greenhouse gas emissions and to evaluate the progress towards meeting the Union greenhouse gas reduction commitments in accordance with the Paris Agreement.
- Austrian "ambient air quality act"[32] comprising the reporting of national emission data on SO_2, NO_x, NMVOC, CO, heavy metals (Pb, Cd, Hg), benzene and particulate matter (PM).
- Industrial Emissions Directive 2010/75/EU[33] which requires the reporting of air emissions from various industrial activities.
- E-PRTR Regulation (EC) No 166/2006[34] concerning the establishment of a European Pollutant Release and Transfer Register. E-PRTR is associated with Article 6 of the Aarhus Convention (United Nations: Aarhus, 1998) which refers to the right of the public to access environmental information and to participate in the decision-making process on environmental issues.

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28 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016L2284&from=EN

29 Emissionshöchstmengengesetz-Luft *EG-L* (*air emissions ceilings law*) https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20010426

30 https://unfccc.int/process-and-meetings/the-convention/status-of-ratification-of-the-convention

31 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999&from=EN

32 Immissionsschutzgesetz-Luft *IG-L* (*ambient air quality law*) https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10011027

33 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:en:PDF

34 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:033:0001:0017:EN:PDF

Table 2: Protocols of UNECE Convention on Long-range Transboundary Air Pollution (LRTAP).

	Tools of UNECE Convention on Long-range Transboundary Air Pollution (LRTAP)	Parties	entered into force	signed/ratified by Austria
1979	Convention on Long-range Transboundary Air Pollution (in Geneva)	51	16.03.1983	13.11.1979 (s) 16.12.1982 (r)
1984	Geneva Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP)	47	28.01.1988	04.06.1987 (ac)
1985	Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent	25	02.09.1987	09.07.1985 (s) 04.06.1987 (r)
1988	Sofia Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes	35	14.02.1991	01.11.1988 (s) 15.01.1990 (r)
1991	Geneva Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes	24	29.09.1997	19.11.1991 (s) 23.08.1994 (r)
1994	Oslo Protocol on Further Reduction of Sulphur Emissions	29	05.08.1998	14.06.1994 (s) 27.08.1998 (r)
1998	Aarhus Protocol on Heavy Metals	35	29.12.2003	24.06.1998 (s) 17.12.2003 (r)[(1)]
1998	Aarhus Protocol on Persistent Organic Pollutants (POPs)	34	23.10.2003	24.06.1998 (s) 27.08.2002 (r)[(1)]
1999	The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone	31	17.05.2005	01.12.1999 (s)

Abbreviation: signed (s), ratified (r), accession (ac), Footnote: [(1)] with declaration upon ratification

Source: http://www.unece.org/env/lrtap/status/lrtap_s.html

1.2.2.1 Reporting obligation under the UNECE/LRTAP Convention and its protocols

As a minimum requirement, each Party shall report on emissions of the substances relevant to the protocol to which they are a Party, as required by that protocol. Since Austria has ratified all protocols to the UNECE/LRTAP Convention (with the exception of the Gothenburg Protocol), the annual reporting obligation enfolds emission data of four groups: main pollutants, particulate matter (PM), heavy metals, and POPs. Table 3, taken from the Reporting Guidelines, gives the present set of components which have to be reported (minimum) and which should be reported voluntarily (additionally).

This report follows the regulations under the UNECE/LRTAP Convention and its protocols that define standards for national emission inventories. In 2013, the Executive Body adopted revised Guidelines for Reporting Emission Data under the Convention on Long-Range Transboundary Air Pollution (LRTAP) (ECE/EB.AIR/122/Add.1, 2013/3 and 2013/4)[35] for estimating and reporting of emission data. They are necessary to ensure transparency, accuracy, consistency, comparability and completeness (TACCC) of the reported emissions. In 2014 the Reporting Guidelines were revised

[35] https://unece.org/decisions

(ECE/EB.AIR.125)[36] and were adopted for application in 2015 and subsequent years. In 2023 the Reporting Guidelines have been updated again[37] and have been adopted for application from 2024 onwards.

The data presented in this report were compiled according to the latest Reporting Guidelines for estimating and reporting emission data, which also define the reporting format (**N**omenclature **f**or **R**eporting – NFR (latest version of the templates 'NFR19'[38] dated 18.11.2019)) as well as standards for providing supporting documentation which should ensure the transparency of the inventory.

Table 3: Emission Reporting Programme.

Element(s)	Pollutant(s)	Inventory years[(1)]
A. National total emissions		
1. Main pollutants	SO_x, NO_x, NH_3, NMVOC, CO	from 1990 to 2022
2. Particulate matter	$PM_{2.5}$, PM_{10}, (*TSP, BC*)	for 1990, 1995, and for 2000 to 2022
3. Heavy metals	Pb, Cd, Hg, (*As, Cr, Cu, Ni, Se, Zn)*	from 1990 to 2022
4. POPs	PCDD/PCDF, PAHs[(2)], HCB, PCBs	from 1990 to 2022
B. Emissions by NFR source category		
1. Main pollutants	SO_x, NO_x, NH_3, NMVOC, CO	from 1990 to 2022
2. Particulate matter	$PM_{2.5}$, PM_{10}, (*TSP, BC*)	for 1990, 1995, and for 2000 to 2022
3. Heavy metals	Pb, Cd, Hg, (*As, Cr, Cu, Ni, Se, Zn)*	from 1990 to 2022
4. POPs	PCDD/PCDF, PAHs [(2)], HCB, PCBs	from 1990 to 2022
C. Activity data by source category		**from 1990 to 2022**
D. Gridded data in the EMEP 0.1x0.1 long/lat grid and LPS (4-yearly)		
Gridded emissions in a grid of 0.1x0.1 long / lat LPS emissions	SO_x, NO_x, NH_3, NMVOC, CO, PM_{10}, $PM_{2.5}$, Pb, Cd, Hg, PCDD/F, PAHs, HCB, PCBs	2000 (optional), 2005, 2010, 2015, 2019 and every 4 years
E. Projected emissions and projected activity data (4-yearly)		
1. National total emission projections	SO_x, NO_x, NH_3, NMVOC, $PM_{2.5}$ and BC where appropriate	2025, 2030, and where available also for 2040 and 2050
2. Emission projections by NFR19	SO_x, NO_x, NH_3, NMVOC, $PM_{2.5}$ and BC where appropriate	2025, 2030, and where available also for 2040 and 2050
3. Projected activity data by NFR19		2025, 2030, and where available also for 2040 and 2050

(1) As a minimum, data for the base year of the relevant protocol and from the year of entry into force of that protocol to the latest year should be reported

(2) polycyclic aromatic hydrocarbons (PAHs) {benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene,Total 1-4}

36 https://www.ceip.at/fileadmin/inhalte/ceip/1_reporting_guidelines2014/ece.eb.air.125_advance_version_reporting_guidelines_2014.pdf

37 https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2022/emissions_reporting_guidelines_2023_final.pdf

38 https://www.ceip.at/fileadmin/inhalte/ceip/1_reporting_guidelines2014/annex_i_rev18-11.xlsx

1.2.2.2 Reporting obligation under Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants (NEC Directive)

According to Article 8 of NEC Directive 2016/2284 and Annex I, Table A, Member States shall prepare and annually update national emission inventories for the pollutants SO_x, NO_x, NH_3, NMVOC, CO, heavy metals (Cd, Hg, Pb), POPs (total PAHs, PCBs, HCB), $PM_{2,5}$, PM_{10} and, if available, BC. Austria reports the national emission totals calculated on the basis of *fuel sold* for compliance assessment under the NEC Directive. While the target comparison for the years 2010 to 2019 was based on emissions without exports of fuels, Austria's total emissions calculated on the basis of the volume of fuel sold will now be taken into account for the new target period 2020–2029.

Additionally, Member States shall prepare and update every four years spatially disaggregated national emission inventories and large point source inventories and, every two years, national emission projections for part of these pollutants as set out in the NEC Directive 2016/2284, Annex I, Table C.

Member States' submissions of national emission inventories and projections shall be accompanied by an informative inventory report (this report). The report follows the regulations under the UNECE/LRTAP Convention and its Protocols that define standards for national emission inventories (see chapter 1.2.2.1).

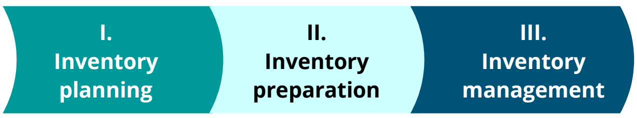
1.3 Inventory Preparation Process

The present Austrian Air Emission Inventory (OLI) for the period 1990 to 2022 was compiled according to the recommendations for inventories as set out by the UNECE Executive Body[39] and in the guidelines mentioned above.

The preparation of the inventory includes the following three stages as illustrated below.

Figure 3: Three stages of inventory preparation.

Three stages of inventory preparation



Source: Umweltbundesamt

umweltbundesamt

[39] https://www.ceip.at/reporting-instructions

1.3.1 Inventory planning

In the first stage, specific responsibilities are defined and allocated: as mentioned before, the Umweltbundesamt has the overall responsibility for the national inventory, comprising greenhouse gases as well as other air pollutants.

Inventory planning also includes planning of how to distribute available resources, and thus, as resources are limited, includes a prioritization of planned improvements, whereby the key category analysis is an important tool.

Within the inventory system, specific responsibilities for the different emission source categories are defined ("sector experts") as well as for all activities related to the preparation of the inventory, including QA/QC, data management and reporting.

Emissions of air pollutants are estimated together with greenhouse gases in a single database based on the CORINAIR[40] scheme, which was formerly also used as reporting format under the UNECE. This nomenclature was designed by the ETC/AE[41] to estimate emissions of all kind of air pollutants as well as greenhouse gases.

The CORINAIR system's nomenclature is called SNAP,[42] which may be expanded to adapt to national circumstances by so-called SPLIT codes, and additionally each SNAP/SPLIT category can be extended using a fuel code.

1.3.2 Inventory preparation

In the second stage, the inventory preparation process, sector experts collect activity data, emission factors and all relevant information needed for finally estimating emissions. The sector experts are also responsible for the choice of methods, data processing and archiving and for service contracting of e.g. studies, if needed.

All data collected together with emission estimates are fed into a database (see below), where data sources are documented for full reproducibility of the inventory.

As mentioned above, the Austrian Inventory is based on the SNAP systematic, and has to be transformed into the current reporting format under the LRTAP Convention and the NEC Directive – the NFR[43] format.

Finally, QA/QC procedures as defined in the inventory planning process are carried out before the data is submitted to the UNECE and the European Commission.

The following table gives an overview on the tasks of inventory preparation together with a typical timeline.

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[40] CORINAIR: CORINE – CO-oRdination d'INformation Environnementale and include a project to gather and organise information on emissions into the air relevant to acid deposition; Council Decision 85/338/EEC (OJ, 1985)

[41] European Topic Centre on Air Emissions

[42] SNAP (Selected Nomenclature for sources of Air Pollution) 90 or 97 respectivley means the stage of development

[43] NFR – Nomenclature For Reporting – is a classification system developed by the UN/ECE TFEIP for the Reporting Guidelines described in eb.air.ge.1.2001.6.e.doc

Table 4: Overview Inventory related tasks.

Task	Description	Deadline
Management Review	Preparation of a report including evaluation of the fulfilment of the previous improvement plan and a plan for QMS and inventory improvement, i.a. based on audit and review findings.	Summer
Kick-Off	Meeting of inventory team (HI, sector experts, project-/quality- and data managers of the inventory, report coordinators, cross-sector analyst and all deputies); definition of a working plan	End of Summer
Activity data collection	Collection of activity data, including contracting out studies.	November 15
Inventory preparation	Estimation of emissions for all sources, including collection of background data.	December 15
Compilation of national inventory	Updating the database and generating NFR data files	December 23
Quality checks	Tier 1 and Tier 2 QA/QC activities	December
Submission NFR tables	Finalization NFR tables and submission to UNECE/EC	February 15
Preparation of IIR	Compilation of the Informative Inventory Report	January–March
Submission IIR	Submission of the Informative Inventory Report to the EC (NEC Directive) and UNECE	March 15

1.3.3 Inventory management

For the inventory management, a reliable data management scheme is needed to fulfil the data collecting and reporting requirements.

Data management is carried out using MS Excel™ spreadsheets in combination with Visual Basic™ macros, which is a very flexible system that can be adjusted easily to new requirements. The data is stored on a central network server, which is backed up periodically for the needs of data security. The inventory management also includes quality management (see Chapter 1.6) as well as documentation on QA/QC activities.

1.4 Methodologies and Data Sources Used

- The main data supplier for the Austrian Emission Inventories is Statistik Austria, providing the underlying energy source data. The Austrian energy balances are based on several datasets mainly prepared by E-Control and Statistik Austria. Their methodology follows the IEA and Eurostat conventions. The aggregated balances, for example transformation input and output or final energy use, are harmonised with the IEA tables as well as their sectoral breakdown, which follows the NACE classification.
- Information about activity data and emissions of the industry sector is mostly obtained directly from individual plants, or in other cases, from Associations of the Austrian Industries.

Activity data for some sources are obtained from Statistik Austria, which provides statistics on production data[44].

- Operators of steam boilers with more than 50 MW report their emissions and their activity data directly to the Umweltbundesamt. Data from national and sometimes international studies are also used.
- Until 2008, operators of landfill sites reported their activity data directly to the Austrian Ministry of Environment or the Umweltbundesamt, where they were – after a check – in turn incorporated into a database on landfills. Emissions for the years 1998–2007 are calculated on basis of these data. Since 2009 landfill operators have to register and report their waste input directly at the portal of the Electronic Data Management. These data are evaluated by the responsible body at federal level (BMK) and are made available for emission calculation.
- Activity data needed for the calculation of non-energetic emissions are based on several statistics collected by Statistik Austria and national and international studies.

The following table presents the main data sources used for activity data.

Table 5: Main data sources for activity data.

Sector	Data Sources for Activity Data
Energy	• Energy Balance from Statistik Austria • EU-ETS • Steam boiler database • Small scale combustion market data • Direct information from industry or associations of industry
Transport	• Energy Balance from Statistik Austria • Yearly new vehicle registrations from Statistik Austria • Yearly growth rates of transport performance on Austrian roads from Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) • ZBD: Zentrale Beguchtachtungsdatenbank (periodically updated specific mileage) • Yearly flight movements from Austro Control • Yearly FC of airport ground activities at Vienna International Airport
IPPU	• National production and foreign trade statistics • Structural business statistics • Surveys conducted at companies and industry associations • Reports submitted under the Industrial Emissions Directive
Agriculture	• National studies • National agricultural statistics obtained from Statistik Austria • National fertiliser statistics, protein content and fat content of milk obtained from Agrarmarkt Austria (AMA) • National statistics on cattle breeding obtained from Rinderzucht Austria • Distributing company (sales data)

[44] „Industrie und Gewerbestatistik" published by STATISTIK AUSTRIA for the years until 1995; „Konjunkturstatistik im produzierenden Bereich" published by STATISTIK AUSTRIA for the years since 1997.

Sector	Data Sources for Activity Data
Waste	• Federal Waste Management Plans (Data sources: Database on landfills (1998–2007), Electronic Data Management (EDM) in environment and waste management) • EMREG-OW (Electronic Emission Register of Surface Water Bodies) • National Studies

Emission calculation and related inventory work (reporting, QA/QC, documentation and archiving, etc.) is carried out by the sector experts of the Inspection Body for Emission Inventories (IBE).

In cases, which exceed the IBE's resources, the IBE concludes service contracts with qualified institutions (particularly universities or research institutes).

The IBE is responsible for

- choice of the contractor i.e. judging his/her expertise with regard to the technical and QMS requirements
- specifying the technical and QMS requirements in the service contract
- performing and documenting a detailed QC check of the results i.e. checking if the specified requirements were fulfilled
- implementation of the results into the emission inventory in line with the technical and QMS requirements particularly the requirement of full reproducibility of the emission inventory

Service contracts have e.g. entered into with:

- Technical University Graz (road and off-road transport)
- University of Natural Resources and Applied Life Sciences (agriculture)

However, the final assessment of fulfilment of the requirements is made by the IBE.

Detailed information on data sources for activity and emission data or emission factors used by sector can be found in Chapters 3–6.

For large point sources the Umweltbundesamt preferably uses – after careful assessment of plausibility of this data – emission data that are reported by the 'operator' of the source because these data usually reflect the actual emissions better than data calculated using general emission factors, as the operator has the best information about the actual circumstances.If such data is not available, and for area sources, national emission factors are used or, if there are no national emission factors, international emission factors are used to estimate emissions. Where no applicable data is found, standard emission factors e.g. from the EMEP/EEA 2023 Guidebook were applied.

The main sources for emission factors are:

- National studies for country specific emission factors
- Plant-specific data reported by plant operators
- IPCC 2006 Guidelines for National Greenhouse Gas Inventories[45]

[45] https://www.ipcc-nggip.iges.or.jp/public/2006gl/

- 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories[46]
- EMEP/EEA air pollutant emission inventory guidebook – 2009. Technical report No 9/2009[47]
- EMEP/EEA air pollutant emission inventory guidebook – 2013. Technical report No. 12/2013[48]
- EMEP/EEA air pollutant emission inventory guidebook – 2016. Technical report No. 21/2016[49]
- EMEP/EEA air pollutant emission inventory guidebook – 2019. Technical report No. 21/2019[50]
- EMEP/EEA air pollutant emission inventory guidebook – 2023. Technical report No. 06/2023[51]
- Handbook emission factors for road transport (HBEFA), Version V4.2

Table 6 presents a main overview of the methods applied and the origin of emission factors used for the categories in the NFR format for the present Austrian inventory.

For key source categories (see Chapter 1.5) the most accurate methods for the preparation of the air emission inventory should be used. Required methodological changes and planned improvements are described in the corresponding sector analysis chapters (Chapters 3–6).

1.4.1 EU Emissions Trading System (EU ETS)

The European Union Emissions Trading Scheme has been established by Directive 2003/87/EC of the European Parliament and of the Council[52] and amended by several legal acts[53]. From 2013 onwards, it is known as the European Union Emissions Trading System (EU ETS). It includes heavy energy-consuming installations in power generation and manufacturing. The activities covered are energy activities, the production and processing of ferrous metals, the mineral industry and some other production activities. From 2012 onwards, CO_2 emissions from aviation have also been included. For the trading period 2013 onwards the scope of the EU ETS has been further extended to include additional installations from the metal and chemical industry and compressor stations. For more detailed information on the included activities please refer to Annex I of the above mentioned directive.

[46] The 2019 Refinement does not revise the 2006 IPCC Guidelines, but updates, supplements and/or elaborates the 2006 IPCC Guidelines where gaps or out-of-date science have been identified. It does not replace the 2006 IPCC Guidelines, but should be used in conjunction with the 2006 IPCC Guidelines and, where indicated, with the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement). https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

[47] http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009

[48] http://www.eea.europa.eu/publications/emep-eea-guidebook-2013

[49] http://www.eea.europa.eu/publications/emep-eea-guidebook-2016

[50] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

[51] https://www.eea.europa.eu/publications/emep-eea-guidebook-2023

[52] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, OJ L 275/32

[53] Directive 2004/101/EC, Directive 2008/101/EC, Regulatin (EC) No 219/2009, Directive 2009/29/EC, Decision No 1359/2013/EU, Regulation (EU) No 421/2014, Decision (EU) 2015/1814, Regulation (EU) 2017/2392, Directive (EU) 2018/410, Commission Delegated Decision (EU) 2020/1071, Commission Delegated Regulation (EU) 2021/1416 and Decision (EU) 2023/136

Greenhouse gases covered under the EU ETS are CO_2 (since 2005), N_2O (since 2010) and PFC (since 2013).[54] About one third of total Austrian GHG emissions currently result from installations under the EU-ETS (~27 Mt CO_2 in 2022).

Plant operators have to report their activity data and emissions annually for the GHG as mentioned above; for the first time they reported their emissions of 2005 in March 2006. The first trading period of the EU ETS ran from 2005–2007. The second trading period, which coincided with the 1st Kyoto commitment period, ran from 2008–2012. The third trading period, which coincides with the 2nd Kyoto commitment period, ran from 2013 to 2020. The fourth trading period started in 2021 and will run until 2030. Since 2012 aircraft operators have also been included into the scheme. They have to report their emissions concerning internal flights in the European Economic Area.

General rules for reporting and verification of emissions in the EU ETS are defined in EU Directive 2003/87/EC and specific rules can be found in Commission Regulation (EU) No 2018/2066[55]. In Austria, Member State specific regulations are defined in the Austrian Emissions Allowance Trading Act[56]. This ordinance also specifies that the Umweltbundesamt has to incorporate, as far as necessary, the verified emissions of the emissions trading scheme into the national greenhouse gas inventory. For a detailed description of the sectors covered and the incorporation of these emissions into the national inventory please refer to the chapters 3 Energy (CRF Sector 1) and 4 Industrial Processes and Product Use (CRF Sector 2).

An important feature of the emissions reported under the EU-ETS is that these emissions have to pass independent verification by an accredited verifier. The Austrian Federal Ministry for Sustainability and Tourism has to fulfil a quality control function, which is implemented by spot checks of emissions and verification reports that the Umweltbundesamt performs on behalf of the Ministry.

1.4.2 Electronic Data Management (EDM)

The electronic data management of the Federal Ministry of 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' is an electronic recording and notification system (information network), implemented as an integrated e-government application. It allows enterprises and authorities to handle registration and notification obligations online in the areas of waste and environment (e.g. on Austrian Emissions Allowances, HFC or EMREG – Emission Register Surface Water). Data from this source are used for reporting in the sector *Wast*e (e.g. landfilled and biologically treated amounts).

There are around 40 000 users registered, covering national and international waste owners (collectors, operators of treatment plants, waste producers) doing their reporting obligations according to national legislation, e.g. on landfilled amounts.

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[54] Austria unilaterally opted-in N_2O as of 2010. Since 2013 N_2O and PFCs have been included in the EU ETS at EU level.

[55] Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 601/2012, amended by Commission Implementing Regulation (EU) 2020/2085, Commission Implementing Regulation (EU) 2022/388 and Commission Implementing Regulation (EU) 2022/1371

[56] Emissionszertifikategesetz 2011, Federal Law Gazette I No. 118/2011, as amended

1.4.3 Other data (E-PRTR)

The European Pollutant Release and Transfer Register (E-PRTR) is the EU-wide register containing key environmental data from industrial facilities in European Union Member States and in Iceland, Liechtenstein, Norway, Serbia and Switzerland. It was established through the E-PRTR Regulation (EC) No 166/2006.

E-PRTR was preceded by the European Pollutant Emission Register (EPER), with reporting years 2001 or 2002 and 2004. It covers 91 pollutants from nine activity groups, including all pollutants reported already under EPER. However, emissions only have to be reported if they exceed certain thresholds. In contrast to EPER, E-PRTR also includes data on releases to land, accidental releases, waste transfers and diffuse emissions[57].

Umweltbundesamt implemented E-PRTR in Austria using an electronic system enabling the facilities and the authorities to fulfil the requirements of the E-PRTR Regulation online. In 2008, installations reported for the first time releases and transfers of pollutants and waste from 2007 under the E-PRTR, which is an annual reporting obligation. The plausibility of the reports is checked by the competent authorities and Umweltbundesamt. Umweltbundesamt also checks the data for consistency with other reporting obligations, across the years and across facilities with the same activity.

Since submission 2018 data from E-PRTR or its predecessor have been used in one source category (*NFR 2.B.10* for NMVOC). The main reason for not using E-PRTR data on a broader scale in the national inventory is that the E-PRTR reports contain only very little information other than emission data, whereby these emissions can either be reported as estimated, measured or calculated emissions. Activity data are often reported in units not useful for the inventory, and also the type of activity data may be different between producers of the same product. In addition, E-PRTR data is not complete for IPCC sectors and it is difficult to include this point source information because no background information (such as fuel consumption data) is available. Furthermore the reporting thresholds are relatively high, so that many of the relevant installations do not have to report.

Thus greenhouse gas emission data from the EU Emissions Trading System (see chapter 1.4.1), combined with the top-down approach of the national inventory has been considered to be more reliable and data of EPER/E-PRTR has not been used as a source for point source data for the national inventory, but for verification purposes – where possible.

1.4.4 Literature

National and sometimes international studies are also used as data suppliers (references are given in the sector analysis chapters).

1.4.4.1 Studies on HM, POPs and PM emissions

Emissions of HM and some POPs have already been estimated in the course of CORINAIR 1990 and 1994, respectively.[58] With these data and other Austrian publications as a basis, comprehensive

[57] Data can be downloaded from: https://www.umweltbundesamt.at/umweltthemen/industrie/daten-industrie/prtr

[58] Orthofer, R. (1996); Hübner, C. (1996); Hübner, C. & Wurst, F. (1997); Hübner, C. (2000)

emission inventories of HM, POPs and PM for different years were prepared by contractors of the Umweltbundesamt and incorporated into the inventory system afterwards.

- Windsperger, A. et. al. *Entwicklung der Schwermetallemissionen – Abschätzung der Emissionen von Blei, Cadmium und Quecksilber für die Jahre 1985, 1990 und 1995 gemäß der CORINAIR-Systematik.* Wien: Institut für Industrielle Ökologie und Österreichisches Forschungszentrum Seibersdorf, 1999 (nicht veröffentlicht).

  Development of Heavy Metal Emissions – Estimation of emissions of Lead, Cadmium and Mercury for the years 1985, 1990 and 1995 according to the CORINAIR-systematics. Department for industrial ecology and Austrian Research Centers Seibersdorf. Vienna. (Not published).
- Österreichische Emissionsinventur für Cadmium, Quecksilber und Blei.

  Austrian emission inventory for Cd, Hg and Pb 1995–2000 prepared by FTU – Forschungsgesellschaft Technischer Umweltschutz GmbH. Vienna November 2001 (not published).
- Hübner, C. *Österreichische Emissionsinventur für POPs 1985–1999.* Wien: FTU – Forschungsgesellschaft Technischer Umweltschutz GmbH. Werkvertrag des Umweltbundesamtes, IB-650. 2001 (nicht veröffentlicht).

  Austrian emission inventory for POPs 1985–1999. Prepared by FTU – Research Center Technical environment protection (Ltd.). Study commissioned by Umweltbundesamt IB-650. Vienna. (Not published).
- Winiwarter, W., Trenker, C. und W. Höflinger. Österreichische Emissionsinventur für Staub. Wien: Österreichisches Forschungszentrum Seibersdorf, 2001.

  Austrian emission inventory for PM. Austrian Research Centers Seibersdorf. Vienna.
- Winiwarter, W., Schmid-Stejskal, H. & A. Windsperger. *Aktualisierung und Verbesserung der österreischen Luftschadstoffinventur für Schwebstaub.* Wien: Systems research – Austrian Research Centers & Institut für Industrielle Ökologie, 2007.

  Updating and Improvement of the Austrian Air Emission Inventory (OLI) for PM. Systems research – Austrian Research Centers & Department for industrial ecology. Vienna.

1.4.5 Summary of methodologies applied for estimating emissions

In Table 6 a summary of methodologies applied for estimating emissions is given.

The following abbreviations are used:

- D DEFAULT
- L Literature
- CS COUNTRY SPECIFIC
- PS PLANT SPECIFIC

Dark shaded cells indicate that no such emissions arise from this source; light shaded cells indicate key sources.

Table 6: Summary of methodologies applied for estimating emissions.

NFR	Description	SO_2	NO_x	NMVOC	NH_3	CO	Cd	Hg	Pb	PAH	DIOX	HCB	PCB	TSP	PM_{10}	$PM_{2.5}$
1.A.1.a	Public Electricity and Heat Production	D/PS, CS	PS, CS	CS	CS	PS, CS	D/CS	D/CS	D/CS	L/CS	L/CS	L/CS	D/CS	PS, CS	PS, CS	PS, CS
1.A.1.b	Petroleum refining	PS	PS		CS	PS	D	CS	CS	L/CS	L/CS	CS	CS	PS	PS	PS
1.A.1.c	Manufac.of Solid fuels a. Oth. Energy Ind.	D/CS	CS	CS	CS	CS	D	D	D	D	L/CS	CS	CS	CS	CS	CS
1.A.2 mobile	Other mobile in industry	D/CS	CS	CS	CS	CS	CS	CS	CS	L/CS	L/CS	CS	L/CS	CS	CS	CS
1.A.2 stat	Manuf. Ind. & Constr. – stationary	D/PS, CS	PS, CS	PS, CS	CS	PS, CS	D/CS	D/CS	D/CS	L/CS	L/CS	CS	D/CS	PS, CS	PS, CS	PS, CS
1.A.3.a	Civil Aviation	CS	CS	CS	CS	CS	CS	CS	CS					CS	CS	CS
1.A.3.b.1	R.T., Passenger cars	CS	CS	CS	CS	CS	CS	CS	CS	L/CS	L/CS	CS	D	CS	CS	CS
1.A.3.b.2	R.T., Light duty vehicles	CS	CS	CS	CS	CS	CS	CS	CS	L/CS	L/CS	CS	D	CS	CS	CS
1.A.3.b.3	R.T., Heavy duty vehicles	CS	CS	CS	CS	CS	CS	CS	CS	L/CS	L/CS	CS	D	CS	CS	CS
1.A.3.b.4	R.T., Mopeds & Motor-cycles	CS	CS	CS	CS	CS	CS	CS	CS	L/CS	L/CS	CS	D	D	D	D
1.A.3.b.5	R.T., Gasoline evaporation			CS												
1.A.3.b.6	R.T., Automobile tyre and break wear						CS							D	D	D
1.A.3.b.7	R.T., Automobile road abrasion						L	L	L					D	D	D
1.A.3.c	Railways	CS	CS	CS	CS	CS	D/CS	D/CS	D/CS	L/CS	L/CS	CS	D/CS	CS	CS	CS
1.A.3.d	Navigation	CS	CS	CS	CS	CS	CS	CS	CS	L/CS	L/CS	CS	D/CS	CS	CS	CS
1.A.3.e.i	Pipeline compressors	D	PS/CS	CS	CS	CS	D	D	D	D	CS	CS	CS	CS	CS	CS
1.A.3.e.ii	Other transportation	CS	CS	CS	CS	CS	CS	CS	CS	L/CS	L/CS	CS	CS	CS	CS	CS

NFR	Description	SO_2	NO_x	NMVOC	NH_3	CO	Cd	Hg	Pb	PAH	DIOX	HCB	PCB	TSP	PM_{10}	$PM_{2.5}$
1.A.4 mob	Other Sectors – mobile	CS	CS	CS	CS	CS	CS	CS	CS	L/CS	L/CS	CS	CS	CS	CS	CS
1.A.4 stat	Other Sectors –stationary	D/CS	D/L/CS	D/L/CS	D/CS	D/L/CS	D/CS	D/CS	D/CS	D/L/CS	D/L/CS	D/CS	D/CS	D/L/CS	D/L/CS	D/L/CS
1.A.5	Other	CS	CS	CS	CS	CS	CS	CS	CS	L/CS	L/CS	CS	L/CS	CS	CS	CS
1.B	FUGITIVE EMISSIONS	PS		D, PS, CS	D			D						CS	CS	CS
2.A	MINERAL PRODUCTS													CS/L/D	CS/L/D	CS/L/D
2.B	CHEMICAL INDUSTRY	PS	PS	PS	PS	PS/L	PS	PS	PS					PS/CS	PS/CS	PS/CS
2.C	METAL PRODUCTION	PS/CS	PS/CS	PS/CS		PS/CS	PS/CS	PS/CS	PS/CS	PS/CS	PS/CS	CS	PS	PS/CS	PS/CS	PS/CS
2.D	NON ENERGY PRODUCTS FROM FUELS AND SOLVENT USE			PS/CS/D		D	CS		CS	L	L	L		D/CS	D/CS	D/CS
2.G	Other product manufacture and use	D	D	D	D	D	D	D	D	D	D			D/CS	D/CS	D/CS
2.H	Other Processes			L						CS	CS	CS		CS	CS	CS
2.I	Wood processing													CS	CS	CS
3.B.1	Cattle		T2	CS/D	CS									L	L	L
3.B.2	Sheep		T2	CS/D	T2									L	L	L
3.B.3	Swine		T2	CS/D	CS									L	L	L
3.B.4.d	Goats		T2	CS/D	T2									L	L	L
3.B.4.e	Horses		T2	CS/D	T2									L	L	L
3.B.4.g	Poultry		T2	CS/D	T2									L	L	L
3.B.4.h	Other animals		T2	CS/D	T2									L	L	L
3.D	AGRICULTURAL SOILS		D	CS/D	CS/D							D		D/L	D/L	D/L
3.F	Field burning of agricultural residues	CS/D	CS/D	CS/D	CS/D	CS/D	CS/D	CS/D	CS/D	CS/D	CS/D	CS/D		CS/D	CS/D	CS/D

NFR	Description	SO_2	NO_x	NMVOC	NH_3	CO	Cd	Hg	Pb	PAH	DIOX	HCB	PCB	TSP	PM_{10}	$PM_{2.5}$
3.I	Agriculture – Other															
5.A	Solid waste disposal on land			CS	CS	CS	CS	CS	CS							
5.B	Biological treatment of waste				CS											
5.C	Waste Incineration	D/CS	CS	CS	CS	CS	D/CS	CS	CS	CS	CS	CS	D	CS	CS	CS
5.D	Wastewater handling			D												
5.E	Other waste						CS/D	CS/D	CS/D		CS/D			CS/D	CS/D	CS/D

1.5 Key Category Analysis

The identification of key categories is described in the "EMEP/EEA air pollutant emission inventory guidebook 2023" (EEA, 2023)".

It stipulates that a key category is one that is prioritised within the national inventory system because it is significantly important for one or a number of air pollutants in a country's national inventory of air pollutants in terms of the absolute level, the trend, or the uncertainty in emissions.

It is good practice for each country to use key category analysis systematically and objectively as a basis for choosing methods of emission calculation. Such a process will lead to improved inventory quality as well as greater confidence in the resulting estimates. This can be achieved by performing a quantitative analysis of the relationship between the magnitude of emissions in any one year (i.e. level) and the change in emissions year to year (i.e. trend) for each category's emissions compared to the total national emissions (EEA, 2023).

All notations, descriptions of identification and results for key categories included in this chapter are based on the latest Inventory Guidebook.

The identification includes all NFR categories and all reported gases

- SO_2, NO_x, NMVOC, NH_3, CO
- PM: TSP, PM_{10}, $PM_{2.5}$
- HM: Cd, Hg, Pb
- POP: PAH, PCDD/F, HCB, PCB

Used methodology for identification of key categories: Approach 1

The methodology follows the IPCC approach to produce pollutant-specific key categories and covers for both level and trend assessment. In Approach 1, key categories are identified using a predetermined cumulative emissions threshold. Key categories are those which, when summed together in descending order of magnitude, cumulatively add up to 80% of the total level.

The suggested aggregation level of analysis for Approach 1 provided in Table 2-1 of Chapter 2 of the EMEP/EEA emission inventory guidebook 2023 was used. No special considerations like disaggregation to main fuel types have been made. For reasons of transparency, the same level of aggregation for all pollutants was used.

The presented key category analysis was performed by the Umweltbundesamt with data for air emissions of the submission 2024 to the UNECE/LRTAP and the European Commission. For all gases a level assessment for all years 1990 (base year) and 2022 (last year), as well as a trend assessment for 1990 to 2022 was prepared.

1.A Combustion Activities

1.A Combustion Activities is the most important sector for emissions reported to UNECE and EC. To account for this fact and help prioritising efforts this sector was analysed in greater detail.

Furthermore, for mobile sources the different means of transport were considered separately, and additionally the sub category road transport was further disaggregated as it is an important source for many pollutants.

For stationary sources a split following the forth level of the NFR was used (1.A.2.g, 1.A.4.a, b, c).

NFR	Description	NFR	Description
1.A.1.a	Public Electricity and Heat Production	1.A.3.a	Civil Aviation – LTO (internatinal and domestic)
1.A.1.b	Petroleum refining	1.A.3.b.1	R.T., Passenger cars
1.A.1.c	Manufacture of Solid fuels and Other Energy Industries	1.A.3.b.2	R.T., Light duty vehicles
1.A.2.a	Iron and Steel	1.A.3.b.3	R.T., Heavy duty vehicles
1.A.2.b	Non-ferrous Metals	1.A.3.b.4	R.T., Mopeds & Motorcycles
1.A.2.c	Chemicals	1.A.3.b.5	R.T., Gasoline evaporation
1.A.2.d	Pulp, Paper and Print	1.A.3.b.6	R.T., Automobile tyre and break wear
1.A.2.e	Food Processing, Beverages and Tobacco		
1.A.2.g.7	Mobile Combustion in Manufacturing Industries and Construction	1.A.3.b.7	R.T., Automobile road abrasion
1.A.2.g.8	Other Stationary Combustion in Manufacturing Industries and Construction	1.A.3.c	Railways
1.A.4.a.1	Commercial/Institutional: Stationary	1.A.3.d	Navigation (national navigation and international inland waterway)
1.A.4.a.2	Commercial/Institutional: Mobile	1.A.3.e.1	Pipeline compressors
1.A.4.b.1	Residential: stationary	1.A.3.e.2	Other transportation
1.A.4.b.2	Residential: Household and gardening (mobile)	1.A.5.a	Other, Stationary (including Military)
1.A.4.c.1	Agriculture/Forestry/Fishing: Stationary	1.A.5.b	Other, Mobile (including Military)
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery		
1.A.4.c.3	Agriculture/Forestry/Fishing: National Fishing		

1.B Fugitive Emission

For fugitive emissions a split following the third level of the NFR was used.

NFR	Description	NFR	Description
1.B.1.a	Coal Mining and Handling	1.B.2.a	Oil
1.B.1.b	Solid fuel transformation	1.B.2.b	Natural gas
1.B.1.c	Other fugitive emissions from solid fuels	1.B.2.c	Venting and flaring (Oil and natural gas)
		1.B.2.d	Other fugitive emissions

2 Industrial Processes and Product Use

For source categories from Industrial processes, a general split following the third level of the NFR was used. As 2.D.3 (Solvents) is an important source for NMVOC emissions, it was broken down into level 4. For the source categories NFR 2.I – NFR 2.L level two of the NFR was used.

NFR	Description	NFR	Description
2.A.1	Cement Production	2.D.3.a	Domestic Solvent Use including Fungicides
2.A.2	Lime Production	2.D.3.b	Road Paving with Asphalt
2.A.3	Glass Production	2.D.3.c	Asphalt Roofing

NFR	Description	NFR	Description
2.A.5	Mining, construction/demolition and handling of Product	2.D.3.d	Coating applications
2.A.6	Other Mineral Products	2.D.3.e	Degreasing
2.B.1	Ammonia Production	2.D.3.f	Dry cleaning
2.B.2	Nitric Acid Production	2.D.3.g	Chemical products
2.B.3	Adipic Acid Production	2.D.3.h	Printing
2.B.4	Carbide Production	2.D.3.i	Other Solvent Use
2.B.5	Other	2.H	Other Processes
2.B.6	Titanium Dioxide Production	2.I	Wood processing
2.B.7	Soda ash Producion	2.J	Production of POPs
2.B.10	Other (Handling of products and other chemical industry)	2.K	Consumption of POPs and Heavy Metals (e.g. electricial and scientific equipment)
2.C.1	Iron and Steel Production	2.L	Other production, consumption, storage, transp. or handling of bulk products
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	Other Metal Production		

3 Agriculture

Level three of the NFR was used; only the sub category 3.B.4 und 3.D.a were further disaggregated, as these are important sources for NH_3. For 3.B.4 also the methodology is different for the animal categories.

NFR	Description	NFR	Description
3.B.1	Cattle	3.D.a.1	Inorganic N-fertilizers
3.B.2	Sheep	3.D.a.2	Organic fertilizers
3.B.3	Swine	3.D.a.3	Urine an dung deposited by grazing animals
3.B.4.a	Buffalo	3.D.d	Off-farm storage, handling and transport of agricultural products
3.B.4.d	Goats	3.D.e	Cultivated crops
3.B.4.e	Horses	3 D f	Use of pesticides
3.B.4.f	Mules and Asses	3.F	Field Burning of agricultural Residues
3.B.4.g	Poultry	3.I	Agriculture Other
3.B.4.h	Other animals		

5 Waste

Level two of the NFR was used.

NFR	Description	NFR	Description
5.A	Solid Waste Disposal on Land	5.C.2	Open burning of waste
5.B.1	Composting	5.D	Wastewater Treatment
5.C.1	Waste Incineration	5.E	Other Waste

Results of the Level and Trend Assessment (Approach 1)

As the analysis was made for all pollutants reported to the UNECE/EC and as these pollutants differ in their way of formation, most of the identified categories are key for more than one pollutant: in total 44 key sources were identified.

Table 7: Summary of Key Categories for the year 2022 – Contributions per pollutant for Level Assessment (LA) and Trend Assessment (TA) in %.

NFR Code	NFR Category	% Contributions to pollutant totals for key categories (cumulative 80%)																														Sum of KC % contributions	Rank
		SO_2		NO_x		NMVOC		NH_3		CO		Cd		Pb		Hg		PAH		DIOX		HCB		PCB		TSP		PM_{10}		$PM_{2.5}$			
		LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA		
1.A.1.a	Public Electricity and Heat Production	7	18	7	4							17		15		16				5	11	5						4		6		**113**	**4**
1.A.1.b	Petroleum refining	5			3							16																				**24**	**21**
1.A.2.a	Iron and Steel	44	3							35	5																					**87**	**6**
1.A.2.d	Pulp, Paper and Print		6	4								6	10			8											3		3		4	**44**	**13**
1.A.2.f	Non-metallic Minerals	6		5	4								8			16	34							15								**88**	**5**
1.A.2.g.7	Mobile Combustion in Manufacturing Industries and Construction			4																												**4**	**41**
1.A.2.g.8	Other Stationary Combustion in Manufacturing Industries and Construction	13										6								6												**24**	**18**
1.A.3.b.1	R.T., Passenger cars			29	25		28			7	56				71												5		6	3	7	**236**	**3**
1.A.3.b.2	R.T., Light duty vehicles			5																							3		3		4	**16**	**29**

NFR Code	**NFR Category**	**% Contributions to pollutant totals for key categories (cumulative 80%)**																																**Sum of KC % contributions**	**Rank**
		SO_2		**NO_X**		**NMVOC**		**NH_3**		**CO**		**Cd**		**Pb**		**Hg**		**PAH**		**DIOX**		**HCB**		**PCB**		**TSP**		**PM_{10}**		**$PM_{2.5}$**			
		LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA		
1.A.3.b.3	R.T., Heavy duty vehicles		4	8	37																						9		11		14	**82**	**7**
1.A.3.b.5	R.T., Gasoline evaporation						9																									**9**	**32**
1.A.3.b.6	R.T., Automobile tyre and break wear													40												6	6	7	5	8	4	**76**	**9**
1.A.3.b.7	R.T., Automobile road abrasion																									5	5	4	3	5		**22**	**22**
1.A.3.c	Railways																									3		2				**5**	**34**
1.A.4.a.1	Commercial/Institutional: Stationary		8																								2			2		**12**	**30**
1.A.4.b.1	Residential: stationary	9	39	8	5	21	6			41	20	25	9	13		14	16	75	44	45	25	58	65		13	14	20	21	22	40	27	**697**	**1**
1.A.4.c.1	Agriculture/Forestry/Fishing: Stationary																	10		4		5								3		**21**	**23**
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery			5	4																						6		8	3	10	**35**	**14**
1.B.2.a	Oil						4																									**4**	**38**
1.B.2.b	Natural gas		3																													**3**	**43**

NFR Code	NFR Category	% Contributions to pollutant totals for key categories (cumulative 80%)																														Sum of KC % contributions	Rank
		SO_2		NO_X		NMVOC		NH_3		CO		Cd		Pb		Hg		PAH		DIOX		HCB		PCB		TSP		PM_{10}		$PM_{2.5}$			
		LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA		
2.A.5	Mining, construction/demolition and handling of products																									43		28		6		**77**	**8**
2.C.1	Iron and Steel Production											6	42	5	14	34	17		46		34			65	20		22		19		11	**334**	**2**
2.C.3	Aluminium production																			11		17										**28**	**17**
2.C.5	Lead Production												7	5											57							**68**	**12**
2.C.7	Other metal production																			4												**4**	**40**
2.D.3.a	Domestic solvent use including fungicides					17																										**17**	**26**
2.D.3.d	Coating applications					8	16																									**24**	**19**
2.D.3.e	Degreasing					3	5																									**7**	**33**
2.D.3.g	Chemical products						5																									**5**	**37**
2.D.3.h	Printing						5																									**5**	**36**
2.D.3.i	Other solvent use						5																									**5**	**35**
2.G	Other product manufacture and use											8		7														2		3		**19**	**25**

NFR Code	NFR Category	% Contributions to pollutant totals for key categories (cumulative 80%)																														Sum of KC % contributions	Rank
		SO_2		NO_X		NMVOC		NH_3		CO		Cd		Pb		Hg		PAH		DIOX		HCB		PCB		TSP		PM_{10}		$PM_{2.5}$			
		LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA		
2.H	Other Processes					3																										**3**	**42**
2.I	Wood processing																									3		2				**4**	**39**
3.B.1	Cattle					21		30	19																							**70**	**11**
3.B.3	Swine							8	20																							**28**	**15**
2.B-10	Handling of products and other chemical industry																17															**17**	**27**
3.D.a.1	Inorganic N-fertilizers			4				10	14																							**28**	**16**
3.D.a.2	Organic fertilizers			5		7		37	27																							**75**	**10**
3.D.c	On-farm storage, handling and transport of agricultural products																									7		12				**19**	**24**
3.D.f	Use of Pesticides																						16									**16**	**28**
5.C.1	Waste incineration												6								18											**24**	**20**
5.E	Other waste handling																			9										2		**11**	**31**

Table 8: Key Categories for SO_2 emissions for the year 2022.

Level Assessment

NFR Code	NFR Category	Latest Year (2022) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1.A.2.a	Iron and Steel	4.69	43.5%	43.5%
1.A.2.g.8	Other Stationary Combustion in Manufacturing Industries and Construction	1.36	12.7%	56.2%
1.A.4.b.1	Residential: stationary	0.99	9.2%	65.4%
1.A.1.a	Public Electricity and Heat Production	0.70	6.5%	71.9%
1.A.2.f	Non-metallic Minerals	0.65	6.0%	77.9%
1.A.1.b	Petroleum refining	0.50	4.6%	82.6%
	National Total	**10.78**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2022) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
1.A.4.b.1	Residential: stationary	25.87	0.99	0.395	39.4%	39.4%
1.A.1.a	Public Electricity and Heat Production	11.81	0.7	0.177	17.6%	57.0%
1.A.4.a.1	Commercial/Institutional: Stationary	4.95	0.04	0.078	7.8%	64.8%
1.A.2.d	Pulp, Paper and Print	4.3	0.4	0.062	6.2%	70.9%
1.A.3.b.3	R.T., Heavy duty vehicles	2.58	0.04	0.04	4.0%	75.0%
1.A.2.a	Iron and Steel	6.73	4.69	0.032	3.2%	78.2%
1.B.2.b	Natural gas	2	0.03	0.031	3.1%	81.3%
	National Total	**73.70**	**10.78**			

Table 9: Key Categories for NO_x emissions for the year 2022.

Level Assessment

NFR Code	NFR Category	Latest Year (2022) Estimate [kt] Ex,t	Level Assessment Lx,t	Cumulative Total of Lx,t
1.A.3.b.1	R.T., Passenger cars	33.54	29.3%	29.3%
1.A.4.b.1	Residential: stationary	9.47	8.3%	37.6%
1.A.3.b.3	R.T., Heavy duty vehicles	9.37	8.2%	45.8%
1.A.1.a	Public Electricity and Heat Production	7.73	6.8%	52.5%
1.A.3.b.2	R.T., Light duty vehicles	6.29	5.5%	58.0%
3.D.a.2	Organic fertilizers	5.52	4.8%	62.8%
1.A.2.f	Non-metallic Minerals	5.45	4.8%	67.6%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	5.35	4.7%	72.3%
1.A.2.g.7	Mobile Combustion in Manufacturing Industries and Construction	4.5	3.9%	76.2%
1.A.2.d	Pulp, Paper and Print	4.27	3.7%	79.9%
3.D.a.1	Inorganic N-fertilizers	4.05	3.5%	83.5%
	National Total	**114.44**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] Ex,0	Latest Year (2022) Estimate [kt] Ex,t	Trend Assessment Lx,t	Contribution to the trend	Cumulative Total of Lx,t
1.A.3.b.3	R.T., Heavy duty vehicles	48.77	9.37	0.387	36.6%	36.6%
1.A.3.b.1	R.T., Passenger cars	59.93	33.54	0.259	24.5%	61.1%
1.A.4.b.1	Residential: stationary	15.39	9.47	0.058	5.5%	66.6%
1.A.2.f	Non-metallic Minerals	9.99	5.45	0.045	4.2%	70.8%
1.A.1.a	Public Electricity and Heat Production	12.09	7.73	0.043	4.1%	74.9%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	9.42	5.35	0.04	3.8%	78.6%
1.A.1.b	Petroleum refining	4.32	1.00	0.033	3.1%	81.7%
	National Total	**216.19**	**114.44**			

Table 10: Key Categories for NMVOC emissions for the year 2022.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2022) Estimate [kt] Ex,t**	**Level Assessment Lx,t**	**Cumulative Total of Lx,t**
3.B.1	Cattle	21.36	21.4%	21.4%
1.A.4.b.1	Residential: stationary	21.04	21.0%	42.4%
2.D.3.a	Domestic solvent use including fungicides	17.11	17.1%	59.5%
2.D.3.d	Coating applications	7.77	7.8%	67.3%
3.D.a.2	Organic fertilizers	6.96	7.0%	74.2%
2.H	Other Processes	3.14	3.1%	77.3%
2.D.3.e	Degreasing	2.7	2.7%	80.1%
	National Total	**100.04**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kt] Ex,0**	**Latest Year (2022) Estimate [kt] Ex,t**	**Trend Assessment Lx,t**	**Contribution to the trend**	**Cumulative Total of Lx,t**
1.A.3.b.1	R.T., Passenger cars	65.8	1.7	0.284	27.8%	27.8%
2.D.3.d	Coating applications	45.79	7.77	0.168	16.5%	44.2%
1.A.3.b.5	R.T., Gasoline evaporation	20.8	0.33	0.091	8.9%	53.1%
1.A.4.b.1	Residential: stationary	35.52	21.04	0.064	6.3%	59.4%
2.D.3.i	Other solvent use	13.2	0.98	0.054	5.3%	64.7%
2.D.3.h	Printing	12.65	0.69	0.053	5.2%	69.9%
2.D.3.g	Chemical products	12.79	2	0.048	4.7%	74.5%
2.D.3.e	Degreasing	13.26	2.7	0.047	4.6%	79.1%
1.B.2.a	Oil	11.52	1.48	0.044	4.3%	83.5%
	National Total	**328.77**	**100.04**			

Table 11: Key Categories for NH_3 emissions for the year 2022.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2022) Estimate [kt] Ex,t**	**Level Assessment Lx,t**	**Cumulative Total of Lx,t**
3.D.a.2	Organic fertilizers	24.86	36.6%	36.6%
3.B.1	Cattle	20.15	29.6%	66.2%
3.D.a.1	Inorganic N-fertilizers	6.85	10.1%	76.3%
3.B.3	Swine	5.67	8.3%	84.6%
	National Total	**67.99**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kt] Ex,0**	**Latest Year (2022) Estimate [kt] Ex,t**	**Trend Assessment Lx,t**	**Contribution to the trend**	**Cumulative Total of Lx,t**
3.D.a.2	Organic fertilizers	30.63	24.86	0.951	27.0%	27.0%
3.B.3	Swine	9.97	5.67	0.709	20.1%	47.1%
3.B.1	Cattle	16.01	20.15	0.683	19.4%	66.4%
3.D.a.1	Inorganic N-fertilizers	9.89	6.85	0.501	14.2%	80.6%
	National Total	**74.09**	**67.99**			

Table 12: Key Categories for CO emissions for the year 2022.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2022) Estimate [kt] Ex,t**	**Level Assessment Lx,t**	**Cumulative Total of Lx,t**
1.A.4.b.1	Residential: stationary	195.31	40.6%	40.6%
1.A.2.a	Iron and Steel	168.46	35.1%	75.7%
1.A.3.b.1	R.T., Passenger cars	34.00	7.1%	82.8%
	National Total	**480.62**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kt] Ex,0**	**Latest Year (2022) Estimate [kt] Ex,t**	**Trend Assessment Lx,t**	**Contribution to the trend**	**Cumulative Total of Lx,t**
1.A.3.b.1	R.T., Passenger cars	464.97	34.00	0.562	55.5%	55.5%
1.A.4.b.1	Residential: stationary	353.17	195.31	0.206	20.3%	75.9%
1.A.2.a	Iron and Steel	210.72	168.46	0.055	5.4%	81.3%
	National Total	**1 248.24**	**480.62**			

Table 13: Key Categories for Cd emissions for the year 2022.

Level Assessment

NFR Code	NFR Category	Latest Year (2022) Estimate [t] Ex,t	Level Assessment Lx,t	Cumulative Total of Lx,t
1.A.4.b.1	Residential: stationary	0.22	24.9%	24.9%
1.A.1.a	Public Electricity and Heat Production	0.15	17.2%	42.1%
1.A.1.b	Petroleum refining	0.14	16.2%	58.3%
2.G	Other product manufacture and use	0.07	8.1%	66.4%
1.A.2.g.8	Other Stationary Combustion in Manufacturing Industries and Construction	0.05	5.9%	72.3%
2.C.1	Iron and Steel Production	0.05	5.7%	78.0%
1.A.2.d	Pulp, Paper and Print	0.05	5.5%	83.5%
	National Total	**0.89**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [t] Ex,0	Latest Year (2022) Estimate [t] Ex,t	Trend Assessment Lx,t	Contribution to the trend	Cumulative Total of Lx,t
2.C.1	Iron and Steel Production	0.46	0.05	0.474	41.8%	41.8%
1.A.2.d	Pulp, Paper and Print	0.15	0.05	0.118	10.4%	52.2%
1.A.4.b.1	Residential: stationary	0.31	0.22	0.104	9.2%	61.4%
1.A.2.f	Non-metallic Minerals	0.1	0.02	0.089	7.9%	69.2%
2.C.5	Lead Production	0.07	0.01	0.076	6.7%	76.0%
5.C.1	Waste incineration	0.06	0	0.067	5.9%	81.9%
	National Total	**1.76**	**0.89**			

Table 14: Key Categories for Pb emissions for the year 2022.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2022) Estimate [t] Ex,t**	**Level Assessment Lx,t**	**Cumulative Total of Lx,t**
1.A.3.b.6	R.T., Automobile tyre and break wear	5.51	40.3%	40.3%
1.A.1.a	Public Electricity and Heat Production	2	14.6%	54.9%
1.A.4.b.1	Residential: stationary	1.72	12.6%	67.5%
2.G	Other product manufacture and use	0.89	6.5%	74.0%
2.C.5	Lead Production	0.65	4.7%	78.8%
2.C.1	Iron and Steel Production	0.63	4.6%	83.4%
	National Total	**13.67**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [t] Ex,0**	**Latest Year (2022) Estimate [t] Ex,t**	**Trend Assessment Lx,t**	**Contribution to the trend**	**Cumulative Total of Lx,t**
1.A.3.b.1	R.T., Passenger cars	161.57	0.01	0.737	71.1%	71.1%
2.C.1	Iron and Steel Production	32.09	0.63	0.144	13.8%	84.9%
	National Total	**232.89**	**13.67**			

Table 15: Key Categories for Hg emissions for the year 2022.

Level Assessment

NFR Code	NFR Category	Latest Year (2022) Estimate [t] Ex,t	Level Assessment Lx,t	Cumulative Total of Lx,t
2.C.1	Iron and Steel Production	0.34	34.0%	34.0%
1.A.2.f	Non-metallic Minerals	0.16	15.9%	49.9%
1.A.1.a	Public Electricity and Heat Production	0.16	15.9%	65.8%
1.A.4.b.1	Residential: stationary	0.14	14.2%	80.0%
1.A.2.d	Pulp, Paper and Print	0.08	8.2%	88.2%
	National Total	**0.99**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [t] Ex,0	Latest Year (2022) Estimate [t] Ex,t	Trend Assessment Lx,t	Contribution to the trend	Cumulative Total of Lx,t
1.A.2.f	Non-metallic Minerals	0.7	0.16	0.357	34.1%	34.1%
2.B-10	Handling of products and other chemical industry	0.27	0	0.177	16.9%	51.1%
2.C.1	Iron and Steel Production	0.6	0.34	0.173	16.5%	67.6%
1.A.4.b.1	Residential: stationary	0.39	0.14	0.164	15.7%	83.2%
	National Total	**2.52**	**0.99**			

Table 16: Key Categories for PAH emissions for the year 2022.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2022) Estimate [t] Ex,t**	**Level Assessment Lx,t**	**Cumulative Total of Lx,t**
1.A.4.b.1	Residential: stationary	4.24	74.6%	74.6%
1.A.4.c.1	Agriculture/Forestry/Fishing: Stationary	0.58	10.1%	84.7%
	National Total	**5.68**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [t] Ex,0**	**Latest Year (2022) Estimate [t] Ex,t**	**Trend Assessment Lx,t**	**Contribution to the trend**	**Cumulative Total of Lx,t**
2.C.1	Iron and Steel Production	6.26	0.07	0.491	46.3%	46.3%
1.A.4.b.1	Residential: stationary	10.15	4.24	0.469	44.3%	90.6%
	National Total	**18.47**	**5.68**			

Table 17: Key Categories for PCDD/F/Furan emissions for the year 2022.

Level Assessment

NFR Code	NFR Category	Latest Year (2022) Estimate [g] Ex,t	Level Assessment Lx,t	Cumulative Total of Lx,t
1.A.4.b.1	Residential: stationary	14.27	45.0%	45.0%
2.C.3	Aluminium production	3.48	11.0%	56.0%
5.E	Other waste handling	2.9	9.2%	65.1%
1.A.2.g.8	Other Stationary Combustion in Manufacturing Industries and Construction	1.88	5.9%	71.0%
1.A.1.a	Public Electricity and Heat Production	1.44	4.5%	75.6%
2.C.7	Other metal production	1.33	4.2%	79.8%
1.A.4.c.1	Agriculture/Forestry/Fishing: Stationary	1.24	3.9%	83.7%
	National Total	**31.72**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [g] Ex,0	Latest Year (2022) Estimate [g] Ex,t	Trend Assessment Lx,t	Contribution to the trend	Cumulative Total of Lx,t
2.C.1	Iron and Steel Production	34.51	0.53	0.383	34.3%	34.3%
1.A.4.b.1	Residential: stationary	39.29	14.27	0.282	25.3%	59.6%
5.C.1	Waste incineration	18.19	0.32	0.201	18.1%	77.7%
1.A.1.a	Public Electricity and Heat Production	12.12	1.44	0.12	10.8%	88.5%
	National Total	**121.68**	**31.72**			

Table 18: Key Categories for HCB emissions for the year 2022.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2022) Estimate [kg] Ex,t**	**Level Assessment Lx,t**	**Cumulative Total of Lx,t**
1.A.4.b.1	Residential: stationary	6.05	58.2%	58.2%
2.C.3	Aluminium production	1.74	16.7%	74.9%
1.A.1.a	Public Electricity and Heat Production	0.5	4.8%	79.8%
1.A.4.c.1	Agriculture/Forestry/Fishing: Stationary	0.48	4.7%	84.4%
	National Total	**10.40**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kg] Ex.0**	**Latest Year (2022) Estimate [kg] Ex.t**	**Trend Assessment Lx.t**	**Contribution to the trend**	**Cumulative Total of Lx.t**
1.A.4.b.1	Residential: stationary	47.56	6.05	0.681	65.4%	65.4%
3.D.f	Use of pesticides	10.12	0.02	0.166	15.9%	81.3%
	National Total	**81.66**	**10.40**			

Table 19: Key Categories for PCB emissions for the year 2022.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2022) Estimate [kg] Ex,t**	**Level Assessment Lx,t**	**Cumulative Total of Lx,t**
2.C.1	Iron and Steel Production	1.79	64.6%	64.6%
1.A.2.f	Non-metallic Minerals	0.43	15.5%	80.1%
	National Total	**2.77**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kg] Ex.0**	**Latest Year (2022) Estimate [kg] Ex.t**	**Trend Assessment Lx.t**	**Contribution to the trend**	**Cumulative Total of Lx.t**
2.C.5	Lead Production	19.16	0.00	0.57	56.9%	56.9%
2.C.1	Iron and Steel Production	8.52	1.79	0.20	20.0%	76.9%
1.A.4.b.1	Residential: stationary	4.53	0.06	0.133	13.3%	90.2%
	National Total	**36.41**	**2.77**			

Table 20: Key Categories for TSP emissions for the year 2022.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2022) Estimate [kt] Ex,t**	**Level Assessment Lx,t**	**Cumulative Total of Lx,t**
2.A.5	Mining, construction/demolition and handling of products	19.6	43.4%	43.4%
1.A.4.b.1	Residential: stationary	6.13	13.6%	57.0%
3.D.c	On-farm storage, handling and transport of agricultural products	3.27	7.2%	64.2%
1.A.3.b.6	R.T., Automobile tyre and break wear	2.66	5.9%	70.1%
1.A.3.b.7	R.T., Automobile road abrasion	2.31	5.1%	75.2%
1.A.3.c	Railways	1.54	3.4%	78.6%
2.I	Wood processing	1.15	2.5%	81.2%
	National Total	**45.16**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kt] Ex,0**	**Latest Year (2022) Estimate [kt] Ex,t**	**Trend Assessment Lx,t**	**Contribution to the trend**	**Cumulative Total of Lx,t**
2.C.1	Iron and Steel Production	6.43	0.51	0.339	22.3%	22.3%
1.A.4.b.1	Residential: stationary	11.39	6.13	0.301	19.8%	42.2%
1.A.3.b.3	R.T., Heavy duty vehicles	2.46	0.11	0.135	8.9%	51.0%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	2.06	0.37	0.097	6.4%	57.4%
1.A.3.b.6	R.T., Automobile tyre and break wear	1.16	2.66	0.086	5.7%	63.0%
1.A.3.b.7	R.T., Automobile road abrasion	1	2.31	0.075	4.9%	68.0%
1.A.3.b.1	R.T., Passenger cars	1.61	0.39	0.07	4.6%	72.6%
1.A.2.d	Pulp, Paper and Print	1.06	0.21	0.049	3.2%	75.8%
1.A.3.b.2	R.T., Light duty vehicles	0.84	0.13	0.041	2.7%	78.4%
1.A.4.a.1	Commercial/Institutional: Stationary	0.92	0.33	0.034	2.2%	80.6%
	National Total	**62.69**	**45.16**			

Table 21: Key Categories for PM_{10} emissions for the year 2022.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2022) Estimate [kt] Ex,t**	**Level Assessment Lx,t**	**Cumulative Total of Lx,t**
2.A.5	Mining, construction/demolition and handling of products	7.54	27.6%	27.6%
1.A.4.b.1	Residential: stationary	5.73	20.9%	48.5%
3.D.c	On-farm storage, handling and transport of agricultural products	3.27	12.0%	60.4%
1.A.3.b.6	R.T., Automobile tyre and break wear	1.97	7.2%	67.7%
1.A.3.b.7	R.T., Automobile road abrasion	1.16	4.2%	71.9%
1.A.1.a	Public Electricity and Heat Production	1.03	3.8%	75.6%
1.A.3.c	Railways	0.54	2.0%	77.6%
2.I	Wood processing	0.46	1.7%	79.3%
2.G	Other product manufacture and use	0.41	1.5%	80.8%
	National Total	**27.37**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kt] Ex,0**	**Latest Year (2022) Estimate [kt] Ex,t**	**Trend Assessment Lx,t**	**Contribution to the trend**	**Cumulative Total of Lx,t**
1.A.4.b.1	Residential: stationary	10.57	5.73	0.304	22.2%	22.2%
2.C.1	Iron and Steel Production	4.56	0.39	0.262	19.1%	41.3%
1.A.3.b.3	R.T., Heavy duty vehicles	2.46	0.11	0.148	10.8%	52.0%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	2.06	0.37	0.106	7.7%	59.7%
1.A.3.b.1	R.T., Passenger cars	1.61	0.39	0.076	5.6%	65.3%
1.A.3.b.6	R.T., Automobile tyre and break wear	0.88	1.97	0.069	5.0%	70.3%
1.A.2.d	Pulp, Paper and Print	0.95	0.19	0.048	3.5%	73.8%
1.A.3.b.2	R.T., Light duty vehicles	0.84	0.13	0.045	3.2%	77.1%
1.A.3.b.7	R.T., Automobile road abrasion	0.5	1.16	0.041	3.0%	80.0%
	National Total	**43.35**	**27.37**			

Table 22: Key Categories for $PM_{2.5}$ emissions for the year 2022.

Level Assessment

NFR Code	NFR Category	Latest Year (2022) Estimate [kt] Ex,t	Level Assessment Lx,t	Cumulative Total of Lx,t
1.A.4.b.1	Residential: stationary	5.42	40.3%	40.3%
1.A.3.b.6	R.T., Automobile tyre and break wear	1.09	8.1%	48.4%
1.A.1.a	Public Electricity and Heat Production	0.86	6.4%	54.8%
2.A.5	Mining, construction/demolition and handling of products	0.84	6.2%	61.0%
1.A.3.b.7	R.T., Automobile road abrasion	0.62	4.6%	65.6%
2.G	Other product manufacture and use	0.4	3.0%	68.6%
1.A.3.b.1	R.T., Passenger cars	0.39	2.9%	71.5%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	0.37	2.8%	74.3%
1.A.4.c.1	Agriculture/Forestry/Fishing: Stationary	0.35	2.6%	76.9%
1.A.4.a.1	Commercial/Institutional: Stationary	0.3	2.2%	79.1%
5.E	Other waste handling	0.29	2.1%	81.2%
	National Total	**13.45**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] Ex,0	Latest Year (2022) Estimate [kt] Ex,t	Trend Assessment Lx,t	Contribution to the trend	Cumulative Total of Lx,t
1.A.4.b.1	Residential: stationary	9.89	5.42	0.324	26.5%	26.5%
1.A.3.b.3	R.T., Heavy duty vehicles	2.46	0.11	0.17	14.0%	40.5%
2.C.1	Iron and Steel Production	2.07	0.17	0.138	11.3%	51.8%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	2.06	0.37	0.122	10.0%	61.8%
1.A.3.b.1	R.T., Passenger cars	1.61	0.39	0.088	7.2%	69.0%
1.A.3.b.2	R.T., Light duty vehicles	0.84	0.13	0.051	4.2%	73.2%
1.A.2.d	Pulp, Paper and Print	0.78	0.15	0.045	3.7%	76.9%
1.A.3.b.6	R.T., Automobile tyre and break wear	0.47	1.09	0.045	3.7%	80.6%
	National Total	**27.33**	**13.45**			

1.6 Quality Assurance, Quality Control and Verification

For fulfilment of the reporting obligations the Umweltbundesamt, in particular the *Inspection Body for Emission Inventories*, operates a QMS based on the International Standard EN ISO/IEC 17020 *Conformity assessment — Requirements for the operation of various types of bodies performing inspection*.

Since 23 December 2005 the Umweltbundesamt has been accredited[59] as Inspection Body for emission inventories, Type A (ID No. 0241), in accordance with EN ISO/IEC 17020 and the Austrian Accreditation Law (AkkG)[60], by decree of Accreditation Austria (first decree, No. BMWA-92.715/0036-I/12/2005, issued by Accreditation Austria / Federal Ministry of Economics and Labour on 19 January 2006).

In addition to the elements of a QMS as described in the EN ISO 9000 series, the EN ISO/IEC 17020 focusses on the competence of the personnel, and ensures strict independence, impartiality and integrity. The implementation is audited by the Austrian Accreditation Body ('Akkreditierung Austria') regularly (about every 20 months). Every five years the accreditation has to be renewed in a more comprehensive audit. The accreditation of the IBE was awarded for the first time in 2005 and was renewed in 2011, 2016 and 2020.

Major elements of the QMS are the Quality Manual of the IBE and its quality and technical procedures ('Austrian QA/QC Plan').

1.6.1 Requirements of the EN ISO/IEC 17020 compared to the IPCC 2006 GL as well as the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023

The implementation of QA/QC procedures as required by the IPCC 2006 GL and the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 support the development of national air emissions inventories that can be readily assessed in terms of quality and completeness. The QMS as implemented in the Austrian inventory includes all elements of the QA/QC system outlined in the 2006 IPCC GL Chapter 6 'Quality Assurance and Quality Control' and the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 Chapter 6 'Inventory management, improvement and QA/QC 2019' (see Table below), and goes beyond. It also comprises supporting and management processes in addition to the QA/QC procedures in inventory compilation and thus ensures agreed standards not only within (i) the inventory compilation process and (ii) supporting processes (e.g. archiving), but also for (iii) management processes (e.g. annual management reviews, internal audits, regular training of personnel, definition of procedures for external communication).

[59] For more information on the accreditation please refer to Annex 5.

[60] Federal Law Gazette I No 28/2012 (Akkreditierungsgesetz 2012)

Table 23: Overview of obligatory QAQC elements in different technical and quality standards.

EMEP/EEA GB 2023[61]	IPCC 2006 GL	EN ISO 9001[62]	EN ISO/IEC 17020[63]
Roles and Responsibilities	Roles and Responsibilities	Responsibilities and authorities	Organisation and Management
QA/QC plan	QA/QC plan	Quality manual and quality procedures	Quality manual and quality procedures
QC procedures	QC procedures	Corrective actions	Corrective actions
QA procedures	QA procedures	Preventive actions	Preventive actions
QA/QC system interaction with uncertainty analysis	QA/QC system interaction with uncertainty analysis	-	-
Verification activities	Verification activities	-	-
Reporting, documenting and archiving procedures	Reporting, documenting and archiving procedures	Records on product realisation	Inspection reports, inspection records
Inventory management report[64]	-	Management review (report)	Management review (report)
-	-	Control of documents and records	Control of documents and records
-	-	Internal audits	Internal audits
-	-	-	Competence
-	-	-	Independence, impartiality and integrity

1.6.2 Quality policy and objectives

As stated in the Quality Manual of the IBE, the overall objective of the work of the IBE is to promote climate change mitigation and air quality control measures via a high quality emission inventory reporting under the relevant national, European and international frameworks and conventions.

To achieve this, the IBE is committed to strict impartiality and quality management. In this context, the term quality means:

- Fulfilment of requirements for emission inventories to provide a solid data basis for the political processes in the context of greenhouse gas and air pollutant emissions.
- Providing emission inventories that facilitate the definition and evaluation of measures, which needs a forward looking maintainance and improvement of the emission inventory. Therefore the IBE keeps its staff updated on the latest technical expertise, scientific findings and the latest developmentsby encouraging the participation of its staff in international technical and political processes and ensure the transfer of knowledge within the IBE.
- Compliance with the EN ISO/IEC 17020 standard by ensuring the implementation and continuous improvement of a QMS as described in the quality manual by the IBE and its personnel.

[61] Requirements largely based on the 'Quality Assurance/Quality Control and Verification' chapter of the 2006 IPCC Guidelines (IPCC, 2006).

[62] Basic international standard for quality management and quality assurance

[63] Contains additional requirements compared to EN ISO 9001

[64] According to the EMEP Guidebook 2023 (A.6 chapter 5.4), it also is good practice to summarize lessons learned from previous inventory preparation cycles in an inventory management report.

> The QMS procedures are designed to facilitate the preparation of the emission inventories in a professional and timely manner, particularly to enhance the transparency to allow full reproduction, and ensure correctness by applying quality checks and validation activities. One of the key managerial functions is raising the personnel's awareness for quality control.

Aim of the IBE is to provide a best-practise example by setting a high quality standard – even higher than specified in the requirements – to improve the quality of air emission reporting in the long term, and to encourage other countries to set up similar systems.

The quality objectives for emission inventories are above all the fulfilment of all relevant requirements in terms of content and format: 'TACCC': transparency, accuracy, completeness, comparability, consistency (as defined in the IPCC 2006 GL) and timeliness.

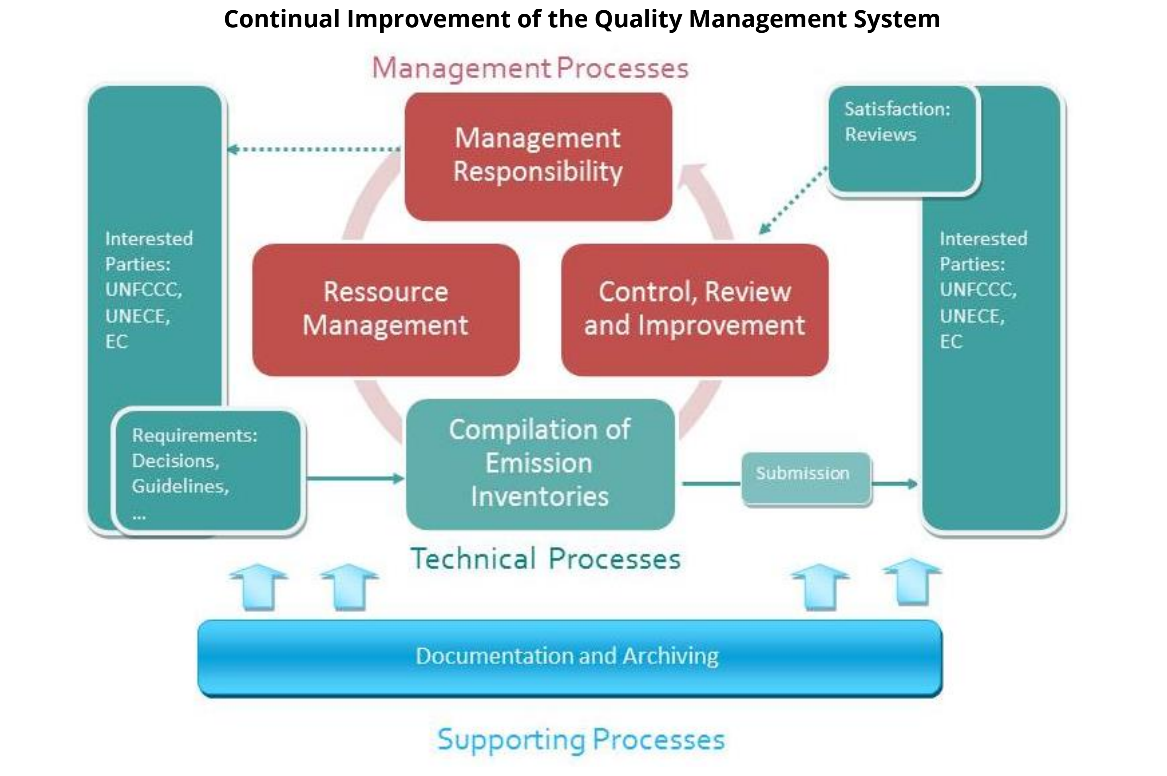
The QMS was primarily developed to meet the requirement of reporting greenhouse gas emissions under the Kyoto Protocol. For this reason the emphasis was originally placed on greenhouse gases, but by now all air pollutants are covered by the QMS.

1.6.3 Design of the Austrian QMS

The design of the QMS of the *Inspection Body for Emission Inventories* (IBE) at the Umweltbundesamt follows a *process based approach* (see Figure 5).

The Quality Manual of the Inspection Body for Emission Inventories is published on:
https://www.umweltbundesamt.at/klima/emissionsinventur/emi-akkreditierung

Figure 4: Process-based QMS of the IBE.



Source: Umweltbundesamt

Roles and Responsibilities

The Umweltbundesamt is designated as the single national entity responsible for Austria's Air Emission Inventory by law, and is thus responsible for QA/QC activities. Within the Umweltbundesamt, the *Inspection Body for Emission Inventories* IBE has been established and entrusted with the preparation of emission inventories. Within the IBE, roles and responsibilities of the different functions – quality representative, sector expert, sector coordinator, project manager, head of inspection body, report coordinator, cross-sector analyst, etc. – are defined in the QMS as well.

1.6.4 QA/QC Plan

Activities to be conducted by the personnel of the IBE are written down in quality and technical procedures that complement the Quality Manual. Such activities are:

- QC activities
- Procedures for country specific methodologies
- Internal audits (QM specific)
- Procedures for service-contracting
- Inventory improvement plan
- Documentation and archiving
- Treatment of confidential data
- Annual Management Review

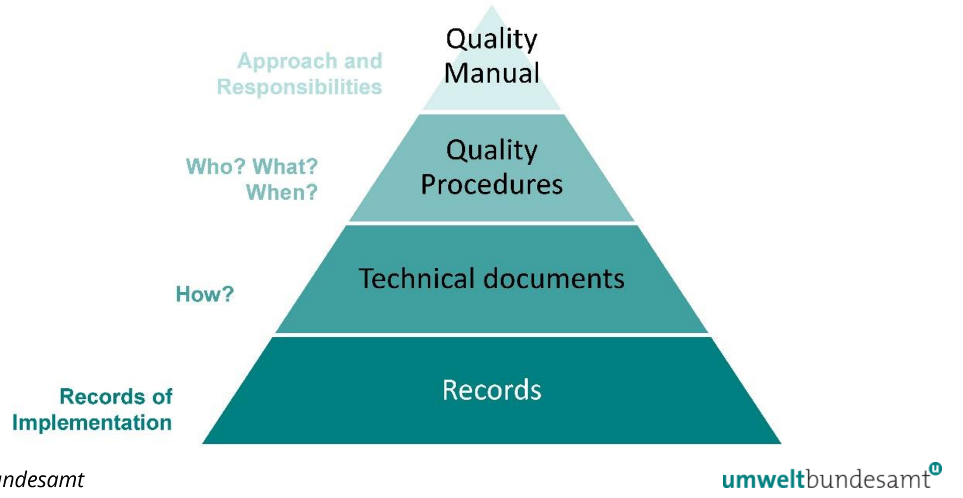
Quality Manual

The Quality System is divided into three levels:

- Level 1: General (the actual 'Quality Manual' containing general information, description of QMS, general responsibilities etc.): https://www.umweltbundesamt.at/klima/emissionsinventur/emi-akkreditierung
- Level 2: Detailed description of activities to be conducted and checklists and forms to be filled in ('quality procedures' and 'technical documents').
- Level 3: Documentation of QC activities (filled in checklists, ...)

Figure 5: Structure of the Austrian Quality Management System (QMS).

Structure of the Austrian Quality Management System



Source: Umweltbundesamt

1.6.5 QC Activities

The following four quality-check-steps are performed before finalization of the data submission:

1. Tier 2 (category specific): by the sector expert in the course of the inventory preparation
2. Tier 1 (general) / Step 1: QC by the sector expert after emissions have been estimated
3. Tier 1 (general) / Step 2: QC by the data manager in the course of the preparation of the overall inventory (electronic checks e.g. check for completeness and comparison with last years' inventory)
4. Tier 1 (general) / Step 3: QC of final submission by the sector expert

Where possible the checks (1), (2) and (4) are conducted by the sector expert that has not predominantly prepared the sectoral inventory in the particular year.

QC activities are conducted according to QC checklists, which cover issues like:

- ✓ documentation of assumptions
- ✓ documentation of expert judgements
- ✓ clear explanation of recalculations
- ✓ completeness
- ✓ correct transformation/transcription into NFR
- ✓ information on background tables

- ✓ provision of references
- ✓ plausibility of data
- ✓ consistency of data
- ✓ consistency of data and information with information in inspection reports
- ✓ treatment of confidential data

Additionally, in the course of the IIR preparation, the following four QC steps are performed:

1. Tier 2 (category specific) / Step 1: check of methodologies, assumptions and explanations by sector expert in the course of report preparation
2. Tier 2 (category specific) / Step 2: check of methodologies, assumptions and explanations by the head of inspection body
3. Tier 1 (general) / Step 1: final check of each sector chapter by the corresponding sector experts (in particular regarding consistency of values in the NIR and the latest CRF tables)
4. Tier 1(general) / Step 2: final check of consistency of figures in reporting format and report by a member of the IBE team (usually done by the report coordinator who checks at least five values per sector)

If NFR tables are updated during the preparation of the inventory, the data manager informs the whole team immediately to make sure that comparisons between NFR and IIR data are done by sector experts with the latest data set.

1.6.6 QA Activities

The following QA activities are performed:

Validation of methodologies and calculation

New and improved methodologies are documented as a SOP (standard operating procedure) together with a template for calculating emissions, where needed. The SOP is checked for applicability and transparency and finally approved by the head of the inspection body. New and changed calculation files are validated before use.

Annual second party audits for every sector

Once a year the documentation of one emission source per sector is checked throughout the whole emission estimation and reporting process (i.e. archiving of underlying information, emission calculation, input into the data management system, documentation, information in the IIR etc.) for transparency, reproducibility, clearness and completeness. This tool has proved to be very helpful in order to further improve the documentation and the implementation of (new) QA/QC routines.

Second party audits for work performed by service-contractors

The sector experts at the Umweltbundesamt are responsible for incorporation of results in the inventory database and additional QA/QC procedures (carried out as second party audit).

Accreditation audits (third party audits)

In the course of the accreditation process, conformity of the QMS with EN ISO/IEC 17020 is regularly monitored. Audits are performed every 20 months on average by the accreditation body (one and a half day audit). Every fifth year the accreditation has to be renewed in a more comprehensive audit. The audits aim to assess the QM system with regard to compliance with the underlying standard EN ISO/IEC 17020, to check its implementation in practice and to assure that measures and recommendations as set out in previous audits have been implemented accordingly.

Input data examination

Input data examinations refer to examinations of complex input data (i.e. collected and aggregated data, particularly statistics, or generally data provided by data collectors as the opposite to input data provided by one single facility). These examinations go beyond the scope of Tier 2 QC procedures performed during inventory preparation and are as far as possible conducted in close cooperation with the data suppliers.

The aim of the examinations is to assess:

- whether the requirements regarding independence and integrity are fulfilled
- the long term availability of the data
- the data collection and data management process
- QC of the data processing

Resulting areas of improvement are discussed with the data suppliers.

Since 2007 input data examinations have been conducted together with all main data suppliers:

- Statistik Austria regarding
  - energy balance in 2007
  - agricultural statistical data in 2009
  - import/export and production statistics in 2016
- the administrator of the landfill database in 2009
- the administrator of the electronic data management for landfills (EDM) in 2014
- the national forest inventory at the Austrian Federal Office and Research Centre for Forests (BFW) in 2016

It is planned to conduct follow-up examinations with these institutions only when substantial changes become apparent.

These input data examinations have proved a good basis for the cooperation with the data suppliers.

1.6.7 Error correction and continuous improvement

All issues regarding transparency, accuracy, completeness, consistency or comparability identified by experts from different backgrounds are incorporated in the inventory improvement plan. Sources of these findings are:

- UNECE/CLRTAP Review: The last in-depth review (stage 3) took place in 2017; the findings are summarized in Chapter 7.8, Table 339. The stage 1 review (initial check of submissions for timeliness, completeness and formats) and stage 2 review (check of consistency, comparability, KCA, trends and IEFs) are carried out annually. In 2022, an ad-hoc review took place with special focus on condensable component of PM emissions of residential heating and road transport. The findings are summarized in Table 340. In 2023, ther ad-hoc review concentrated on emissions from agriculture and corresponding gridded data. The recommendations are provided in Table 341.

- NEC Review: From 2017 onwards the national emission inventory data is also checked by the European Commission as set out in Article 10 of Directive 2016/2284 (NEC Directive). The findings of the NEC Review 2023 are summarized in Chapter 7.8, Table 342.
- external experts (e.g. experts from federal provinces who prepare a partly independent emission inventory for their federal province compare their results with the disaggregated national inventory)
- stakeholders (e.g. industrial facilities or association of industries: the IIR is communicated to every data supplier and Austrian experts involved in emission inventorying after submission)
- personnel of the inspection body (head of inspection body, sector experts etc.)

These findings are documented including a plan to improve the inventory, a timeline and responsibilities. Improvements that are relevant in terms of resources are presented in the annual Management Review to the managing directors, and if additional resources are needed, these are notified to the Federal Ministry 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' (BMK).

1.6.8 Archiving and documentation

For each sector the documentation includes:

Documentation of the methodology:

- description (source/sink category, emissions, key source, completeness, uncertainty)
- methodology
- template for emission estimation
- documentation of validation

Documentation of actual emission calculation:

- methodology
- 'logbook' (who did what and when)
- calculation file
- references for activity data, emission factors and/or emissions, respectively
- documentation of assumptions, sources of data and information, expert judgments etc. to allow full reproduction and understanding of choices,
- recalculations
- planned improvements
- QC activities

Documentation of expert judgements in line with the IPCC 2006 GL and the EMEP/EEA GB 2019:

- name of the expert and institution/department
- date
- basis of judgement (references to relevant studies etc.)

- underlying assumptions

Relevant literature has to be archived and references to be stated in the internal documentation as well as in the IIR.

1.6.9 Treatment of confidentiality issues

The IBE ensures confidential treatment of sensitive information obtained in the course of its inspection activities.

According to the Austrian Envirionmental Information Act[65] §4 (2) emissions data are generally publicly accessible and are explicitely not seen as confidential data, with the possibility to request confidentiality in justified exceptional cases. This is the case for emissions of fluorinated substances for semiconductors, where detailed emissions data could give clues regarding the setting up of industrial processes and therefore emissions are reported at a higher aggregated level

Generally, for transparency reasons, activity data is reported together with emissions data. Activity data, particularly which relates to less than three plant operators, in some cases has to be treated confidential and is therefore not reported because this data is sensitive according to a plant operator.

Compliance with confidentiality provisions is organized and documented in the QM manual, which contains specific quality system procedures. Staff of the inspection body is obliged to issue a written commitment stating their full compliance with all provisions.

- Confidentiality of statistics

  The strict confidentiality provisions concerning handling of sensitive data relating to individuals and organisations are regulated by the Austrian Federal Statistics Act 2000[66]. The Envirionmental Control Act[67] allows the Umweltbundesamt to request confidential statistical data, this data is then incorporated in the emission inventory. To protect the confidential data, only aggregated results are reported.

- Security of data

  Confidentiality of sensitive data used to calculate emission is a legal obligation: Ensuring confidentiality through technical and organisational measures (e.g. final QC whether confidential information is not visible in NFR tables) is obligatory for Umweltbundesamt and consequently also for the Inspection Body.

- Trust of respondents

  Individuals, associations and organizations providing information to the Inspection Body can be sure that the provided data are used exclusively for purposes of inspection activities. Data – either of official, private or of another nature – are treated confidentially and will not be passed on to third parties. In the course of inventory reviews, such data and information is exchanged with the review team only if needed for judging the conformity of emission calculation following the strict rules for confidentiality set up by the review process.

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[65] *„UIG Umweltinformationsgesetz"* Federal Law Gazette No 495/1993

[66] Federal Act on Federal Statistics (Federal Statistics Act 2000) No 163/1999

[67] *„UKG Umweltkontrollgesetz"* Federal Law Gazette I No 152/1998

Also in case of voluntary reviews an absolute confidential treatment of data exchanged is ensured by strictly adhering to the rules of the QM System of the Inspection Body.

1.6.10 QMS activities and improvements 2023

In 2023 four of our experts participated in the international inventory reviews (NEC and CLRTAP). An audit by the accreditation body was successfully passed in June 2023.

1.7 Uncertainty Assessment

From submission 2017 onwards a qualitative uncertainty assessment and additionally a quantitative uncertainty analysis for the main pollutants (SO_2, NO_x, NMVOC, NH_3 and $PM_{2.5}$) has been carried out. The submission 2019 first time includes CO, heavy metals and POPs (Cd, Hg, Pb, PAH, DIOX, HCB and PCB) and PMs (TSP and PM_{10}). Information on methodology and data sources used is provided in the following sections.

1.7.1 Method used

The method used for the assessment of uncertainty is described in the "EMEP/EEA air pollutant emission inventory guidebook 2023 (EEA 2023)".

In the Austrian uncertainty analysis the Approach 1 was applied for the following pollutants: SO_2, NO_x, NMVOC, NH_3, CO, Cd, Hg, Pb, PAH, DIOX, HCB, PCB, TSP, PM_{10} and $PM_{2.5}$. By using the error propagation method, the uncertainties for a specific source category can be estimated and by combining these uncertainties an overall uncertainty can be calculated. For the remaining other pollutants a qualitative indication of the uncertainty is presented.

The Approach 2 (Monte Carlo Simulation) was not included in this assessment as the less comprehensive Approach 1 (error propagation) method already gives a clear reference point of the general uncertainty per pollutant.

1.7.2 Data source

In order to estimate the overall uncertainty, the uncertainty of activity data and emission factor, respectively, has to be quantified. The uncertainties of activity data on sectoral level are based on the GHG uncertainty analysis (for more information see Umweltbundesamt, 2022).

Uncertainties of emission factors of the relevant pollutants are based on the qualitative ratings following the EMEP/EEA air pollutant emission inventory guidebook 2023 (EEA, 2023). Therefore, the arithmetic mean value of the proposed upper and lower emission factor uncertainty was calculated and used for the calculation of the overall combined uncertainty.

The quality of estimates for all relevant pollutants has been rated using qualitative indicators as suggested in Chapter 5 (Table 2-2) of the EMEP/EEA air pollutant emission inventory guidebook 2023 (EEA, 2023). The definition of the ratings is given in Table 24, the ratings for the emission estimates are presented in Table 25.

Table 24: Rating definitions.

Rating	Definition	Typical Error Range
A	An estimate based on a large number of measurements made at a large number of facilities that fully represent the sector	10 to 30%
B	An estimate based on a large number of measurements made at a large number of facilities that represent a large part of the sector	20 to 60%
C	An estimate based on a number of measurements made at a small number of representative facilities, or an engineering judgement based on a number of relevant facts	50 to 200%
D	An estimate based on single measurements, or an engineering calculation derived from a number of relevant facts	100 to 300%
E	An estimate based on an engineering calculation derived from assumptions only	order of magnitude

Source: Table 3-2 Rating definitions, Chapter 5 of the EMEP/EEA emission inventory guidebook 2023.

1.7.3 Results of uncertainty estimation

1.7.3.1 Qualitative assessment for all pollutants

A qualitative assessment was performed on sectoral level for all pollutants. The relevant sectors of each pollutant were classified in different quality groups from A to E (see Table 25) following the EMEP/EEA air pollutant emission inventory guidebook 2023 (EEA, 2023). Table 24 presents a definition and default error ranges for each quality group.

Table 25: Quality of emission estimates.

NFR	Description	SO_2	NO_x	NMVOC	NH_3	CO	Cd	Hg	Pb	PAH	Diox	HCB	PCB	TSP	PM_{10}	$PM_{2.5}$
1.A.1.a	Public Electricity and Heat Production	A	A	D	E	A	C	C	C	C	C	C	C	B	C	C*
1.A.1.b	Petroleum refining	A	A*		E	A	C	C	C	D	D	D	D	A	B	B
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	C	B	D	E	D	C	C	C	C	D	D	C	B	B	B
1.A.2 mobile	Other mobile in industry	A	B	B	C	B	C	C	C	D	D	D	D	B	B	B
1.A.2 stat (l)	Manuf. Ind. and Constr. stationary LIQUID	A	B	D	E	C	C	B	C	C	E	D	D	C	C	C
1.A.3.a	Civil Aviation	A	B	B	C	B	B	B	B					B	B	B
1.A.3.b.1	R.T., Passenger cars	A	B	C	D	B	B	B	C	C	D	D	D	B	B	C
1.A.3.b.2	R.T., Light duty vehicles	A	B	C	D	B	B	B	C	C	D	D	D	B	B	C
1.A.3.b.3	R.T., Heavy duty vehicles	A	B	C	D	B	B	B	C	C	D	D	D	B	B	C
1.A.3.b.4	R.T., Mopeds & Motorcycles	A	B	C	D	B	B	B	C	D	D	D	D	B	C	C
1.A.3.b.5	R.T., Gasoline evaporation			C												
1.A.3.b.6	R.T., Automobile tyre and break wear						B	B	B	C				C	C	C
1.A.3.b.7	R.T., Automobile road abrasion									C				C	C	C
1.A.3.c	Railways	A	B	B	C	B	B	B	C	D	D	D	D	B	B	B
1.A.3.d	Navigation	A	B	B	C	B	B	B	C	D	D	D	D	B	B	B
1.A.3.e	Other transportation	C	A*	D	E	C	C	C	C	C	D	D		C	C	C
1.A.4.a	Commercial/ Institut.	A	B	C*	C	C	C	C	C	D	D	D	E	C	C	C*
1.A.4.b	Residential	A	B	C*	C	C	C	C	C	D	D	D	E	C	C	C*
1.A.4.c	Agriculture/Forestry/ Fisheries	A	C*	C*	C	C	C	C	C	D	D	D	E	C	C	C*
1.A.5	Other	B	C	C	D	C	C	C	C	D	D	D	D	C	C	C
1.B	FUGITIVE EMISSIONS	A		A	C			C						D	D	D
2.A	MINERAL PRODUCTS													D	D	D
2.B	CHEMICAL INDUSTRY	B	B	A	A	D	A	A	B			D		A	A	A

NFR	Description	SO_2	NO_x	NMVOC	NH_3	CO	Cd	Hg	Pb	PAH	Diox	HCB	PCB	TSP	PM_{10}	$PM_{2.5}$
2.C	METAL PRODUCTION	C	B	C		B	B	B	C	C	C	C	C	B	B	B
2.D.	NON ENERGY PRODUCTS FROM FUELS /SOLVENT USE			B*		B	B		B	B	B	B		B	B	B
2.G	Other product manufacture and use	C	C	C	B	D	D	D	D	D	D			C	C	C
2.H	Other Processes			B		B				E	E	E		D	D	D
2.I	Wood Processing													B	B	B
3.B.1	Cattle		C	C	A									D	D	D
3.B.2	Sheep		C	C	B									D	D	D
3.B.3	Swine		C	C	A									D	D	D
3.B.4.d	Goats		C	C	B									D	D	D
3.B.4.e	Horses		C	C	B									D	D	D
3.B.4.g	Poultry		C	C	B									D	D	D
3.B.4.h	Other animals		C	C	B									D	D	D
3.D	Agricultural Soils		C	C/E	B							C		D	D	D
3.F	Field burning of agricultural residues	C	C	C	C	C	C	C	C	C	C	C		C	C	C
5.A	Solid waste disposal on land			B*	B*	C	B	B	B					D	D	D
5.B	Biological treatment of waste				C											
5.C	Incineration and open burn-ing of waste	D	D	C	C	C	B	B	B	C	C	C	C	D	D	D
5.D	Wastewater treatment			C												
5.E	Other waste						C	C	C		C			D	D	D

Abbreviations: see Table 24

** value for calculation lies within quality rating, but is based on expert judgement and therefore no arithmetic mean value has been applied.*

1.7.3.2 Quantitative uncertainty assessment

The quantitative uncertainty assessment was performed with the Approach 1 according to (EEA 2023) for the air pollutants SO_2, NO_x, NMVOC, NH_3, CO, Cd, Hg, Pb, PAH, DIOX, HCB, PCB, TSP, PM_{10} and $PM_{2.5}$ in the year 2022 and the respective level and trend uncertainties. Basis for this assessment is the qualitative rating as presented in Table 25.

The results of the uncertainty analysis are indicated in the following tables.

Table 26: Result of overall uncertainty estimation for the main pollutants (SO_2, NO_x, NMVOC, NH_3, CO), heavy metals and POPs (Cd, Hg, Pb, PAH, DIOX, HCB and PCB) and PMs (TSP, PM_{10} and $PM_{2.5}$).

Pollutant	Unit	Emissions 2022	Level uncertainty 2022 [%]	Trend uncertainty 2022 [%]
SO_2	[kt]	10.8	6.9	1.2
NO_x	[kt]	114.4	18.1	3.9
NMVOC	[kt]	100.0	36.3	10.0
NH_3	[kt]	68.0	21.3	5.8
CO	[kt]	480.6	70.1	12.2
Cd	[t]	0.9	47.9	11.0
Hg	[t]	1.0	31.2	3.7
Pb	[t]	13.7	33.9	5.4
PAH	[t]	5.7	152.2	19.6
DIOX	[g]	31.7	98.1	14.8
HCB	[kg]	10.4	119.6	4.1
PCB	[kg]	2.8	90.4	8.9
TSP	[kt]	45.2	90.4	20.2
PM_{10}	[kt]	27.4	66.9	16.7
$PM_{2.5}$	[kt]	13.4	32.0	9.6

A more detailed presentation of the uncertainties on sectoral level per pollutant is given in the following tables below.

Table 27: Uncertainty estimation of SO_2 emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
	SO2	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G \cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J \cdot E \cdot \sqrt{2}$ Note D	$K^2 + L^2$
1 A 1 a	SO2	11.8	0.7	8.0	20.0	21.54	1.98	-0.01	0.01	-0.28	0.11	0.09
1 A 1 b	SO2	2.3	0.5	1.0	10.0	10.05	0.21	0.00	0.01	0.02	0.01	0.00
1 A 1 c	SO2	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	SO2	6.7	4.7	5.0	10.0	11.18	23.66	0.05	0.06	0.50	0.45	0.45
1 A 2 b	SO2	0.2	0.1	5.0	20.0	20.62	0.05	0.00	0.00	0.02	0.01	0.00
1 A 2 c	SO2	0.7	0.2	5.0	20.0	20.62	0.15	0.00	0.00	0.03	0.02	0.00
1 A 2 d	SO2	4.3	0.4	10.0	20.0	22.36	0.70	0.00	0.01	-0.06	0.08	0.01
1 A 2 e	SO2	1.6	0.1	5.0	20.0	20.62	0.07	0.00	0.00	-0.03	0.01	0.00
1 A 2 f	SO2	2.2	0.7	5.0	20.0	20.62	1.55	0.00	0.01	0.09	0.06	0.01
1 A 2 g 7	SO2	0.2	0.0	1.0	20.0	20.02	0.00	0.00	0.00	-0.01	0.00	0.00
1 A 2 g 8	SO2	1.9	1.4	10.0	20.0	22.36	8.01	0.01	0.02	0.30	0.26	0.16
1 A 3 a	SO2	0.0	0.1	3.0	20.0	20.22	0.02	0.00	0.00	0.02	0.00	0.00
1 A 3 b 1	SO2	1.5	0.1	3.1	20.0	20.24	0.01	0.00	0.00	-0.04	0.00	0.00
1 A 3 b 2	SO2	0.7	0.0	3.1	20.0	20.24	0.00	0.00	0.00	-0.03	0.00	0.00
1 A 3 b 3	SO2	2.6	0.0	3.1	20.0	20.24	0.01	0.00	0.00	-0.09	0.00	0.01
1 A 3 b 4	SO2	0.0	0.0	3.1	20.0	20.24	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 c	SO2	0.3	0.0	3.0	20.0	20.22	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 d	SO2	0.1	0.0	3.0	20.0	20.22	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 e	SO2	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	SO2	4.9	0.0	5.0	20.0	20.62	0.01	-0.01	0.00	-0.18	0.00	0.03
1 A 4 b	SO2	25.9	1.0	15.0	20.0	25.00	5.31	-0.04	0.01	-0.76	0.29	0.65
1 A 4 c	SO2	1.8	0.1	5.0	20.0	20.62	0.02	0.00	0.00	-0.05	0.01	0.00
1 A 5 b	SO2	0.0	0.0	1.0	40.0	40.01	0.00	0.00	0.00	0.00	0.00	0.00
1 B 2 b	SO2	2.0	0.0	5.0	20.0	20.62	0.00	0.00	0.00	-0.07	0.00	0.01
2 B 1	SO2	0.0	0.0	2.0	40.0	40.05	0.00	0.00	0.00	0.00	0.00	0.00
2 B-10	SO2	1.6	0.4	2.0	40.0	40.05	1.84	0.00	0.00	0.07	0.01	0.01
2 C 1	SO2	0.3	0.0	0.5	125.0	125.00	0.30	0.00	0.00	0.02	0.00	0.00
2 C 7	SO2	0.1	0.2	5.0	125.0	125.10	4.28	0.00	0.00	0.27	0.02	0.08
2 G	SO2	0.0	0.0	20.0	125.0	126.59	0.00	0.00	0.00	0.00	0.00	0.00
3 F	SO2	0.0	NO	100.0	125.0	160.08						
5 C	SO2	0.1	0.0	7.0	200.0	200.12	0.08	0.00	0.00	0.01	0.00	0.00
Total		**73.7**	**10.8**				**48.28**					**1.51**
Total Uncertainties						Uncertainty in total inventory %:	**6.95**				Trend uncertainty %:	**1.23**

Table 28: Uncertainty estimation of NO_x emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
	NOX	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G \cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J \cdot E \cdot \sqrt{2}$ Note D	$K^2 + L^2$
1 A 1 a	NOX	12.1	7.7	8.0	20.0	21.54	2.12	0.01	0.04	0.12	0.40	0.18
1 A 1 b	NOX	4.3	1.0	1.0	10.0	10.05	0.01	-0.01	0.00	-0.06	0.01	0.00
1 A 1 c	NOX	1.4	0.9	1.0	40.0	40.01	0.11	0.00	0.00	0.04	0.01	0.00
1 A 2 a	NOX	5.4	3.9	5.0	10.0	11.18	0.14	0.00	0.02	0.05	0.13	0.02
1 A 2 b	NOX	0.3	0.2	5.0	40.0	40.31	0.01	0.00	0.00	0.02	0.01	0.00
1 A 2 c	NOX	1.7	1.3	5.0	40.0	40.31	0.22	0.00	0.01	0.08	0.04	0.01
1 A 2 d	NOX	7.2	4.3	10.0	40.0	41.23	2.36	0.00	0.02	0.09	0.28	0.09
1 A 2 e	NOX	1.7	0.8	5.0	40.0	40.31	0.08	0.00	0.00	-0.02	0.03	0.00
1 A 2 f	NOX	10.0	5.4	5.0	40.0	40.31	3.68	0.00	0.03	0.03	0.18	0.03
1 A 2 g 7	NOX	3.0	4.5	1.0	40.0	40.01	2.48	0.01	0.02	0.54	0.03	0.29
1 A 2 g 8	NOX	3.7	4.0	10.0	40.0	41.23	2.10	0.01	0.02	0.38	0.26	0.21
1 A 3 a	NOX	0.4	1.3	3.0	40.0	40.11	0.22	0.01	0.01	0.21	0.03	0.05
1 A 3 b 1	NOX	59.9	33.5	3.1	40.0	40.12	138.26	0.01	0.16	0.33	0.68	0.57
1 A 3 b 2	NOX	7.3	6.3	3.1	40.0	40.12	4.87	0.01	0.03	0.45	0.13	0.22
1 A 3 b 3	NOX	48.8	9.4	3.1	40.0	40.12	10.78	-0.08	0.04	-3.04	0.19	9.26
1 A 3 b 4	NOX	0.1	0.2	3.1	40.0	40.12	0.00	0.00	0.00	0.02	0.00	0.00
1 A 3 c	NOX	1.8	0.6	3.0	40.0	40.11	0.04	0.00	0.00	-0.07	0.01	0.01
1 A 3 d	NOX	1.1	1.3	3.0	40.0	40.11	0.19	0.00	0.01	0.12	0.02	0.01
1 A 3 e	NOX	0.7	0.1	1.0	10.0	10.05	0.00	0.00	0.00	-0.01	0.00	0.00
1 A 4 a	NOX	3.1	1.0	5.0	40.0	40.31	0.13	0.00	0.00	-0.12	0.03	0.01
1 A 4 b	NOX	16.2	9.8	15.0	40.0	42.72	13.31	0.01	0.05	0.22	0.96	0.97
1 A 4 c	NOX	10.5	5.9	5.0	100.0	100.12	26.23	0.00	0.03	0.14	0.19	0.06
1 A 5 b	NOX	0.1	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 1	NOX	0.5	0.2	2.0	40.0	40.05	0.00	0.00	0.00	-0.01	0.00	0.00
2 B 2	NOX	0.7	0.0	2.0	40.0	40.05	0.00	0.00	0.00	-0.06	0.00	0.00
2 B-10	NOX	0.2	0.0	2.0	40.0	40.05	0.00	0.00	0.00	-0.01	0.00	0.00
2 C 1	NOX	0.2	0.1	0.5	40.0	40.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 7	NOX	0.0	0.0	5.0	40.0	40.31	0.00	0.00	0.00	0.00	0.00	0.00
2 G	NOX	0.0	0.0	20.0	125.0	126.59	0.00	0.00	0.00	0.00	0.00	0.00
3 B 1	NOX	0.4	0.2	1.0	125.0	125.00	0.07	0.00	0.00	0.02	0.00	0.00
3 B 2	NOX	0.0	0.0	10.0	125.0	125.40	0.00	0.00	0.00	0.01	0.00	0.00
3 B 3	NOX	0.0	0.0	4.0	125.0	125.06	0.00	0.00	0.00	-0.01	0.00	0.00
3 B 4	NOX	0.2	0.3	10.0	125.0	125.40	0.10	0.00	0.00	0.11	0.02	0.01
3 D a	NOX	13.0	10.0	5.0	125.0	125.10	119.81	0.01	0.05	1.82	0.33	3.42
3 F	NOX	0.0	NO	100.0	125.0	160.08						
5 C	NOX	0.1	0.0	7.0	200.0	200.12	0.00	0.00	0.00	-0.04	0.00	0.00
Total		**216.2**	**114.4**				**327.32**					**15.42**
Total Uncertainties						Uncertainty in total inventory %:	**18.09**				Trend uncertainty %:	**3.93**

Table 29: Uncertainty estimation of NMVOC emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
	NMVOC	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G\cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J\cdot E\cdot\sqrt{2}$ Note D	K^2+L^2
1 A 1 a	NMVOC	0.3	0.3	8.0	200.0	200.16	0.38	0.00	0.00	0.13	0.01	0.02
1 A 1 c	NMVOC	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	NMVOC	0.1	0.2	5.0	200.0	200.06	0.14	0.00	0.00	0.10	0.00	0.01
1 A 2 b	NMVOC	0.0	0.0	5.0	200.0	200.06	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 c	NMVOC	0.0	0.0	5.0	200.0	200.06	0.01	0.00	0.00	0.02	0.00	0.00
1 A 2 d	NMVOC	0.7	0.2	10.0	200.0	200.25	0.20	0.00	0.00	0.00	0.01	0.00
1 A 2 e	NMVOC	0.0	0.0	5.0	200.0	200.06	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 f	NMVOC	0.2	0.2	5.0	200.0	200.06	0.14	0.00	0.00	0.07	0.00	0.00
1 A 2 g 7	NMVOC	0.5	0.2	1.0	40.0	40.01	0.01	0.00	0.00	0.01	0.00	0.00
1 A 2 g 8	NMVOC	0.0	0.1	10.0	40.0	41.23	0.00	0.00	0.00	0.01	0.01	0.00
1 A 3 a	NMVOC	0.2	0.2	3.0	40.0	40.11	0.00	0.00	0.00	0.01	0.00	0.00
1 A 3 b 1	NMVOC	65.8	1.7	3.1	125.0	125.04	4.50	-0.06	0.01	-6.95	0.02	48.36
1 A 3 b 2	NMVOC	2.8	0.1	3.1	125.0	125.04	0.01	0.00	0.00	-0.30	0.00	0.09
1 A 3 b 3	NMVOC	5.1	0.3	3.1	125.0	125.04	0.10	0.00	0.00	-0.49	0.00	0.24
1 A 3 b 4	NMVOC	2.9	1.1	3.1	125.0	125.04	1.96	0.00	0.00	0.09	0.01	0.01
1 A 3 b 5	NMVOC	20.8	0.3	3.1	125.0	125.04	0.17	-0.02	0.00	-2.28	0.00	5.19
1 A 3 c	NMVOC	0.4	0.1	3.0	40.0	40.11	0.00	0.00	0.00	-0.01	0.00	0.00
1 A 3 d	NMVOC	0.9	0.5	3.0	40.0	40.11	0.04	0.00	0.00	0.02	0.01	0.00
1 A 3 e	NMVOC	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	NMVOC	1.3	0.5	5.0	70.0	70.18	0.15	0.00	0.00	0.03	0.01	0.00
1 A 4 b	NMVOC	41.6	21.9	15.0	70.0	71.59	245.05	0.03	0.07	1.96	1.41	5.84
1 A 4 c	NMVOC	5.5	2.4	5.0	100.0	100.12	5.71	0.00	0.01	0.21	0.05	0.05
1 A 5 b	NMVOC	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
1 B 1 a	NMVOC	2.9	NA	5.0	20.0	20.62						
1 B 2 a	NMVOC	11.5	1.5	0.5	20.0	20.01	0.09	-0.01	0.00	-0.12	0.00	0.02
1 B 2 b	NMVOC	1.1	0.4	5.0	20.0	20.62	0.01	0.00	0.00	0.00	0.01	0.00
2 B 1	NMVOC	0.0	0.0	2.0				0.00	0.00		0.00	
2 B-10	NMVOC	1.6	0.3	2.0	20.0	20.10	0.00	0.00	0.00	-0.01	0.00	0.00
2 C 1	NMVOC	0.3	0.2	0.5	125.0	125.00	0.09	0.00	0.00	0.05	0.00	0.00
2 C 7	NMVOC	0.2	0.2	5.0	125.0	125.10	0.05	0.00	0.00	0.05	0.00	0.00
2 D	NMVOC	114.5	31.4	20.0	30.0	36.06	127.88	-0.01	0.10	-0.32	2.70	7.39
2 G	NMVOC	0.1	0.1	20.0	125.0	126.59	0.01	0.00	0.00	0.01	0.01	0.00
2 H	NMVOC	2.2	3.1	10.0	40.0	41.23	1.67	0.01	0.01	0.30	0.13	0.11
3 B 1	NMVOC	26.7	21.4	1.0	125.0	125.00	712.52	0.04	0.06	5.02	0.09	25.24
3 B 2	NMVOC	0.1	0.1	10.0	125.0	125.40	0.03	0.00	0.00	0.04	0.01	0.00
3 B 3	NMVOC	1.3	0.8	4.0	125.0	125.06	1.11	0.00	0.00	0.17	0.01	0.03
3 B 4	NMVOC	1.0	1.6	10.0	125.0	125.40	4.06	0.00	0.00	0.49	0.07	0.25
3 D a	NMVOC	13.6	7.0	5.0	125.0	125.10	76.99	0.01	0.02	1.09	0.15	1.21
3 D e	NMVOC	1.8	1.5	5.0	750.0	750.02	133.24	0.00	0.00	2.29	0.03	5.23
3 F	NMVOC	0.1	NO	100.0	125.0	160.08						
5 A	NMVOC	0.1	0.0	12.0	25.0	27.73	0.00	0.00	0.00	0.00	0.00	0.00
5 C	NMVOC	0.0	0.0	7.0	125.0	125.20	0.00	0.00	0.00	0.00	0.00	0.00
5 D	NMVOC	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	0.01	0.00	0.00
Total		**328.8**	**100.0**				**1 316.31**					**99.28**
Total						Uncertainty in total inventory %:	**36.28**				Trend uncertainty %:	**9.96**

Table 30: Uncertainty estimation of NH_3 emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
	NH3	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G \cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	$I \cdot F$ Note C	$J \cdot E \cdot \sqrt{2}$ Note D	$K^2 + L^2$
1 A 1 a	NH3	0.1	0.4	8.0	750.0	750.04	15.29	0.00	0.00	2.56	0.05	6.54
1 A 1 b	NH3	0.1	0.1	1.0	750.0	750.00	0.58	0.00	0.00	0.00	0.00	0.00
1 A 1 c	NH3	0.0	0.0	1.0	750.0	750.00	0.00	0.00	0.00	-0.02	0.00	0.00
1 A 2 a	NH3	0.0	0.0	5.0	750.0	750.02	0.05	0.00	0.00	0.07	0.00	0.01
1 A 2 b	NH3	0.0	0.0	5.0	750.0	750.02	0.00	0.00	0.00	0.03	0.00	0.00
1 A 2 c	NH3	0.0	0.0	5.0	750.0	750.02	0.17	0.00	0.00	0.12	0.00	0.01
1 A 2 d	NH3	0.1	0.1	10.0	750.0	750.07	0.59	0.00	0.00	0.03	0.01	0.00
1 A 2 e	NH3	0.0	0.0	5.0	750.0	750.02	0.05	0.00	0.00	0.00	0.00	0.00
1 A 2 f	NH3	0.1	0.1	5.0	750.0	750.02	2.64	0.00	0.00	0.19	0.01	0.04
1 A 2 g 7	NH3	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 g 8	NH3	0.1	0.1	10.0	125.0	125.40	0.06	0.00	0.00	0.14	0.03	0.02
1 A 3 a	NH3	0.0	0.0	3.0	125.0	125.04	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 1	NH3	0.8	0.8	3.1	200.0	200.02	5.51	0.00	0.01	0.26	0.05	0.07
1 A 3 b 2	NH3	0.0	0.0	3.1	200.0	200.02	0.01	0.00	0.00	0.05	0.00	0.00
1 A 3 b 3	NH3	0.0	0.1	3.1	200.0	200.02	0.11	0.00	0.00	0.29	0.01	0.08
1 A 3 b 4	NH3	0.0	0.0	3.1	200.0	200.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 c	NH3	0.0	0.0	3.0	125.0	125.04	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 d	NH3	0.0	0.0	3.0	125.0	125.04	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 e	NH3	0.0	0.0	1.0	750.0	750.00	0.00	0.00	0.00	-0.01	0.00	0.00
1 A 4 a	NH3	0.1	0.0	5.0	125.0	125.10	0.01	0.00	0.00	-0.03	0.00	0.00
1 A 4 b	NH3	0.5	0.5	15.0	125.0	125.90	0.84	0.00	0.01	0.03	0.14	0.02
1 A 4 c	NH3	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	0.00	0.00	0.00
1 A 5 b	NH3	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 B 2 d	NH3	NO	0.0	5.0	125.0	125.10	0.00		0.00		0.00	
2 B 1	NH3	0.0	0.0	2.0	20.0	20.10	0.00	0.00	0.00	0.00	0.00	0.00
2 B 2	NH3	0.0	0.0	2.0	20.0	20.10	0.00	0.00	0.00	0.00	0.00	0.00
2 B-10	NH3	0.3	0.1	2.0	20.0	20.10	0.00	0.00	0.00	-0.05	0.00	0.00
2 G	NH3	0.1	0.1	20.0	40.0	44.72	0.00	0.00	0.00	-0.01	0.02	0.00
3 B 1	NH3	16.0	20.2	1.0	20.0	20.02	35.23	0.07	0.27	1.47	0.38	2.31
3 B 2	NH3	0.7	1.0	10.0	40.0	41.23	0.34	0.00	0.01	0.15	0.18	0.06
3 B 3	NH3	10.0	5.7	4.0	20.0	20.40	2.89	-0.05	0.08	-0.94	0.43	1.07
3 B 4	NH3	2.9	4.9	10.0	40.0	41.23	8.68	0.03	0.07	1.17	0.93	2.22
3 D a	NH3	41.7	32.6	5.0	40.0	40.31	373.34	-0.08	0.44	-3.06	3.11	19.06
3 F	NH3	0.0	NO	100.0	125.0	160.08						
5 A	NH3	0.0	0.0	12.0	25.0	27.73	0.00	0.00	0.00	0.00	0.00	0.00
5 B	NH3	0.4	1.2	20.0	125.0	126.59	5.23	0.01	0.02	1.52	0.47	2.54
5 C	NH3	0.0	0.0	7.0	125.0	125.20	0.00	0.00	0.00	-0.01	0.00	0.00
Total		**74.1**	**68.0**				**451.63**					**34.05**
Total Uncertainties						Uncertainty in total inventory %:	**21.25**				Trend uncertainty %:	**5.84**

Table 31: Uncertainty estimation of CO emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		t	t	%	%	%	%	%	%	%	%	%
	CO	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G \cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J \cdot E \cdot \sqrt{2}$ Note D	$K^2 + L^2$
1 A 1 a	CO	1.4	4.2	8.0	20.0	21.54	0.04	0.00	0.00	0.06	0.04	0.00
1 A 1 b	CO	4.7	0.2	1.0	20.0	20.02	0.00	0.00	0.00	-0.02	0.00	0.00
1 A 1 c	CO	0.1	0.1	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	CO	210.7	168.5	5.0	125.0	125.10	1 922.79	0.07	0.13	8.73	0.95	77.13
1 A 2 b	CO	0.0	0.1	5.0	125.0	125.10	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 c	CO	0.5	0.4	5.0	125.0	125.10	0.01	0.00	0.00	0.03	0.00	0.00
1 A 2 d	CO	4.2	1.7	10.0	125.0	125.40	0.19	0.00	0.00	0.01	0.02	0.00
1 A 2 e	CO	0.2	0.1	5.0	125.0	125.10	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 f	CO	11.0	3.9	5.0	125.0	125.10	1.03	0.00	0.00	-0.04	0.02	0.00
1 A 2 g 7	CO	3.8	3.9	1.0	40.0	40.01	0.11	0.00	0.00	0.08	0.00	0.01
1 A 2 g 8	CO	0.8	1.9	10.0	40.0	41.23	0.03	0.00	0.00	0.05	0.02	0.00
1 A 3 a	CO	2.6	3.1	3.0	40.0	40.11	0.07	0.00	0.00	0.07	0.01	0.00
1 A 3 b 1	CO	465.0	34.0	3.1	40.0	40.12	8.05	-0.12	0.03	-4.63	0.12	21.45
1 A 3 b 2	CO	42.1	2.9	3.1	40.0	40.12	0.06	-0.01	0.00	-0.43	0.01	0.18
1 A 3 b 3	CO	12.4	4.7	3.1	40.0	40.12	0.15	0.00	0.00	0.00	0.02	0.00
1 A 3 b 4	CO	7.8	4.2	3.1	40.0	40.12	0.13	0.00	0.00	0.04	0.01	0.00
1 A 3 c	CO	2.0	0.4	3.0	40.0	40.11	0.00	0.00	0.00	-0.01	0.00	0.00
1 A 3 d	CO	3.1	2.4	3.0	40.0	40.11	0.04	0.00	0.00	0.04	0.01	0.00
1 A 3 e	CO	0.2	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	CO	11.4	3.8	5.0	125.0	125.10	0.97	0.00	0.00	-0.06	0.02	0.00
1 A 4 b	CO	382.2	206.8	15.0	125.0	125.90	2 934.91	0.05	0.17	5.96	3.51	47.82
1 A 4 c	CO	33.1	16.7	5.0	125.0	125.10	18.81	0.00	0.01	0.39	0.09	0.16
1 A 5 b	CO	0.2	0.2	1.0	125.0	125.00	0.00	0.00	0.00	0.01	0.00	0.00
2 B 1	CO	0.1	0.0	2.0	200.0	200.01	0.00	0.00	0.00	0.00	0.00	0.00
2 B-10	CO	12.5	11.1	2.0	200.0	200.01	21.21	0.00	0.01	1.00	0.03	1.00
2 C 1	CO	23.2	1.8	0.5	40.0	40.00	0.02	-0.01	0.00	-0.23	0.00	0.05
2 C 7	CO	0.1	0.1	5.0	40.0	40.31	0.00	0.00	0.00	0.00	0.00	0.00
2 D	CO	0.3	0.3	20.0	40.0	44.72	0.00	0.00	0.00	0.01	0.01	0.00
2 G	CO	0.9	0.7	20.0	200.0	201.00	0.09	0.00	0.00	0.06	0.02	0.00
3 F	CO	1.0	NO	100.0	125.0	160.08						
5 A	CO	10.3	2.3	12.0	125.0	125.57	0.37	0.00	0.00	-0.16	0.03	0.03
5 C	CO	0.3	0.1	7.0	125.0	125.20	0.00	0.00	0.00	0.00	0.00	0.00
Total		**1248.2**	**480.6**				**4 909.09**					**147.86**
Total Uncertainties						Uncertainty in total inventory %:	**70.06**				Trend uncertainty %:	**12.16**

Table 32: Uncertainty estimation of Cd emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		t	t	%	%	%	%	%	%	%	%	%
	Cd	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G\cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J\cdot E\cdot\sqrt{2}$ Note D	K^2+L^2
1 A 1 a	Cd	0.2	0.2	8.0	125.0	125.26	463.01	0.04	0.09	4.42	0.99	20.55
1 A 1 b	Cd	0.1	0.1	1.0	125.0	125.00	409.77	0.04	0.08	4.92	0.12	24.20
1 A 1 c	Cd	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	Cd	0.0	0.0	5.0	125.0	125.10	0.19	0.00	0.00	0.00	0.01	0.00
1 A 2 b	Cd	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	-0.05	0.00	0.00
1 A 2 c	Cd	0.0	0.0	5.0	125.0	125.10	6.08	0.00	0.01	0.23	0.07	0.06
1 A 2 d	Cd	0.2	0.0	10.0	125.0	125.40	48.38	-0.02	0.03	-1.93	0.40	3.88
1 A 2 e	Cd	0.0	0.0	5.0	125.0	125.10	0.04	0.00	0.00	0.03	0.01	0.00
1 A 2 f	Cd	0.1	0.0	5.0	125.0	125.10	8.53	-0.02	0.01	-2.03	0.08	4.13
1 A 2 g 7	Cd	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.03	0.00	0.00
1 A 2 g 8	Cd	0.0	0.1	10.0	125.0	125.40	54.91	0.02	0.03	2.97	0.43	8.99
1 A 3 a	Cd	0.0	0.0	3.0	40.0	40.11	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 1	Cd	0.0	0.0	3.1	40.0	40.12	0.02	0.00	0.00	0.04	0.01	0.00
1 A 3 b 2	Cd	0.0	0.0	3.1	40.0	40.12	0.00	0.00	0.00	0.01	0.00	0.00
1 A 3 b 3	Cd	0.0	0.0	3.1	40.0	40.12	0.01	0.00	0.00	0.03	0.00	0.00
1 A 3 b 4	Cd	0.0	0.0	3.1	40.0	40.12	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 6	Cd	0.0	0.0	3.1	40.0	40.12	1.35	0.01	0.01	0.43	0.06	0.19
1 A 3 c	Cd	0.0	0.0	3.0	40.0	40.11	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 d	Cd	0.0	0.0	3.0	40.0	40.11	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 e	Cd	0.0	0.0	1.0	40.0	40.01	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	Cd	0.1	0.0	5.0	125.0	125.10	8.54	0.00	0.01	-0.58	0.08	0.34
1 A 4 b	Cd	0.3	0.2	15.0	125.0	125.90	986.44	0.04	0.13	4.55	2.69	27.98
1 A 4 c	Cd	0.0	0.0	5.0	125.0	125.10	35.87	0.02	0.02	1.92	0.17	3.70
1 A 5 b	Cd	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B-10	Cd	0.0	0.0	2.0	20.0	20.10	0.00	0.00	0.00	0.00	0.00	0.00
2 C 1	Cd	0.5	0.1	0.5	40.0	40.00	5.14	-0.10	0.03	-4.11	0.02	16.93
2 C 5	Cd	0.1	0.0	10.0	40.0	41.23	0.06	-0.02	0.00	-0.69	0.04	0.48
2 C 7	Cd	0.0	0.0	5.0	40.0	40.31	0.00	0.00	0.00	-0.15	0.00	0.02
2 D	Cd	0.0	0.0	20.0	40.0	44.72	0.00	0.00	0.00	0.00	0.00	0.00
2 G	Cd	0.1	0.1	20.0	200.0	201.00	262.39	0.01	0.04	2.79	1.16	9.15
3 F	Cd	0.0	NO	100.0	125.0	160.08						
5 A	Cd	0.0	0.0	12.0	40.0	41.76	0.00	0.00	0.00	-0.01	0.00	0.00
5 C	Cd	0.1	0.0	7.0	40.0	40.61	0.00	-0.02	0.00	-0.66	0.00	0.44
5 E	Cd	0.0	0.0	50.0	200.0	206.16	0.15	0.00	0.00	0.12	0.07	0.02
Total		**1.8**	**0.9**				**2 290.89**					**121.08**
Total Uncertainties						Uncertainty in total inventory %:	**47.86**				Trend uncertainty %:	**11.00**

Table 33: Uncertainty estimation of Hg emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		t	t	%	%	%	%	%	%	%	%	%
	Hg	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G \cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J \cdot E \cdot \sqrt{2}$ Note D	$K^2 + L^2$
1 A 1 a	Hg	0.3	0.2	8.0	125.0	125.26	398.10	0.01	0.06	1.02	0.71	1.55
1 A 1 b	Hg	0.0	0.0	1.0	125.0	125.00	1.55	0.00	0.00	0.35	0.01	0.12
1 A 1 c	Hg	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 a	Hg	0.0	0.0	5.0	40.0	40.31	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 b	Hg	0.0	0.0	5.0	40.0	40.31	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 c	Hg	0.0	0.0	5.0	40.0	40.31	0.22	0.00	0.00	0.11	0.03	0.01
1 A 2 d	Hg	0.1	0.1	10.0	40.0	41.23	11.40	0.02	0.03	0.85	0.46	0.94
1 A 2 e	Hg	0.0	0.0	5.0	40.0	40.31	0.01	0.00	0.00	0.02	0.01	0.00
1 A 2 f	Hg	0.7	0.2	5.0	40.0	40.31	41.25	-0.05	0.06	-1.88	0.44	3.74
1 A 2 g 7	Hg	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 g 8	Hg	0.0	0.0	10.0	125.0	125.40	14.18	0.01	0.01	1.28	0.17	1.66
1 A 3 a	Hg	0.0	0.0	3.0	40.0	40.11	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 1	Hg	0.0	0.0	3.1	40.0	40.12	0.00	0.00	0.00	0.01	0.00	0.00
1 A 3 b 2	Hg	0.0	0.0	3.1	40.0	40.12	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 3	Hg	0.0	0.0	3.1	40.0	40.12	0.00	0.00	0.00	0.01	0.00	0.00
1 A 3 b 4	Hg	0.0	0.0	3.1	40.0	40.12	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 c	Hg	0.0	0.0	3.0	40.0	40.11	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 d	Hg	0.0	0.0	3.0	40.0	40.11	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 e	Hg	0.0	0.0	1.0	40.0	40.01	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	Hg	0.0	0.0	5.0	125.0	125.10	0.91	0.00	0.00	-0.09	0.02	0.01
1 A 4 b	Hg	0.4	0.1	15.0	125.0	125.90	318.03	-0.01	0.06	-0.66	1.18	1.84
1 A 4 c	Hg	0.0	0.0	5.0	125.0	125.10	2.21	0.00	0.00	0.32	0.03	0.11
1 A 5 b	Hg	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
1 B 2 d	Hg	NO	0.0	5.0	0.0	5.00	0.00		0.00		0.00	
2 B-10	Hg	0.3	0.0	2.0	20.0	20.10	0.00	-0.04	0.00	-0.85	0.00	0.71
2 C 1	Hg	0.6	0.3	0.5	40.0	40.00	184.57	0.04	0.13	1.59	0.09	2.54
2 C 7	Hg	0.0	0.0	5.0	40.0	40.31	0.00	0.00	0.00	-0.04	0.00	0.00
2 G	Hg	0.0	0.0	20.0	200.0	201.00	0.00	0.00	0.00	0.00	0.00	0.00
3 F	Hg	0.0	NO	100.0	125.0	160.08						
5 A	Hg	0.0	0.0	12.0	40.0	41.76	0.00	0.00	0.00	0.00	0.00	0.00
5 C	Hg	0.1	0.0	7.0	40.0	40.61	2.45	0.01	0.02	0.27	0.15	0.10
5 E	Hg	0.0	0.0	50.0	200.0	206.16	0.12	0.00	0.00	0.09	0.05	0.01
Total		**2.5**	**1.0**				**975.00**					**13.34**
Total Uncertainties						Uncertainty in total inventory %:	**31.23**				Trend uncertainty %:	**3.65**

Table 34: Uncertainty estimation of Pb emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		t	t	%	%	%	%	%	%	%	%	%
	Pb	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2 + F^2)}$	$\frac{(G \cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J \cdot E \cdot \sqrt{2}$ Note D	$K^2 + L^2$
1 A 1 a	Pb	1.3	2.0	8.0	125.0	125.26	335.40	0.01	0.01	1.03	0.10	1.08
1 A 1 b	Pb	0.2	0.3	1.0	125.0	125.00	5.32	0.00	0.00	0.13	0.00	0.02
1 A 1 c	Pb	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	Pb	0.3	0.1	5.0	125.0	125.10	1.69	0.00	0.00	0.07	0.00	0.00
1 A 2 b	Pb	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 c	Pb	0.2	0.4	5.0	125.0	125.10	11.59	0.00	0.00	0.19	0.01	0.04
1 A 2 d	Pb	0.6	0.3	10.0	125.0	125.40	8.42	0.00	0.00	0.15	0.02	0.02
1 A 2 e	Pb	0.0	0.0	5.0	125.0	125.10	0.02	0.00	0.00	0.01	0.00	0.00
1 A 2 f	Pb	4.3	0.2	5.0	125.0	125.10	3.13	0.00	0.00	-0.03	0.01	0.00
1 A 2 g 7	Pb	0.1	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 g 8	Pb	0.1	0.6	10.0	125.0	125.40	25.71	0.00	0.00	0.29	0.03	0.09
1 A 3 a	Pb	1.6	0.0	3.0	40.0	40.11	0.00	0.00	0.00	-0.02	0.00	0.00
1 A 3 b 1	Pb	161.6	0.0	3.1	125.0	125.04	0.00	-0.04	0.00	-5.05	0.00	25.53
1 A 3 b 2	Pb	6.9	0.0	3.1	125.0	125.04	0.00	0.00	0.00	-0.22	0.00	0.05
1 A 3 b 3	Pb	4.3	0.0	3.1	125.0	125.04	0.00	0.00	0.00	-0.13	0.00	0.02
1 A 3 b 4	Pb	1.7	0.0	3.1	125.0	125.04	0.00	0.00	0.00	-0.05	0.00	0.00
1 A 3 b 6	Pb	3.0	5.5	3.1	40.0	40.12	260.96	0.02	0.02	0.92	0.10	0.85
1 A 3 c	Pb	0.0	0.0	3.0	125.0	125.04	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 d	Pb	0.3	0.0	3.0	125.0	125.04	0.00	0.00	0.00	-0.01	0.00	0.00
1 A 3 e	Pb	0.0	0.0	1.0	40.0	40.01	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	Pb	0.4	0.1	5.0	125.0	125.10	1.87	0.00	0.00	0.07	0.00	0.00
1 A 4 b	Pb	6.8	1.7	15.0	125.0	125.90	251.83	0.01	0.01	0.71	0.16	0.53
1 A 4 c	Pb	1.0	0.1	5.0	125.0	125.10	1.65	0.00	0.00	0.04	0.00	0.00
1 A 5 b	Pb	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B-10	Pb	0.0	0.0	2.0	40.0	40.05	0.00	0.00	0.00	0.00	0.00	0.00
2 C 1	Pb	32.1	0.6	0.5	125.0	125.00	33.40	-0.01	0.00	-0.67	0.00	0.45
2 C 3	Pb	0.0	0.1	2.0	125.0	125.02	0.83	0.00	0.00	0.05	0.00	0.00
2 C 5	Pb	3.5	0.6	10.0	125.0	125.40	35.31	0.00	0.00	0.24	0.04	0.06
2 C 7	Pb	0.5	0.0	5.0	125.0	125.10	0.00	0.00	0.00	-0.02	0.00	0.00
2 D	Pb	0.0	0.0	20.0	40.0	44.72	0.00	0.00	0.00	0.00	0.00	0.00
2 G	Pb	1.2	0.9	20.0	200.0	201.00	172.28	0.00	0.00	0.70	0.11	0.51
3 F	Pb	0.0	NO	100.0	125.0	160.08						
5 A	Pb	0.0	0.0	12.0	40.0	41.76	0.00	0.00	0.00	0.00	0.00	0.00
5 C	Pb	1.0	0.0	7.0	40.0	40.61	0.00	0.00	0.00	-0.01	0.00	0.00
5 E	Pb	0.0	0.0	50.0	200.0	206.16	0.00	0.00	0.00	0.00	0.00	0.00
Total		**232.9**	**13.7**				**1 149.43**					**29.25**
Total Uncertainties						Uncertainty in total inventory %:	**33.90**				Trend uncertainty %:	**5.41**

Table 35: Uncertainty estimation of PAH emissions 1990 and 2022.

NRF sector	**Pollutant**	**Base year emissions**	**Year t emissions**	**Activity data uncertainty (1)**	**Emission factor uncertainty (1)**	**Combined uncertainty**	**Contribution to variance by category in year x**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)**	**Uncertainty in trend in national emissions introduced by activity data uncertainty (3)**	**Uncertainty introduced into the trend in total national emissions**
		t	t	%	%	%	%	%	%	%	%	%
	PAH	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G\cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J\cdot E\cdot\sqrt{2}$ Note D	K^2+L^2
1 A 1 a	PAH	0.0	0.0	8.0	125.0	125.26	0.31	0.00	0.00	0.16	0.02	0.03
1 A 1 b	PAH	0.0	0.0	1.0	200.0	200.00	0.01	0.00	0.00	0.02	0.00	0.00
1 A 1 c	PAH	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	PAH	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 b	PAH	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 c	PAH	0.0	0.0	5.0	125.0	125.10	0.32	0.00	0.00	0.14	0.01	0.02
1 A 2 d	PAH	0.0	0.0	10.0	125.0	125.40	0.01	0.00	0.00	0.02	0.00	0.00
1 A 2 e	PAH	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 f	PAH	0.0	0.0	5.0	125.0	125.10	0.05	0.00	0.00	0.06	0.00	0.00
1 A 2 g 7	PAH	0.0	0.1	1.0	200.0	200.00	21.88	0.01	0.01	1.36	0.01	1.86
1 A 2 g 8	PAH	0.0	0.1	10.0	200.0	200.25	6.86	0.00	0.00	0.76	0.06	0.58
1 A 3 b 1	PAH	0.2	0.1	3.1	125.0	125.04	8.95	0.00	0.01	0.56	0.03	0.32
1 A 3 b 2	PAH	0.0	0.0	3.1	125.0	125.04	0.14	0.00	0.00	0.03	0.00	0.00
1 A 3 b 3	PAH	0.0	0.1	3.1	125.0	125.04	7.37	0.01	0.01	0.73	0.03	0.54
1 A 3 b 4	PAH	0.0	0.0	3.1	200.0	200.02	0.00	0.00	0.00	0.01	0.00	0.00
1 A 3 b 6	PAH	0.0	0.0	3.1	125.0	125.04	0.02	0.00	0.00	0.04	0.00	0.00
1 A 3 c	PAH	0.0	0.0	3.0	200.0	200.02	0.07	0.00	0.00	0.01	0.00	0.00
1 A 3 d	PAH	0.0	0.0	3.0	200.0	200.02	0.10	0.00	0.00	0.07	0.00	0.01
1 A 3 e	PAH	0.0	0.0	1.0	40.0	40.01	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	PAH	0.3	0.1	5.0	200.0	200.06	5.94	0.00	0.00	-0.32	0.03	0.10
1 A 4 b	PAH	10.2	4.3	15.0	200.0	200.56	22 569.31	0.06	0.23	12.10	4.89	170.31
1 A 4 c	PAH	0.6	0.6	5.0	200.0	200.06	523.81	0.03	0.04	5.16	0.25	26.65
1 A 5 b	PAH	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 1	PAH	6.3	0.1	0.5	125.0	125.00	2.61	-0.10	0.00	-12.49	0.00	155.89
2 C 7	PAH	0.0	0.0	5.0				0.00	0.00		0.00	
2 D	PAH	0.2	NA	20.0	40.0	44.72						
2 G	PAH	0.0	0.0	20.0	200.0	201.00	0.01	0.00	0.00	0.02	0.00	0.00
2 H	PAH	0.5	0.0	10.0	750.0	750.07	23.86	-0.01	0.00	-5.30	0.03	28.10
3 F	PAH	0.0	NO	100.0	125.0	160.08						
5 C	PAH	0.0	0.0	7.0	125.0	125.20	0.07	0.00	0.00	-0.01	0.01	0.00
Total		**18.5**	**5.7**				**23 171.71**					**384.40**
Total Uncertainties						Uncertainty in total inventory %:	**152.22**				Trend uncertainty %:	**19.61**

Table 36: Uncertainty estimation of DIOX emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		g	g	%	%	%	%	%	%	%	%	%
	DIOX	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G\cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J\cdot E\cdot\sqrt{2}$ Note D	K^2+L^2
1 A 1 a	DIOX	12.1	1.4	8.0	125.0	125.26	32.45	-0.01	0.01	-1.76	0.13	3.12
1 A 1 b	DIOX	0.0	0.0	1.0	200.0	200.00	0.01	0.00	0.00	0.02	0.00	0.00
1 A 1 c	DIOX	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	DIOX	0.0	0.0	5.0	750.0	750.02	0.52	0.00	0.00	0.13	0.00	0.02
1 A 2 b	DIOX	0.0	0.0	5.0	750.0	750.02	0.92	0.00	0.00	0.22	0.00	0.05
1 A 2 c	DIOX	0.4	0.7	5.0	750.0	750.02	238.82	0.00	0.01	3.33	0.04	11.08
1 A 2 d	DIOX	0.5	0.6	10.0	750.0	750.07	192.27	0.00	0.00	2.81	0.07	7.92
1 A 2 e	DIOX	0.0	0.1	5.0	750.0	750.02	2.59	0.00	0.00	0.37	0.00	0.14
1 A 2 f	DIOX	0.3	0.5	5.0	750.0	750.02	131.40	0.00	0.00	2.52	0.03	6.33
1 A 2 g 7	DIOX	0.0	0.2	1.0	200.0	200.00	1.07	0.00	0.00	0.26	0.00	0.07
1 A 2 g 8	DIOX	0.3	1.9	10.0	200.0	200.25	140.81	0.01	0.02	2.94	0.22	8.69
1 A 3 b 1	DIOX	3.6	0.5	3.1	200.0	200.02	10.25	0.00	0.00	-0.71	0.02	0.50
1 A 3 b 2	DIOX	0.2	0.1	3.1	200.0	200.02	0.40	0.00	0.00	0.09	0.00	0.01
1 A 3 b 3	DIOX	0.3	0.7	3.1	200.0	200.02	20.47	0.01	0.01	1.04	0.03	1.08
1 A 3 b 4	DIOX	0.0	0.0	3.1	200.0	200.02	0.00	0.00	0.00	0.01	0.00	0.00
1 A 3 c	DIOX	0.0	0.0	3.0	200.0	200.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 d	DIOX	0.0	0.0	3.0	200.0	200.02	0.01	0.00	0.00	0.02	0.00	0.00
1 A 3 e	DIOX	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	DIOX	1.7	0.6	5.0	200.0	200.06	12.52	0.00	0.00	0.18	0.03	0.03
1 A 4 b	DIOX	39.4	14.3	15.0	200.0	200.56	8 179.08	0.03	0.12	6.62	2.49	50.09
1 A 4 c	DIOX	1.5	1.3	5.0	200.0	200.06	71.35	0.01	0.01	1.55	0.08	2.40
1 A 5 b	DIOX	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 1	DIOX	34.5	0.5	0.5	125.0	125.00	4.32	-0.07	0.00	-8.67	0.00	75.23
2 C 3	DIOX	2.4	3.5	2.0	125.0	125.02	188.01	0.02	0.03	2.93	0.08	8.59
2 C 5	DIOX	0.1	0.1	10.0	125.0	125.40	0.10	0.00	0.00	0.06	0.01	0.00
2 C 7	DIOX	0.8	1.3	5.0	125.0	125.10	27.73	0.01	0.01	1.16	0.08	1.35
2 D	DIOX	1.1	NA	20.0	40.0	44.72						
2 G	DIOX	0.0	0.0	20.0	200.0	201.00	0.00	0.00	0.00	0.00	0.00	0.00
2 H	DIOX	1.8	0.1	10.0	750.0	750.07	9.60	0.00	0.00	-2.07	0.02	4.27
3 F	DIOX	0.1	NO	100.0	125.0	160.08						
5 C	DIOX	18.2	0.3	7.0	125.0	125.20	1.69	-0.04	0.00	-4.54	0.03	20.61
5 E	DIOX	2.1	2.9	50.0	200.0	206.16	356.48	0.02	0.02	3.88	1.69	17.87
Total		**121.7**	**31.7**				**9 622.87**					**219.46**
Total Uncertainties						Uncertainty in total inventory %:	**98.10**				Trend uncertainty %:	**14.81**

Table 37: Uncertainty estimation of HCB emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		kg	kg	%	%	%	%	%	%	%	%	%
	HCB	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G \cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J \cdot E \cdot \sqrt{2}$ Note D	$K^2 + L^2$
1 A 1 a	HCB	0.3	0.5	8.0	125.0	125.26	36.83	0.01	0.01	0.72	0.07	0.52
1 A 1 b	HCB	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 1 c	HCB	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	HCB	0.0	0.0	5.0	200.0	200.06	0.01	0.00	0.00	0.01	0.00	0.00
1 A 2 b	HCB	0.0	0.0	5.0	200.0	200.06	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 c	HCB	0.1	0.1	5.0	200.0	200.06	3.75	0.00	0.00	0.23	0.01	0.05
1 A 2 d	HCB	0.1	0.1	10.0	200.0	200.25	5.09	0.00	0.00	0.26	0.02	0.07
1 A 2 e	HCB	0.0	0.0	5.0	200.0	200.06	0.04	0.00	0.00	0.02	0.00	0.00
1 A 2 f	HCB	0.1	0.1	5.0	200.0	200.06	2.38	0.00	0.00	0.18	0.01	0.03
1 A 2 g 7	HCB	0.0	0.0	1.0	200.0	200.00	0.40	0.00	0.00	0.08	0.00	0.01
1 A 2 g 8	HCB	0.1	0.3	10.0	200.0	200.25	31.99	0.00	0.00	0.70	0.05	0.50
1 A 3 b 1	HCB	0.7	0.1	3.1	200.0	200.02	3.81	0.00	0.00	0.02	0.01	0.00
1 A 3 b 2	HCB	0.0	0.0	3.1	200.0	200.02	0.15	0.00	0.00	0.04	0.00	0.00
1 A 3 b 3	HCB	0.1	0.1	3.1	200.0	200.02	7.61	0.00	0.00	0.33	0.01	0.11
1 A 3 b 4	HCB	0.0	0.0	3.1	200.0	200.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 c	HCB	0.0	0.0	3.0	200.0	200.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 d	HCB	0.0	0.0	3.0	200.0	200.02	0.00	0.00	0.00	0.01	0.00	0.00
1 A 3 e	HCB	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	HCB	1.2	0.3	5.0	200.0	200.06	24.48	0.00	0.00	0.26	0.02	0.07
1 A 4 b	HCB	47.6	6.1	15.0	200.0	200.56	13 657.27	0.00	0.07	0.00	1.57	2.48
1 A 4 c	HCB	0.9	0.5	5.0	200.0	200.06	94.02	0.00	0.01	0.96	0.04	0.91
1 A 5 b	HCB	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B-10	HCB	1.3	NA	2.0	200.0	200.01						
2 C 1	HCB	8.1	0.1	0.5	125.0	125.00	2.15	-0.01	0.00	-1.39	0.00	1.93
2 C 3	HCB	1.2	1.7	2.0	125.0	125.02	436.96	0.02	0.02	2.43	0.06	5.90
2 C 7	HCB	0.1	0.2	5.0	125.0	125.10	4.36	0.00	0.00	0.25	0.02	0.06
2 D	HCB	9.1	NA	20.0	40.0	44.72						
2 H	HCB	0.4	0.0	10.0	750.0	750.07	3.57	0.00	0.00	-0.18	0.00	0.03
3 D f	HCB	10.1	0.0	0.0	125.0	125.00	0.04	-0.02	0.00	-1.94	0.00	3.78
3 F	HCB	0.0	NO	100.0	125.0	160.08						
5 C	HCB	0.4	0.1	7.0	125.0	125.20	0.97	0.00	0.00	0.05	0.01	0.00
Total		**81.7**	**10.4**				**14 315.88**					**16.46**
Total Uncertainties						Uncertainty in total inventory %:	**119.65**				Trend uncertainty %:	**4.06**

Table 38: Uncertainty estimation of PCB emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		kg	kg	%	%	%	%	%	%	%	%	%
	PCB	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G \cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J \cdot E \cdot \sqrt{2}$ Note D	$K^2 + L^2$
1 A 1 a	PCB	1.2	0.0	8.0	125.0	125.26	3.62	0.00	0.00	-0.16	0.01	0.03
1 A 1 b	PCB	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 1 c	PCB	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	PCB	0.1	0.0	5.0	200.0	200.06	1.08	0.00	0.00	0.04	0.00	0.00
1 A 2 b	PCB	0.0	0.0	5.0	200.0	200.06	2.81	0.00	0.00	0.11	0.00	0.01
1 A 2 c	PCB	0.2	0.1	5.0	200.0	200.06	53.29	0.00	0.00	0.47	0.02	0.22
1 A 2 d	PCB	1.5	0.3	10.0	200.0	200.25	343.04	0.00	0.01	0.78	0.10	0.62
1 A 2 e	PCB	0.2	0.0	5.0	200.0	200.06	3.66	0.00	0.00	0.08	0.01	0.01
1 A 2 f	PCB	0.5	0.4	5.0	200.0	200.06	956.77	0.01	0.01	2.16	0.08	4.65
1 A 2 g 7	PCB	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 g 8	PCB	0.2	0.0	10.0	200.0	200.25	0.08	0.00	0.00	-0.06	0.00	0.00
1 A 3 b 1	PCB	0.0	0.0	3.1	200.0	200.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 2	PCB	0.0	0.0	3.1	200.0	200.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 3	PCB	0.0	0.0	3.1	200.0	200.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 4	PCB	0.0	0.0	3.1	200.0	200.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 c	PCB	0.0	0.0	3.0	200.0	200.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 d	PCB	0.0	0.0	3.0	200.0	200.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 e	PCB	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	PCB	0.3	0.0	5.0	750.0	750.02	0.00	0.00	0.00	-0.47	0.00	0.22
1 A 4 b	PCB	4.5	0.1	15.0	750.0	750.15	281.91	-0.01	0.00	-5.82	0.04	33.86
1 A 4 c	PCB	0.1	0.0	5.0	750.0	750.02	0.24	0.00	0.00	-0.11	0.00	0.01
1 A 5 b	PCB	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 1	PCB	8.5	1.8	0.5	125.0	125.00	6 527.49	0.03	0.05	3.92	0.03	15.35
2 C 5	PCB	19.2	0.0	10.0	125.0	125.40	0.00	-0.04	0.00	-4.99	0.00	24.85
2 C 7	PCB	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	0.00	0.00	0.00
5 C	PCB	0.0	0.0	7.0	200.0	200.12	1.97	0.00	0.00	0.11	0.01	0.01
Total		**36.4**	**2.8**				**8 174.00**					**79.86**
Total Uncertainties						Uncertainty in total inventory %:	**90.41**				Trend uncertainty %:	**8.94**

Table 39: Uncertainty estimation of TSP emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
	TSP	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G\cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J\cdot E\cdot\sqrt{2}$ Note D	K^2+L^2
1 A 1 a	TSP	0.83	1.1	8.0	40.0	40.79	1.06	0.01	0.02	0.34	0.21	0.16
1 A 1 b	TSP	0.15	0.0	1.0	20.0	20.02	0.00	0.00	0.00	-0.02	0.00	0.00
1 A 1 c	TSP	0.07	0.1	1.0	40.0	40.01	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 a	TSP	0.06	0.0	5.0	125.0	125.10	0.00	0.00	0.00	-0.06	0.00	0.00
1 A 2 b	TSP	0.01	0.0	5.0	125.0	125.10	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 c	TSP	0.23	0.2	5.0	125.0	125.10	0.39	0.00	0.00	0.12	0.03	0.01
1 A 2 d	TSP	1.06	0.2	10.0	125.0	125.40	0.34	-0.01	0.00	-1.10	0.05	1.21
1 A 2 e	TSP	0.12	0.1	5.0	125.0	125.10	0.02	0.00	0.00	-0.07	0.01	0.01
1 A 2 f	TSP	0.08	0.1	5.0	125.0	125.10	0.09	0.00	0.00	0.10	0.01	0.01
1 A 2 g 7	TSP	0.52	0.1	1.0	40.0	40.01	0.00	0.00	0.00	-0.19	0.00	0.04
1 A 2 g 8	TSP	0.29	0.3	10.0	40.0	41.23	0.07	0.00	0.00	0.05	0.06	0.01
1 A 3 a	TSP	0.04	0.1	3.0	40.0	40.11	0.01	0.00	0.00	0.04	0.01	0.00
1 A 3 b 1	TSP	1.61	0.4	3.1	40.0	40.12	0.12	-0.01	0.01	-0.49	0.03	0.24
1 A 3 b 2	TSP	0.84	0.1	3.1	40.0	40.12	0.01	-0.01	0.00	-0.30	0.01	0.09
1 A 3 b 3	TSP	2.46	0.1	3.1	40.0	40.12	0.01	-0.03	0.00	-1.06	0.01	1.13
1 A 3 b 4	TSP	0.13	0.1	3.1	40.0	40.12	0.00	0.00	0.00	-0.01	0.01	0.00
1 A 3 b 6	TSP	1.16	2.7	3.1	125.0	125.04	54.32	0.03	0.04	3.64	0.19	13.29
1 A 3 b 7	TSP	1.00	2.3	3.1	125.0	125.04	41.00	0.03	0.04	3.17	0.16	10.06
1 A 3 c	TSP	2.00	1.5	3.0	40.0	40.11	1.86	0.00	0.02	0.06	0.10	0.01
1 A 3 d	TSP	0.06	0.1	3.0	40.0	40.11	0.00	0.00	0.00	0.01	0.00	0.00
1 A 3 e	TSP	0.01	0.0	1.0	125.0	125.00	0.00	0.00	0.00	-0.01	0.00	0.00
1 A 4 a	TSP	0.92	0.3	5.0	125.0	125.10	0.85	-0.01	0.01	-0.65	0.04	0.43
1 A 4 b	TSP	11.53	6.1	15.0	125.0	125.90	293.04	-0.03	0.10	-4.30	2.08	22.84
1 A 4 c	TSP	2.59	0.8	5.0	125.0	125.10	5.01	-0.02	0.01	-2.11	0.09	4.47
1 A 5 b	TSP	0.02	0.0	1.0	125.0	125.00	0.00	0.00	0.00	-0.01	0.00	0.00
1 B 1 a	TSP	0.85	0.3	5.0	200.0	200.06	2.02	0.00	0.01	-0.94	0.04	0.88
2 A 1	TSP	0.17	0.0	1.1	200.0	200.00	0.03	0.00	0.00	-0.27	0.00	0.07
2 A 2	TSP	0.06	0.1	1.6	200.0	200.01	0.19	0.00	0.00	0.17	0.00	0.03
2 A 3	TSP	0.04	0.0	10.0	200.0	200.25	0.00	0.00	0.00	-0.07	0.00	0.00
2 A 5	TSP	19.22	19.6	5.0	200.0	200.06	7 537.49	0.09	0.31	18.29	2.21	339.39
2 B-10	TSP	0.83	0.4	2.0	20.0	20.10	0.04	0.00	0.01	-0.06	0.02	0.00
2 D	TSP	0.35	0.4	20.0	40.0	44.72	0.19	0.00	0.01	0.12	0.20	0.05
2 C 1	TSP	6.43	0.5	0.5	40.0	40.00	0.21	-0.07	0.01	-2.63	0.01	6.90
2 C 2	TSP	0.02	0.0	5.0	40.0	40.31	0.00	0.00	0.00	0.00	0.00	0.00
2 C 3	TSP	0.12	0.0	2.0	40.0	40.05	0.00	0.00	0.00	-0.05	0.00	0.00
2 C 5	TSP	0.00	0.0	10.0	40.0	41.23	0.00	0.00	0.00	0.00	0.00	0.00
2 C 7	TSP	0.03	0.0	5.0	40.0	40.31	0.00	0.00	0.00	-0.01	0.00	0.00
2 G	TSP	0.54	0.4	20.0	125.0	126.59	1.33	0.00	0.01	0.05	0.19	0.04
2 H	TSP	0.00	0.0	10.0	200.0	200.25	0.00	0.00	0.00	0.00	0.00	0.00
2 I	TSP	0.90	1.1	1.0	40.0	40.01	1.03	0.01	0.02	0.32	0.03	0.10
3 B 1	TSP	0.61	0.4	1.0	200.0	200.00	3.75	0.00	0.01	0.00	0.01	0.00
3 B 2	TSP	0.07	0.1	10.0	200.0	200.25	0.17	0.00	0.00	0.13	0.02	0.02
3 B 3	TSP	0.37	0.3	4.0	200.0	200.04	1.25	0.00	0.00	-0.05	0.02	0.00
3 B 4	TSP	0.23	0.3	10.0	200.0	200.25	2.35	0.00	0.01	0.57	0.08	0.33
3 D c	TSP	3.56	3.3	5.0	200.0	200.06	210.26	0.01	0.05	2.26	0.37	5.24
3 D d	TSP	0.03	0.1	5.0	200.0	200.06	0.07	0.00	0.00	0.11	0.01	0.01
3 F	TSP	0.08	NO	100.0	125.0	160.08						
5 A	TSP	0.14	0.5	12.0	200.0	200.36	4.79	0.01	0.01	1.24	0.13	1.56
5 C	TSP	0.02	0.0	7.0	200.0	200.12	0.00	0.00	0.00	-0.03	0.00	0.00
5 E	TSP	0.21	0.3	50.0	200.0	206.16	1.70	0.00	0.00	0.44	0.32	0.30
Total		**62.7**	**45.2**				**8 165.08**					**408.96**
Total Uncertainties						Uncertainty in total inventory %:	**90.36**				Trend uncertainty %:	**20.22**

Table 40: Uncertainty estimation of PM_{10} emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
	PM10	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G \cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J \cdot E \cdot \sqrt{2}$ Note D	K^2+L^2
1 A 1 a	PM10	0.8	1.0	8.0	125.0	125.26	22.10	0.01	0.02	1.54	0.27	2.43
1 A 1 b	PM10	0.1	0.0	1.0	40.0	40.01	0.00	0.00	0.00	-0.06	0.00	0.00
1 A 1 c	PM10	0.1	0.1	1.0	40.0	40.01	0.01	0.00	0.00	0.03	0.00	0.00
1 A 2 a	PM10	0.1	0.0	5.0	125.0	125.10	0.00	0.00	0.00	-0.06	0.00	0.00
1 A 2 b	PM10	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 c	PM10	0.2	0.2	5.0	125.0	125.10	0.87	0.00	0.00	0.21	0.03	0.04
1 A 2 d	PM10	0.9	0.2	10.0	125.0	125.40	0.74	-0.01	0.00	-1.19	0.06	1.41
1 A 2 e	PM10	0.1	0.0	5.0	125.0	125.10	0.04	0.00	0.00	-0.07	0.01	0.00
1 A 2 f	PM10	0.1	0.1	5.0	125.0	125.10	0.19	0.00	0.00	0.15	0.02	0.02
1 A 2 g 7	PM10	0.5	0.1	1.0	40.0	40.01	0.01	-0.01	0.00	-0.24	0.00	0.06
1 A 2 g 8	PM10	0.3	0.3	10.0	40.0	41.23	0.15	0.00	0.01	0.09	0.08	0.01
1 A 3 a	PM10	0.0	0.1	3.0	40.0	40.11	0.02	0.00	0.00	0.07	0.01	0.00
1 A 3 b 1	PM10	1.6	0.4	3.1	40.0	40.12	0.33	-0.01	0.01	-0.57	0.04	0.33
1 A 3 b 2	PM10	0.8	0.1	3.1	40.0	40.12	0.04	-0.01	0.00	-0.37	0.01	0.13
1 A 3 b 3	PM10	2.5	0.1	3.1	40.0	40.12	0.03	-0.03	0.00	-1.33	0.01	1.78
1 A 3 b 4	PM10	0.1	0.1	3.1	125.0	125.04	0.13	0.00	0.00	0.00	0.01	0.00
1 A 3 b 6	PM10	0.9	2.0	3.1	125.0	125.04	81.25	0.03	0.05	4.09	0.20	16.79
1 A 3 b 7	PM10	0.5	1.2	3.1	125.0	125.04	27.91	0.02	0.03	2.42	0.12	5.87
1 A 3 c	PM10	1.0	0.5	3.0	40.0	40.11	0.62	0.00	0.01	-0.06	0.05	0.01
1 A 3 d	PM10	0.1	0.1	3.0	40.0	40.11	0.01	0.00	0.00	0.02	0.01	0.00
1 A 3 e	PM10	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	-0.01	0.00	0.00
1 A 4 a	PM10	0.8	0.3	5.0	125.0	125.10	2.10	-0.01	0.01	-0.63	0.05	0.40
1 A 4 b	PM10	10.7	5.7	15.0	125.0	125.90	696.59	-0.02	0.13	-2.94	2.81	16.53
1 A 4 c	PM10	2.5	0.8	5.0	125.0	125.10	12.22	-0.02	0.02	-2.43	0.12	5.92
1 A 5 b	PM10	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	-0.01	0.00	0.00
1 B 1 a	PM10	0.4	0.2	5.0	200.0	200.06	1.23	0.00	0.00	-0.47	0.02	0.22
2 A 1	PM10	0.2	0.0	1.1	200.0	200.00	0.07	0.00	0.00	-0.29	0.00	0.09
2 A 2	PM10	0.1	0.1	1.6	200.0	200.01	0.41	0.00	0.00	0.24	0.00	0.06
2 A 3	PM10	0.0	0.0	10.0	200.0	200.25	0.00	0.00	0.00	-0.07	0.00	0.01
2 A 5	PM10	7.2	7.5	5.0	200.0	200.06	3 038.36	0.07	0.17	13.94	1.23	195.75
2 B-10	PM10	0.4	0.3	2.0	20.0	20.10	0.04	0.00	0.01	0.00	0.02	0.00
2 C 1	PM10	4.6	0.4	0.5	40.0	40.00	0.32	-0.06	0.01	-2.30	0.01	5.28
2 C 2	PM10	0.0	0.0	5.0	40.0	40.31	0.00	0.00	0.00	0.00	0.00	0.00
2 C 3	PM10	0.1	0.0	2.0	40.0	40.05	0.00	0.00	0.00	-0.04	0.00	0.00
2 C 5	PM10	0.0	0.0	10.0	40.0	41.23	0.00	0.00	0.00	0.00	0.00	0.00
2 C 7	PM10	0.0	0.0	5.0	40.0	40.31	0.00	0.00	0.00	-0.01	0.00	0.00
2 D	PM10	0.2	0.3	20.0	40.0	44.72	0.23	0.00	0.01	0.13	0.19	0.05
2 G	PM10	0.5	0.4	20.0	125.0	126.59	3.61	0.00	0.01	0.21	0.27	0.12
2 H	PM10	0.0	0.0	10.0	200.0	200.25	0.00	0.00	0.00	0.00	0.00	0.00
2 I	PM10	0.4	0.5	1.0	40.0	40.01	0.46	0.01	0.01	0.21	0.02	0.05
3 B 1	PM10	0.3	0.2	1.0	200.0	200.00	2.07	0.00	0.00	0.11	0.01	0.01
3 B 2	PM10	0.0	0.0	10.0	200.0	200.25	0.10	0.00	0.00	0.10	0.01	0.01
3 B 3	PM10	0.2	0.1	4.0	200.0	200.04	0.69	0.00	0.00	0.04	0.01	0.00
3 B 4	PM10	0.1	0.2	10.0	200.0	200.25	1.29	0.00	0.00	0.42	0.05	0.17
3 D c	PM10	3.6	3.3	5.0	200.0	200.06	572.60	0.02	0.08	4.73	0.53	22.65
3 D d	PM10	0.0	0.0	5.0	200.0	200.06	0.04	0.00	0.00	0.08	0.00	0.01
3 F	PM10	0.1	NO	100.0	125.0	160.08						
5 A	PM10	0.1	0.2	12.0	200.0	200.36	2.92	0.00	0.01	0.88	0.09	0.78
5 C	PM10	0.0	0.0	7.0	200.0	200.12	0.00	0.00	0.00	-0.04	0.00	0.00
5 E	PM10	0.2	0.3	50.0	200.0	206.16	4.62	0.00	0.01	0.72	0.47	0.73
Total		**43.4**	**27.4**				**4 474.42**					**277.74**
Total Uncertainties						Uncertainty in total inventory %:	**66.89**				Trend uncertainty %:	**16.67**

Table 41: Uncertainty estimation of $PM_{2.5}$ emissions 1990 and 2022.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
	PM2.5	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G \cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J \cdot E \cdot \sqrt{2}$ Note D	$K^2 + L^2$
1 A 1 a	PM2.5	0.7	0.9	8.0	60.0	60.53	14.85	0.02	0.03	1.17	0.35	1.49
1 A 1 b	PM2.5	0.1	0.0	1.0	40.0	40.01	0.01	0.00	0.00	-0.05	0.00	0.00
1 A 1 c	PM2.5	0.1	0.1	1.0	40.0	40.01	0.05	0.00	0.00	0.06	0.00	0.00
1 A 2 a	PM2.5	0.0	0.0	5.0	125.0	125.10	0.01	0.00	0.00	-0.05	0.00	0.00
1 A 2 b	PM2.5	0.0	0.0	5.0	125.0	125.10	0.01	0.00	0.00	0.02	0.00	0.00
1 A 2 c	PM2.5	0.2	0.2	5.0	125.0	125.10	2.49	0.00	0.01	0.38	0.04	0.15
1 A 2 d	PM2.5	0.8	0.2	10.0	125.0	125.40	2.08	-0.01	0.01	-1.05	0.08	1.11
1 A 2 e	PM2.5	0.1	0.0	5.0	125.0	125.10	0.12	0.00	0.00	-0.03	0.01	0.00
1 A 2 f	PM2.5	0.1	0.1	5.0	125.0	125.10	0.55	0.00	0.00	0.23	0.02	0.06
1 A 2 g 7	PM2.5	0.5	0.1	1.0	40.0	40.01	0.05	-0.01	0.00	-0.27	0.00	0.07
1 A 2 g 8	PM2.5	0.2	0.2	10.0	60.0	60.83	0.94	0.00	0.01	0.24	0.11	0.07
1 A 3 a	PM2.5	0.0	0.1	3.0	40.0	40.11	0.09	0.00	0.00	0.11	0.02	0.01
1 A 3 b 1	PM2.5	1.6	0.4	3.1	125.0	125.04	13.26	-0.01	0.01	-1.82	0.06	3.32
1 A 3 b 2	PM2.5	0.8	0.1	3.1	125.0	125.04	1.56	-0.01	0.00	-1.28	0.02	1.65
1 A 3 b 3	PM2.5	2.5	0.1	3.1	125.0	125.04	1.01	-0.04	0.00	-5.04	0.02	25.39
1 A 3 b 4	PM2.5	0.1	0.1	3.1	125.0	125.04	0.54	0.00	0.00	0.08	0.01	0.01
1 A 3 b 6	PM2.5	0.5	1.1	3.1	125.0	125.04	102.43	0.03	0.04	3.91	0.17	15.34
1 A 3 b 7	PM2.5	0.3	0.6	3.1	125.0	125.04	33.71	0.02	0.02	2.25	0.10	5.05
1 A 3 c	PM2.5	0.6	0.2	3.0	40.0	40.11	0.32	0.00	0.01	-0.15	0.03	0.02
1 A 3 d	PM2.5	0.1	0.1	3.0	40.0	40.11	0.02	0.00	0.00	0.04	0.01	0.00
1 A 3 e	PM2.5	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	-0.01	0.00	0.00
1 A 4 a	PM2.5	0.8	0.3	5.0	60.0	60.21	1.81	0.00	0.01	-0.17	0.08	0.04
1 A 4 b	PM2.5	10.0	5.4	15.0	60.0	61.85	623.15	0.02	0.20	1.08	4.21	18.91
1 A 4 c	PM2.5	2.5	0.7	5.0	100.0	100.12	28.82	-0.02	0.03	-1.87	0.19	3.54
1 A 5 b	PM2.5	0.0	0.0	1.0	125.0	125.00	0.01	0.00	0.00	-0.01	0.00	0.00
1 B 1 a	PM2.5	0.1	0.0	5.0	200.0	200.06	0.51	0.00	0.00	-0.04	0.01	0.00
2 A 1	PM2.5	0.1	0.0	1.1	40.0	40.02	0.01	0.00	0.00	-0.05	0.00	0.00
2 A 2	PM2.5	0.0	0.1	1.6	125.0	125.01	0.35	0.00	0.00	0.20	0.01	0.04
2 A 3	PM2.5	0.0	0.0	10.0	125.0	125.40	0.00	0.00	0.00	-0.04	0.00	0.00
2 A 5	PM2.5	0.8	0.8	5.0	200.0	200.06	154.34	0.02	0.03	3.33	0.22	11.11
2 B-10	PM2.5	0.3	0.1	2.0	20.0	20.10	0.05	0.00	0.01	0.00	0.01	0.00
2 C 1	PM2.5	2.1	0.2	0.5	20.0	20.01	0.06	-0.03	0.01	-0.62	0.00	0.39
2 C 2	PM2.5	0.0	0.0	5.0	40.0	40.31	0.00	0.00	0.00	0.01	0.00	0.00
2 C 3	PM2.5	0.0	0.0	2.0	40.0	40.05	0.00	0.00	0.00	-0.02	0.00	0.00
2 C 5	PM2.5	0.0	0.0	10.0	40.0	41.23	0.00	0.00	0.00	0.00	0.00	0.00
2 C 7	PM2.5	0.0	0.0	5.0	40.0	40.31	0.00	0.00	0.00	-0.01	0.00	0.00
2 D	PM2.5	0.0	0.0	20.0	40.0	44.72	0.00	0.00	0.00	0.01	0.02	0.00
2 G	PM2.5	0.5	0.4	20.0	125.0	126.59	14.18	0.01	0.01	0.66	0.41	0.60
2 H	PM2.5	0.0	0.0	10.0	200.0	200.25	0.00	0.00	0.00	0.00	0.00	0.00
2 I	PM2.5	0.1	0.2	1.0	40.0	40.01	0.30	0.00	0.01	0.16	0.01	0.03
3 B 1	PM2.5	0.1	0.0	1.0	200.0	200.00	0.42	0.00	0.00	0.10	0.00	0.01
3 B 2	PM2.5	0.0	0.0	10.0	200.0	200.25	0.02	0.00	0.00	0.04	0.00	0.00
3 B 3	PM2.5	0.0	0.0	4.0	200.0	200.04	0.14	0.00	0.00	0.05	0.01	0.00
3 B 4	PM2.5	0.0	0.0	10.0	200.0	200.25	0.26	0.00	0.00	0.17	0.02	0.03
3 D c	PM2.5	0.1	0.1	5.0	200.0	200.06	3.51	0.00	0.00	0.43	0.03	0.18
3 D d	PM2.5	0.0	0.0	5.0	200.0	200.06	0.02	0.00	0.00	0.05	0.00	0.00
3 F	PM2.5	0.1	NO	100.0	125.0	160.08						
5 A	PM2.5	0.0	0.1	12.0	200.0	200.36	1.20	0.00	0.00	0.46	0.05	0.21
5 C	PM2.5	0.0	0.0	7.0	200.0	200.12	0.01	0.00	0.00	-0.04	0.00	0.00
5 E	PM2.5	0.2	0.3	50.0	200.0	206.16	19.14	0.01	0.01	1.35	0.74	2.36
Total		**27.3**	**13.4**				**1 022.38**					**91.22**
Total Uncertainties						Uncertainty in total inventory %:	**31.97**				Trend uncertainty %:	**9.55**

1.8 Completeness

The emission data presented in this report were compiled according to the 2023 CLRTAP Reporting Guidelines, adopted by the Executive Body for the UNECE/LRTAP Convention at its 42nd session.

The inventory is complete with regard to reported gases, reported years and reported emissions from all sources, and also complete in terms of geographic coverage.

Geographic Coverage

The geographic coverage is complete. There is no territory in Austria not covered by the inventory.

However, if fuel prices vary considerably in neighbouring countries, fuel sold within the territory of a Party is used outside its territory (so-called 'fuel export'). Austria has experienced a considerable amount of 'fuel export' in the last few years (see also Chapter 2.5).

According to the new 2023 Reporting Guidelines, Parties within the EMEP region should calculate and report emissions, consistent with national energy balances reported to Eurostat or the International Energy Agency (IEA). Emissions from road vehicle transport should therefore be calculated and reported on the basis of the fuel sold. In addition, Parties may voluntarily report emissions from road vehicles based on fuel used in the geographic area of the Party.

Emissions of the Austrian road transport sector are therefore generally reported on the basis of fuel sold. In previous submissions, with respect to compliance with the 2010 emission ceilings under Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants, emissions are accounted on the basis of 'fuel used'. The Austrian NEC Totals therefore differed from the LRTAP Totals for the target period 2010–2019. Emissions on the basis of fuel used are also presented in this report (see Appendix, Chapter 12.2).

In contrast to the absolute emission ceilings for the years 2010 to 2019, which applied until the reporting year 2021, the NEC targets from 2020 onwards are set as relative values compared to base year values. The base year for the calculations of the emission reduction commitments is 2005. While the target comparison for the years 2010 to 2019 was based on emissions without exports of fuels, Austria's total emissions calculated on the basis of the volume of fuel sold will now be taken into account for the current target period 2020–2029. This is justified in the inventory reporting guidelines[68].

Gases, Reporting Years

In accordance with the Austrian obligation, all relevant pollutants mentioned in Table 3 (minimum reporting programme), are covered by the Austrian inventory and are reported for the years 1990–2022 for the main pollutants, from 1990 onwards for POPs and HMs and for the years 1990, 1995 and from 2000 onwards for PM.

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[68] 2023 Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution. These guidelines are also applicable under the NEC Directive.

In submission 2020 Austria reported for the first time all pollutants in the NFR19 reporting format from 1990 to the latest inventory year. Emissions of the years before 1990 were last updated and published in submission 2014[69].

In response to a recommendation of the NEC Review 2020 (EC, 2020) Austria reports benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene emissions for all sectors across all years from submission 2021 onwards.

Notation Keys

Notation keys are used according to the 2023 Reporting Guidelines (see Table 42) to indicate where emissions are not occurring in Austria, where emissions have not been estimated or have been included elsewhere as suggested by EMEP/EEA Emission Inventory Guidebook 2023.

Table 42: Notation keys used in the NFR.

Abbreviation	Meaning	Objective
NA	not applicable	is used for activities in a given source category which are believed not to result in significant emissions of a specific compound;
NE	not estimated	for activity data and/or emissions by sources of pollutants which have not been estimated but for which a corresponding activity may occur within a Party. Where NE is used in an inventory to report emissions of pollutants, the Party should indicate in the IIR why such emissions have not been estimated. Furthermore, a Party may consider that a disproportionate amount of effort would be required to collect data for a pollutant from a specific category that would be insignificant in terms of the overall level and trend in national emissions and in such cases use the notation key NE. The Party should in the IIR provide justifications for their use of NE notation keys, e.g., lack of robust data, lack of methodology etc. Once emissions from a specific category have been reported in a previous submission, emissions from this specific category should be reported in subsequent inventory submissions;
IE	included elsewhere	for emissions by sources of pollutants estimated but included elsewhere in the inventory instead of under the expected source category. Where IE is used in an inventory, the Party should indicate, in the IIR, where in the inventory the emissions for the displaced source category have been included, and the Party should explain such a deviation from the inclusion under the expected category, especially if it is due to confidentiality;
C	confidential	(confidential information), for emissions by sources of pollutants of which the reporting could lead to the disclosure of confidential information. The source category where these emissions are included should be indicated;
NO	not occurring	for categories or processes within a particular source category that do not occur within a Party;
NR	not relevant	according to paragraph 37 in the Guidelines, emission inventory reporting for the main pollutants should cover all years from 1990 onwards if data are available. However, NR is introduced to ease the reporting where reporting of emissions is not strictly required by the different protocols, e.g., emissions for some Parties prior to agreed base years.

[69] Austria´s submission 2014 under the Convention on Long-range Transboundary Air Pollution covering the years 1980–2012: https://cdr.eionet.europa.eu/at/un/CLRTAP_AT/envuvyara/

Assessment of transparency and completeness

In the Austrian QMS a transparency and completeness index is used to quantify the quality of the inventory, calculated as follows:

*Transparency [%] = [1 – (number of IE/number of estimates)]*100*

*Completeness [%] = [1 – (number of NE/number of estimates)]*100*

The total number of data records (emission data) are counted as well as the numbers reported as 'not estimated' and 'included elsewhere'. Then the share of 'NE' and 'IE' to total data records are determined.

The result of this years' analysis is shown in Table 43. As can be seen the completeness parameter is very high. For PAHs the lowest completeness was investigated, which is due to not estimated PAH emissions from sectors *Transport* (international and domestic aviation), *Industrial Processes and Product Use* (Chemical Industry: other[70], Ferroalloys Production, Aluminium Production, Copper Production, Other Metal Production) and *Waste* (Other Waste).

The transparency analysis for the reporting year 2022 shows also a high transparency of the Austrian inventory. For SO_2 the largest number of 'IE' has been identified, which was applied for eleven sub-categories. Explanations are provided in the respective sector chapters on 'Completeness'.

Table 43: Transparency and completeness in submission 2024.

Pollutants	Submission 2024			
	IE	NE	Transparency	Completeness
NO_x (as NO_2)	10	1	92%	99%
NMVOC	10	4	92%	97%
SO_x (as SO_2)	11	2	91%	98%
NH_3	10	0	92%	100%
$PM_{2.5}$	8	3	94%	98%
PM_{10}	8	3	94%	98%
TSP	8	3	94%	98%
CO	8	3	94%	98%
Pb	7	2	94%	98%
Cd	7	2	94%	98%
Hg	7	3	94%	98%
PCDD/PCDF	7	4	94%	97%
PAHs (total)	7	8	94%	94%
benzo(a) pyrene	7	8	94%	94%
benzo(b) fluoranthene	7	8	94%	94%
benzo(k) fluoranthene	7	9	94%	93%
Indeno (1,2,3-cd) pyrene	7	7	94%	94%
HCB	7	4	94%	97%
PCBs	7	1	94%	99%

[70] PAH emissions from graphite production (production of graphite electrodes only) are not estimated, as no emission factor is available.

2 EXPLANATIONS OF KEY TRENDS

This chapter describes the trends and the drivers of air pollutant emissions, which Austria is obliged to report based on the following listed protocols. Additionally information on fuel exports are described in chapter 2.5.

From submission 2019 onwards Austria reports all mandatory pollutants in the NFR19 reporting format from 1990 to the latest inventory year. Emissions of the years before 1990 were last updated and published in submission 2014[71]. From submission 2021 onwards the individual PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene) were reported for the first time for all sectors as recommended in the NEC Review 2020 (EC 2020).

1985 Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes: This protocol requires parties to reduce their sulphur emissions by at least 30%. All parties achieved this reduction target by the target year 1993. In 2022, Austria's SO_2 emissions were 85% lower than in 1990.

1988 Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes: This Protocol requires as a first step, to freeze emissions of nitrogen oxides or their transboundary fluxes. The general reference year is 1987. The second step to the NO_x Protocol requires the application of an effects-based approach to further reduce emissions of nitrogen compounds. Nineteen of the 25 Parties to the 1988 NO_x Protocol have reached the target and stabilized emissions at 1987[72] levels or reduced emissions below that level according to the latest emission data reported. Austria was successful in fulfilling the stabilisation target set out in the Protocol. Since 2003–2005, when emissions reached an all-time high due to a considerable increase of fuel export and the failure of European provisions for the reduction of vehicle emissions, NO_x emissions are decreasing.

1991 Geneva Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes: This Protocol specifies three options for emission reduction targets that have to be chosen upon signature or upon ratification. Austria chose the option, which requires a 30% reduction of VOCs by 1999 using a base year between 1984 and 1990 and chose 1988 as base year. Austria met the reduction target.

1998 Aarhus Protocol on Heavy Metals: It targets three particularly harmful metals: cadmium, lead and mercury. According to one of the basic obligations, Parties have to reduce their emissions for these three metals below their levels in the reference year. Austria has chosen 1985 as the reference year and current emissions are well below the level of the reference year.

1998 Aarhus Protocol on Persistent Organic Pollutants (POPs): The protocol focuses on a list of 16 substances that were singled out according to agreed risk criteria. These 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. Parties have to reduce their emissions for PAHs, Dioxins/Furans and HCB below their levels in the reference year. Austria has chosen 1985 as the reference year and current emissions are well below the level of the reference year.

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[71] Austria´s submission 2014 under the Convention on Long-range Transboundary Air Pollution covering the years 1980–2012: https://cdr.eionet.europa.eu/at/un/CLRTAP_AT/envuvyara/

[72] or in the case of the United States 1978

1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone "Multi-Effect Protocol": The Protocol sets emission ceilings for 2010 for four pollutants: sulphur, NO_x, VOCs and ammonia. In May 2012 the protocol was amended to include national emission reduction commitments to be achieved in 2020 and beyond. Austria has not ratified the Protocol and is not Party to the Protocol, but reports the concerned emissions.

2.1 Emission Trends for Air Pollutants covered by the Multi-Effect Protocol as well as CO

National total emissions and trends (1990–2022) for air pollutants covered by the Multi-Effect Protocol are shown in Table 44 Please note that emissions from mobile sources are calculated based on fuel sold in Austria, thus national total emissions include 'fuel export'. Information on fuel export are presented in chapter 2.5.

Table 44: National total emissions and trends 1990–2022 for air pollutants covered by the Multi-Effect Protocol and CO.

Year	Emission [kt]				
	SO_2	NO_x	NMVOC	NH_3	CO
1990	73.70	216.19	328.77	74.09	1248.24
1995	47.31	199.39	244.38	72.10	972.94
2000	31.52	212.65	177.23	68.05	727.65
2005	25.89	247.83	154.07	66.01	625.00
2010	15.98	206.00	134.75	68.43	579.35
2011	15.17	198.08	130.01	68.14	562.44
2012	14.79	193.32	127.74	68.45	562.00
2013	14.35	193.75	121.98	68.31	565.80
2014	14.52	186.70	115.35	69.16	530.60
2015	14.10	184.03	111.68	70.12	541.34
2016	13.26	176.41	110.31	71.15	535.80
2017	12.79	167.27	110.70	71.70	525.96
2018	11.58	155.00	106.94	70.42	484.39
2019	11.17	145.81	106.69	69.13	497.21
2020	10.41	124.41	107.93	68.73	472.72
2021	10.88	123.21	108.05	69.15	537.39
2022	10.78	114.44	100.04	67.99	480.62
Trend 1990–2022	**-85%**	**-47%**	**-70%**	**-8.2%**	**-61%**

2.1.1 SO_2 Emissions

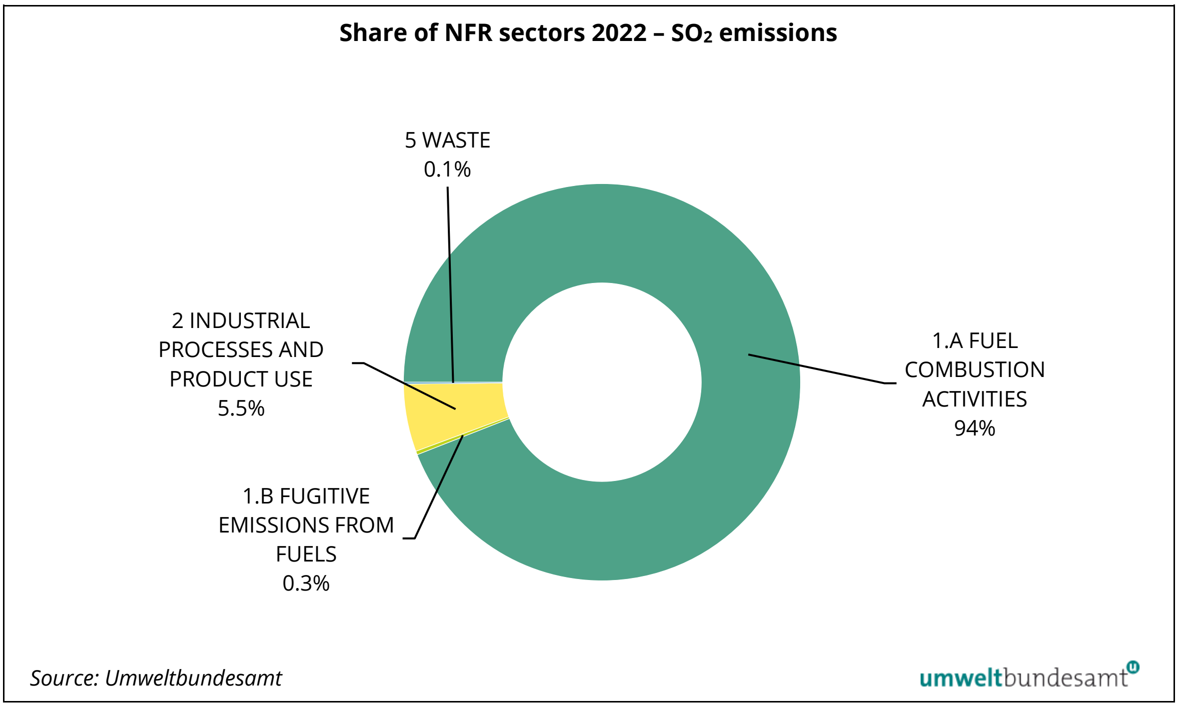
In 1990, national total SO_2 emissions amounted to 74 kt. Since then emissions have decreased quite steadily. In the year 2022, emissions were reduced by 85% compared to 1990 and amounted to 11 kt. This decline is mainly caused by a reduction of the sulphur content in mineral oil products and fuels (according to the Austrian Fuel Ordinance), the installation of desulphurisation units in plants (according to the Clean Air Act for boilers) and an increased use of low-sulphur fuels like natural gas. The strong reduction in emissions between 1991 and 1992 can be explained by a reduced consumption of coal in power plants (*1.A.1.a*) and a reduction of SO_2 emissions from oil fired power plants (*1.A.1.a*) as well as from iron and steel (*1.A.2.a*) and pulp and paper (1.*A.2.d*) production. The economic crisis in 2009 caused a decrease in emissions, followed by an increase due to the recovery of the economy. From 2021 to 2022, SO_2 emissions decreased by 0.9% (-0.1 kt) mainly because of other sectors (*1.A.4*, predominantly households). In the case of households (*1.A.4.b.1*), the reduction in the use of biomass (-20 %) and coal (-25 %) led to a significant decrease in emissions compared to the previous year. This is due to milder weather conditions and price changes on the energy market. This decline was partly offset by higher emissions from energy supply and increased production from industry, with only the paper industry showing a decline. SO_2 emissions from the paper industry (*1.A.2.d*) decreased by 20 % compared to 2021 due to lower production.

Main sources and emission trends in Austria

As shown in Figure 6 the main source of SO_2 emissions in Austria in 2022 is NFR sector *1.A Fuel Combustion Activities* with 94% in national total SO_2 emissions. Sector *2 Industrial Processes and Product Use* contributes with 5.5%.

NFR sectors *1.B Fugitive Emissions* and *5 Waste* are only minor contributors to national total SO_2 emissions in 2022 with 0.3% and 0.1%, respectively. No SO_2 emissions were emitted from *3 Agriculture* (“not occurring”).

Figure 6: Share of NFR sectors 2022 in SO_2 emissions.



NFR 1.A Fuel Combustion Activities

As shown in Table 45 the main source for SO_2 emissions in Austria, with a share of 95% in 1990 and 94% in 2022 is category *1.A Fuel Combustion Activities*. Within this source, the main contributors to total SO_2 emissions are *1.A.2 Manufacturing Industries ans Construction* with 70% (more than half of the emissions stem from iron and steel industry), *1.A.1 Energy Industries* with 11% and *1.A.4 Other Sectors* (residential heating) with 10%.

The constant decrease of emissions since 1990 from *1.A.1 Energy Industries*, *1.A.2 Manufacturing Industries and Construction*, *1.A.3 Transport* and *1.A.4 Other Sectors* (mainly residential heating) is mainly due to:

- a lowering of the sulphur content in mineral oil products and fuels (due to e.g. Fuel Ordinance[73]),
- a switch-over from high sulfur fuels to low-sulphur fuels or to even sulphur free fuel (e.g. natural gas) – sulphur-free fuels, such as those offered nationwide in Austria since 2006, are a precondition for the use of advanced exhaust gas after treatment technologies.
- implementation of desulphurisation units in power plants (due to e.g. LCP directive[74] and preceding national legislation),
- abatement techniques like combined flue gas treatment.

NFR 2 Industrial Processes and Product Use

The share in national total SO_2 emissions from NFR sector *2 Industrial Processes and Product Use* in 2022 is 5.5%. Within this source, SO_2 emissions result from *2.B Chemical Industry* (61%) and *2.C Metal Production* (38%). In both subcategories emissions have decreased since 1990 mainly caused by abatement techniques such as systems for purification of waste gases and desulfurization facilities.

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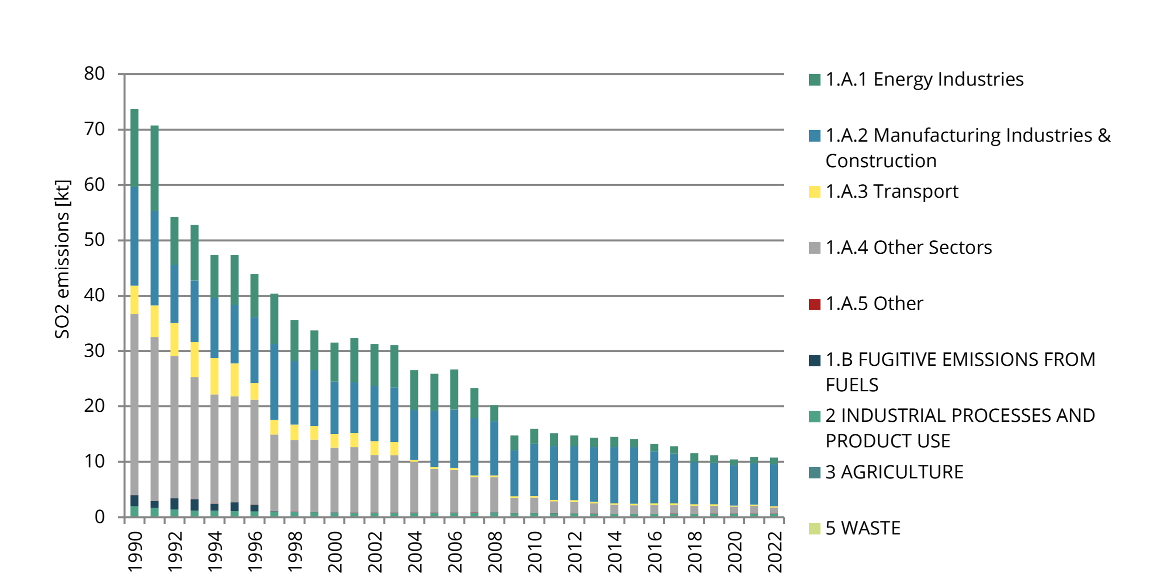
[73] BGBl_II_417-04_Kraftstoffverordnung; idF. BGBl. II Nr. 398/2012

[74] Luftreinhaltegesetz für Kesselanlagen (LRG-K) BGBl. I Nr. 127/2013 (older version: BGBl. Nr. 380/1988 idF. BGBl. Nr. 185/1993, BGBl. I Nr. 150/2004; Umsetzung der Richtlinie 96/61/EG; Richtlinie 96/82/EG, Richtlinie 88/609/EWG, Richtlinie 2001/80/EG, Richtlinie 2002/49/EG)

Figure 7: SO_2 emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 45: SO_2 emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		SO_2 Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1	ENERGY	71.69	10.17	-85.8%	-0.9%	97%	94%
1.A	FUEL COMBUSTION ACTIVITIES	69.69	10.14	-85.5%	-1.0%	95%	94%
1.A.1	Energy Industries	14.07	1.20	-91.4%	5.8%	19%	11%
1.A.1.a	Public Electricity and Heat Production	11.81	0.70	-94.0%	3.1%	16%	7%
1.A.1.b	Petroleum refining	2.25	0.50	-77.9%	10.0%	3%	5%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-40.3%	-8.1%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	17.83	7.58	-57.5%	1.5%	24%	70%
1.A.2.a	Iron and Steel	6.73	4.69	-30.3%	0.3%	9%	44%
1.A.2.b	Non-ferrous Metals	0.18	0.12	-33.4%	31.0%	<1%	1%
1.A.2.c	Chemicals	0.66	0.20	-69.3%	16.0%	1%	2%
1.A.2.d	Pulp, Paper and Print	4.30	0.40	-90.6%	-19.5%	6%	4%
1.A.2.e	Food Processing, Beverages and Tobacco	1.65	0.14	-91.6%	40.3%	2%	1%
1.A.2.f	Non-metallic Minerals	2.23	0.65	-70.9%	1.1%	3%	6%
1.A.2.g	Manufacturing Industries and Constr. other	2.08	1.37	-34.0%	7.4%	3%	13%
1.A.3	Transport	5.13	0.24	-95.4%	10.2%	7%	2%
1.A.3.a	Civil Aviation	0.04	0.08	92.7%	66.7%	<1%	1%
1.A.3.b	Road Transportation	4.77	0.12	-97.5%	-5.8%	6%	1%
1.A.3.c	Railways	0.26	0.03	-87.5%	-2.6%	<1%	<1%

NFR Category		SO_2 Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1.A.3.d	Navigation	0.05	0.00	-95.3%	-8.8%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	-81.6%	-57.1%	<1%	<1%
1.A.4	Other Sectors	32.66	1.12	-96.6%	-21.1%	44%	10%
1.A.4.a	Commercial/Institutional	4.95	0.04	-99.1%	-28.0%	7%	<1%
1.A.4.b	Residential	25.93	0.99	-96.2%	-21.0%	35%	9%
1.A.4.c	Agriculture/Forestry/Fisheries	1.78	0.08	-95.6%	-18.5%	2%	1%
1.A.5	Other	0.01	0.01	-42.2%	-1.9%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	2.00	0.03	-98.4%	6.7%	3%	<1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	1.93	0.59	-69.3%	0.2%	3%	6%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	1.56	0.37	-76.6%	0.0%	2%	3%
2.C	METAL PRODUCTION	0.36	0.23	-38.0%	-0.4%	<1%	2%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NA	NA	NA	NA	NA	NA
2.G	Other product manufacture and use	0.00	0.00	-27.2%	133.5%	<1%	<1%
2.H	Other Processes	NA	NA	NA	NA	NA	NA
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, transportation or handling of bulk products	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	0.00	NA	NA	NA	<1%	NA
5	WASTE	0.07	0.02	-79.5%	1.5%	<1%	<1%
	Total without sinks	**73.70**	**10.78**	**-85.4%**	**-0.9%**		

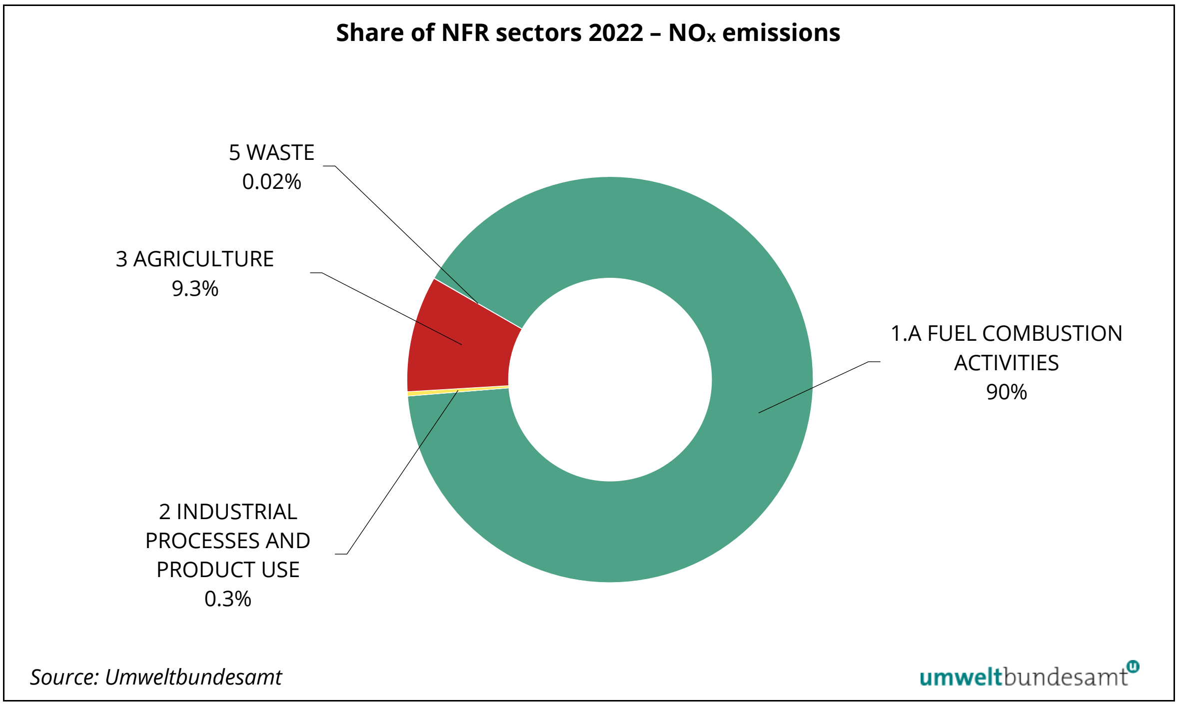
2.1.2 NO_x Emissions

In 1990, national total NO_x emissions amounted to 216 kt. After an all-time high of emissions between 2003 and 2005 emissions are decreasing continuously. This is mainly due to reduced emissions from heavy trucks, especially because of improvements in the after treatment technology. In 2022, NO_x emissions amounted to 114 kt and were about 47% lower than in 1990. From 2021 to 2022 emissions decreased by 7.1%. One of the reasons for this is the renewal of the fleet with low-emission vehicles in passenger car and truck traffic (*1.A.3.b*), which reduces the level of emissions despite an increase in mileage. NO_x emissions from fuel combustion of other sectors (*1.A.4*, predominantly households) fell significantly by 3.0 kt (and 15 %) compared to the previous year. This was due to the lower use of biomass, gas and oil, the milder weather and price changes on the energy market.

Main sources and emission trends in Austria

As can be seen in Figure 8 and Table 46, the main source for NO_x emissions in Austria with a share of 90% in 2022 is *1.A Fuel Combustion Activities.* Sector *3 Agriculture* contributes with 9.3%. NFR sectors *2 Industrial Processes and Product Use* and *5 Waste* are minor sources regarding NO_x emissions. These sectors contribute with 0.3% and 0.02% to national total NO_x emissions in 2022.

Figure 8: Share of NFR sectors 2022 in NO_x emissions.



Note: NO_x emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as IE.

NFR 1.A Fuel Combustion Activities

Within source category *1.A Fuel Combustion Activities*, *1.A.3.b Road Transportation*, with about 43% of national total emissions in 2022, is the main contributor to total NO_x emissions.

Please note that emissions from mobile sources are calculated based on fuel sold, which is higher than fuel used because of the high extent of fuel export in *1.A.3 Transport* since the 1990ies. For information on fuel export please refer to chapter 2.5.

The most important NO_x sources within NFR *1.A Fuel Combustion Activities* are:

- *NFR 1.A.3 Transport* – in particular diesel-powered passenger cars and heavy duty traffic. In passenger transport the number of diesel vehicles has rapidly increased since the 1990ies. Also mileage has increased in passenger and freight transport. While NMVOC and CO emissions from road transport have been reduced significantly since 1990 due to well-functioning after-treatment devices, NO_x emissions increased up to 2005. Since then NO_x emissions have shown a decreasing trend, which is due to a combination of several facts. First of all, NO_x emissions from gasoline passenger cars are declining and are negligible now; second, NO_x emissions from heavy duty vehicles have decreased significantly due to the above mentioned well-functioning after-treatment devices (SCR, EGR). Additionally, NO_x emissions from fuel export show a decreasing trend because of the rapid renewal rate of the transit fleet and the associated decrease in specific emissions per vehicle kilometre. From 2021 to 2022 emissions from *1.A.3 Transport* decreased by 8.1%. One of the reasons is the renewal of the fleet with low-emission vehicles in passenger car and truck traffic (1.A.3.b), which reduces the level of emissions (-5.4 kt) despite an increase in mileage.

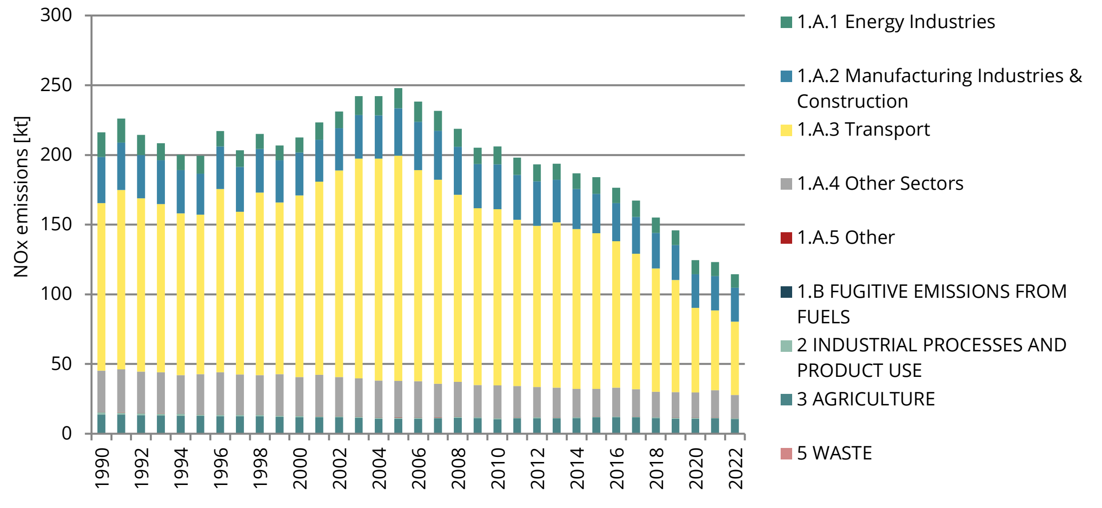
- Although energy consumption (especially biomass) increased significantly, NO_X emissions from *NFR 1.A.2 Manufacturing Industries and Construction* decreased compared to 1990 (-26%), mainly caused by increased efficiency, implementation/installation of denitrification installations (SCR/SNCR) and/or low-NO_x burners, introduction of modern fuel technology, gas-fired equipment and furnaces.
- NFR *1.A.4 Other Sectors* (mainly residential heating): NO_x emissions decreased steadily between 1990 and 2022 (-44%) mainly due to increased efficiency and modern fuel technology. From 2021 to 2022, NO_x emissions of this source category decreased by 15% because of the lower use of biomass, gas and oil, the milder weather and price changes on the energy market compared to the previous year.

NFR 3 Agriculture

Besides the main NO_x emitter NFR sector *1.A Fuel Combustion Activities,* sector *3 Agriculture* is also a source of NO_x emissions in Austria, although to a much lesser extent. It is responsible for 9.3% of national total NO_x emissions in Austria in 2022. Within the Agriculture sector, source category 3.*D Agricultural Soils* is the biggest contributor with 95% in 2022. Emissions mainly result from the application of N-fertilizers and organic waste (largely animal manure) on agricultural soils.

Since 1990 the agricultural NO_x emissions decreased by 22%, mainly influenced by livestock numbers and N-fertilizer consumption. Compared to the previous year emissions in 2022 decreased by 4.0%.

Figure 9: NO_x emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 46: NO_x emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		NO_x Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1	ENERGY	200.87	103.42	-48.5%	-7.4%	93%	90%
1.A	FUEL COMBUSTION ACTIVITIES	200.87	103.42	-48.5%	-7.4%	93%	90%
1.A.1	Energy Industries	17.78	9.66	-45.7%	-4.1%	8%	8%
1.A.1.a	Public Electricity and Heat Production	12.09	7.73	-36.1%	-3.0%	6%	7%
1.A.1.b	Petroleum refining	4.32	1.00	-76.8%	-8.1%	2%	1%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	1.37	0.93	-32.3%	-8.1%	1%	1%
1.A.2	Manufacturing Industries and Construction	33.04	24.45	-26.0%	-1.1%	15%	21%
1.A.2.a	Iron and Steel	5.41	3.86	-28.8%	0.4%	3%	3%
1.A.2.b	Non-ferrous Metals	0.25	0.25	-2.4%	4.9%	<1%	<1%
1.A.2.c	Chemicals	1.69	1.32	-22.3%	-7.8%	1%	1%
1.A.2.d	Pulp, Paper and Print	7.17	4.27	-40.5%	1.5%	3%	4%
1.A.2.e	Food Processing, Beverages & Tobacco	1.74	0.79	-54.5%	18.5%	1%	1%
1.A.2.f	Non-metallic Minerals	9.99	5.45	-45.5%	-6.6%	5%	5%
1.A.2.g	Manufacturing Industries and Constr. - other	6.77	8.52	26.0%	0.2%	3%	7%
1.A.3	Transport	120.14	52.63	-56.2%	-8.1%	56%	46%
1.A.3.a	Civil Aviation	0.37	1.34	266.4%	64.1%	<1%	1%
1.A.3.b	Road Transportation	116.13	49.35	-57.5%	-9.9%	54%	43%
1.A.3.c	Railways	1.82	0.57	-68.4%	-3.2%	1%	1%
1.A.3.d	Navigation	1.15	1.25	9.3%	43.9%	1%	1%
1.A.3.e	Other transportation	0.68	0.10	-84.8%	-51.4%	<1%	<1%
1.A.4	Other Sectors	29.81	16.63	-44.2%	-15.1%	14%	15%
1.A.4.a	Commercial/Institutional	3.09	1.01	-67.5%	-20.6%	1%	1%
1.A.4.b	Residential	16.23	9.77	-39.8%	-18.7%	8%	9%
1.A.4.c	Agriculture/Forestry/Fisheries	10.49	5.85	-44.2%	-7.1%	5%	5%
1.A.5	Other	0.10	0.05	-51.7%	-2.9%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	IE	IE	IE	IE	IE	IE
2	INDUSTRIAL PROCESSES /PRODUCT USE	1.53	0.40	-73.9%	-13.7%	1%	<1%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	1.33	0.27	-79.5%	-18.5%	1%	<1%
2.C	METAL PRODUCTION	0.17	0.10	-39.9%	-0.9%	<1%	<1%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NA	NA	NA	NA	NA	NA
2.G	Other product manufacture and use	0.03	0.02	-22.8%	-2.7%	<1%	<1%
2.H	Other Processes	NA	NA	NA	NA	NA	NA
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	13.66	10.59	-22.5%	-4.0%	6%	9%
3.B	MANURE MANAGEMENT	0.67	0.58	-13.2%	-0.5%	<1%	1%
3.D	AGRICULTURAL SOILS	12.97	10.01	-22.8%	-4.2%	6%	9%
3.F	FIELD BURNING OF AGRICULTURAL RESIDUES	0.03	NO	NO	NO	<1%	NO
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.12	0.03	-77.9%	2.3%	<1%	<1%
	Total without sinks	**216.19**	**114.44**	**-47.1%**	**-7.1%**		

2.1.3 NMVOC Emissions

In 1990, national total NMVOC emissions amounted to 329 kt. Emissions have decreased steadily since then and in the year 2022 emissions were reduced by 70% to 100 kt compared to 1990. From 2021 to 2022, NMVOC emissions decreased by 8.0 kt (-7.4%).

The largest reductions since 1990 have been achieved in the road transport sector due to an increased use of catalytic converters and diesel cars. Currently the road transport sector (*1.A.3.b.*) accounts only for a small share (3.5%) of Austria's total NMVOC emissions. Compared to the previous year, the emission reduction was mainly due to the decline in the use of biomass (-20 %) from residential heating as a result of the milder weather and price changes on the energy market and lower emissions from industrial paint application.

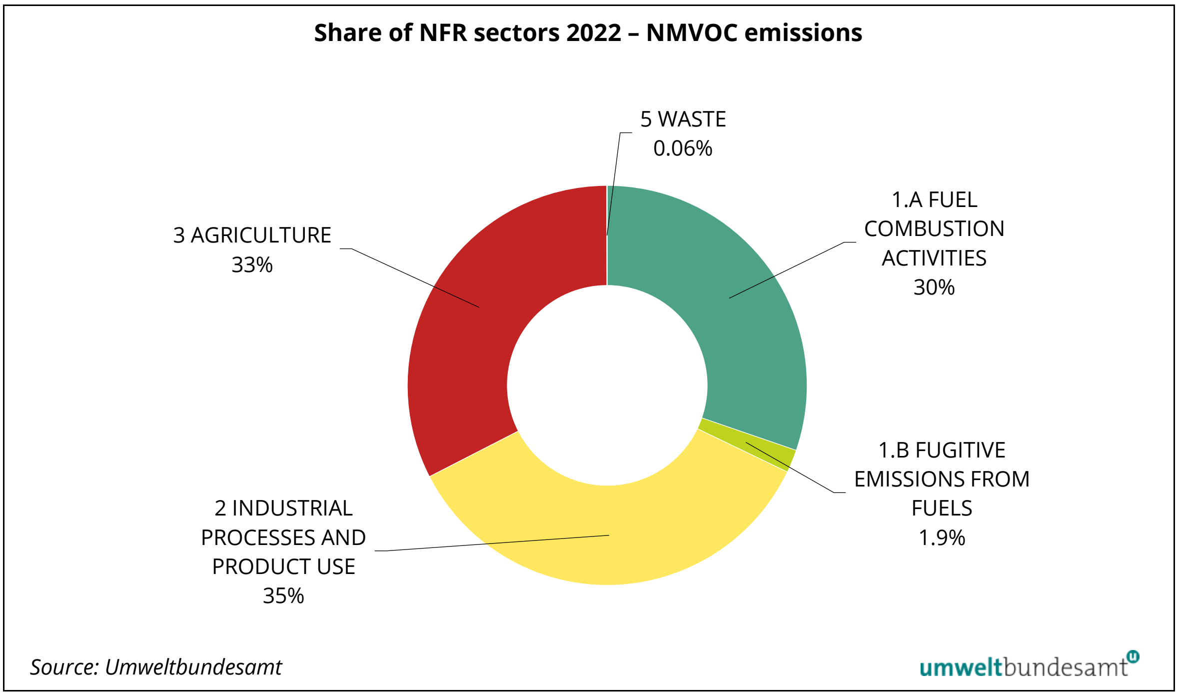
Reductions in the solvent sector (*2.D.3*) have been achieved due to the Solvent Ordinance and the VOC Installation Ordinance.

Main sources and emission trends in Austria

As can be seen in Figure 10 and Table 47, the main sources of NMVOC emissions in 2022 in Austria are NFR sectors *2 Industrial Processes and Product Use* with a share of 35% in national total emissions as well as *3 Agriculture and 1.A Fuel Combustion Activities,* with a contribution of 32% and 30%, respectively.

NMVOC emissions resulting from NFR sectors *1.B Fugitive Emissions* and *5 Waste* are minor sources contributing to national total NMVOC emissions with 1.9% and 0.06%, respectively.

Figure 10: Share of NFR sectors 2022 in NMVOC emissions.



NFR 2 Industrial Processes and Product Use

The main source of NMVOC emissions within sector *2 Industrial Processes and Product Use* is NFR *2.D.3 Solvent Use* (31% of the national total).

The overall reduction in sector *Solvent Use* is due to a combination of primary measures such as substitution, using products with lower solvent content and secondary measures such as exhaust gas collection and after treatment.

- *NFR 2.D.3.a Domestic Solvent use including fungicides:* products domestically used that are relevant regarding their solvent contents mainly are cleaning agents (particularly for glass and windsheelds) and cosmetics (particularly perfumes and deodorants). Domestic use of products containing solvents - apart from the solvent content in paints that is limited by the EU Paints Directive – does not underly regulations targeting to reduce solvent emissions. (Statistical) data on product use and estimated solvent content are the basis for estimating emissions, it has to be considered that both parameters are associated with comparatively high uncertainties. Thus, interpretation of the trend is limited to very obvious developments, such as the sharp increase of disinfectants during the COVID 19 pandemic.
- *NFR 2.D.3.d Coating Application*: In absolute terms, half of the overall reduction in category 2.D.3 was accomplished in sub category *2.D.3.d Coating Applications*. High reductions were achieved in the 90s, the downward trend sustained also after that. This is a result of stringent enforcement of EU legistlation, both general primary measues such as reduction of solvents in paints placed on the markets, as well as secondary measures on installation level (see Chapter 4.5).
- Significant reductions ranging from 80% to 98% between 1990 and 2022 can also be noted in the other subcategories *NFR 2.D.3.e and 2.D.3.f Degreasing and Dry Cleaning, NFR 2.D.3.g Chemical Products, NFR 2.D.3.h Printing* and *NFR 2.D.3.i Other solvent use*: The emission reductions were achieved due to technical progress such as closed loop processes as well as use of substances with a lower solvent content as well as waste gas purification, which was i.a. driven by the enforced legal requirements.

NFR 3 Agriculture

Within NFR sector *3 Agriculture*, the largest part of NMVOC emissions stems from NFR subcategory *3.B Manure Management* (74%). Smaller amounts arise from NFR subcategory *3.D Agricultural Soils* (26%). In 2022, no emissions resulted from source category *3.F Field burning of agricultural* (“not occurring”).

- *NFR 3.B Manure Management*: The NMVOC emission trend is related to livestock numbers and feeding situation (silage and non-silage feeding) and shows a decrease of 18% between 1990 and 2022. Compared to the previous year, 2022 emissions increased slightly by 0.6%, due to the rising number of dairy cattle (+4.6%). Within this source category manure management of cattle has the highest contribution with 89%.
- *NFR 3.D Agricultural Soils*: Emissions arise from animal manure spread on agricultural soils (3.D.a.2.a), grazing animals (3.D.a.3) and cultivated crops (3.D.e). The falling emission trend since 1990 by 44% is mainly driven by the reduced livestock numbers resulting in smaller amounts of manure that is applied to agricultural soils.

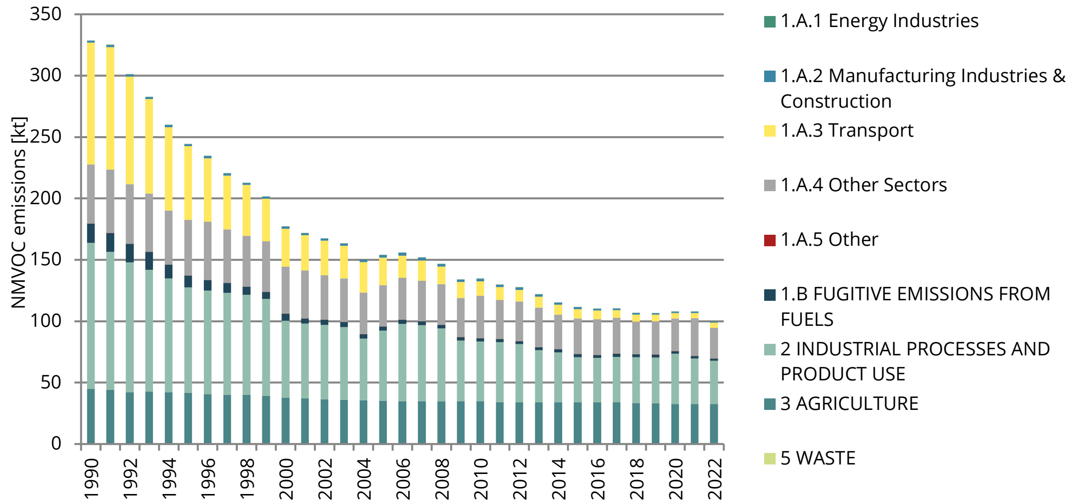
NFR 1.A Fuel Combustion Activities

NMVOC emissions from *1.A Fuel Combustion Activities* contribute with 30% to the national total. Within sector *1.A Fuel Combustion Activities* the main emitters in 2022 are *1.A.4 Other Sectors* (25% of the national total, mainly residential heating) and *1.A.3 Transport* (4.2% of the national total).

In source category *1.A Fuel Combustion Activities*, NMVOC emissions decreased notably in both main categories since 1990:

- *NFR 1.A.4 Other Sectors*: NMVOC emissions from this sector decreased by 49% since 1990 mainly due to the strong decrease in coal consumption but also due to improved biomass heating in households. Compared to the previous year emissions from this source category decreased by 19% in 2022 due to a considerably lower level of biomass used for residential stationary heating (*1.A.4.b.i*) because of milder weather and price changes on the energy market.
- *NFR 1.A.3 Transport*: The introduction of more stringent emission standards for passenger cars according to the state-of-art (regulated catalytic converter) and the increased use of diesel vehicles in the passenger car sector are drivers for the decreasing trend since 1990 of NMVOC emissions (-96%). Compared with 2021, emissions in 2022 were lower by 2.3%. The main reductions in absolute numbers came from passenger cars diesel and heavy duty vehicles, which show improved specific exhaust emissions per kilometer on a year to year basis.

Figure 11: NMVOC emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 47: NMVOC emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		**NMVOC Emission in [kt]**		**Trend**		**Share in National Total**	
		1990	**2022**	**1990–2022**	**2021–2022**	**1990**	**2022**
1	ENERGY	164.98	32.15	-80.5%	-16.2%	50%	32%
1.A	FUEL COMBUSTION ACTIVITIES	149.38	30.28	-79.7%	-16.7%	45%	30%
1.A.1	Energy Industries	0.32	0.31	-1.7%	0.7%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	1.68	0.97	-42.2%	1.3%	1%	1%
1.A.3	Transport	98.94	4.18	-95.8%	-2.3%	30%	4%
1.A.3.a	Civil Aviation	0.20	0.17	-18.4%	23.8%	<1%	<1%
1.A.3.b	Road Transportation	97.42	3.47	-96.4%	-6.8%	30%	3%
1.A.3.c	Railways	0.37	0.06	-84.5%	-3.1%	<1%	<1%

NFR Category		NMVOC Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1.A.3.d	Navigation	0.94	0.49	-48.1%	34.2%	<1%	<1%
1.A.3.e	Other transportation	0.02	0.00	-90.4%	-47.9%	<1%	<1%
1.A.4	Other Sectors	48.43	24.81	-48.8%	-19.4%	15%	25%
1.A.4.a	Commercial/Institutional	1.32	0.55	-58.4%	-22.8%	<1%	1%
1.A.4.b	Residential	41.58	21.88	-47.4%	-20.0%	13%	22%
1.A.4.c	Agriculture/Forestry/Fisheries	5.53	2.39	-56.8%	-12.5%	2%	2%
1.A.5	Other	0.02	0.01	-53.4%	-2.4%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	15.59	1.86	-88.0%	-7.5%	5%	2%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	118.97	35.34	-70.3%	-4.7%	36%	35%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	1.62	0.34	-78.9%	20.6%	<1%	<1%
2.C	METAL PRODUCTION	0.51	0.42	-18.7%	-0.3%	<1%	<1%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	114.52	31.38	-72.6%	-5.4%	35%	31%
2.D.3	Solvent use	114.52	31.38	-72.6%	-5.4%	35%	31%
2.D.3.a	Domestic solvent use including fungicides	16.30	17.11	5.0%	0.0%	5%	17%
2.D.3.b	Road paving with asphalt	0.09	0.11	23.7%	0.0%	<1%	<1%
2.D.3.c	Asphalt roofing	0.00	0.00	17.3%	0.0%	<1%	<1%
2.D.3.d	Coating applications	45.79	7.77	-83.0%	-14.5%	14%	8%
2.D.3.e	Degreasing	13.26	2.70	-79.6%	-4.2%	4%	3%
2.D.3.f	Dry cleaning	0.44	0.01	-98.3%	-20.6%	<1%	<1%
2.D.3.g	Chemical products	12.79	2.00	-84.3%	-15.3%	4%	2%
2.D.3.h	Printing	12.65	0.69	-94.6%	13.7%	4%	1%
2.D.3.i	Other solvent use	13.20	0.98	-92.6%	-6.3%	4%	1%
2.G	Other product manufacture and use	0.08	0.06	-22.7%	-3.5%	<1%	<1%
2.H	Other Processes	2.23	3.14	40.8%	-0.5%	1%	3%
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	44.66	32.50	-27.2%	-0.2%	14%	32%
3.B	MANURE MANAGEMENT	29.20	23.94	-18.0%	0.6%	9%	24%
3.D	AGRICULTURAL SOILS	15.40	8.56	-44.4%	-2.1%	5%	9%
3.F	FIELD BURNING OF AGRICULTURAL RES.	0.06	NO	NO	NO	<1%	NO
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.17	0.06	-66.8%	-5.2%	<1%	<1%
	Total without sinks	**328.77**	**100.04**	**-69.6%**	**-7.4%**		

2.1.4 NH_3 Emissions

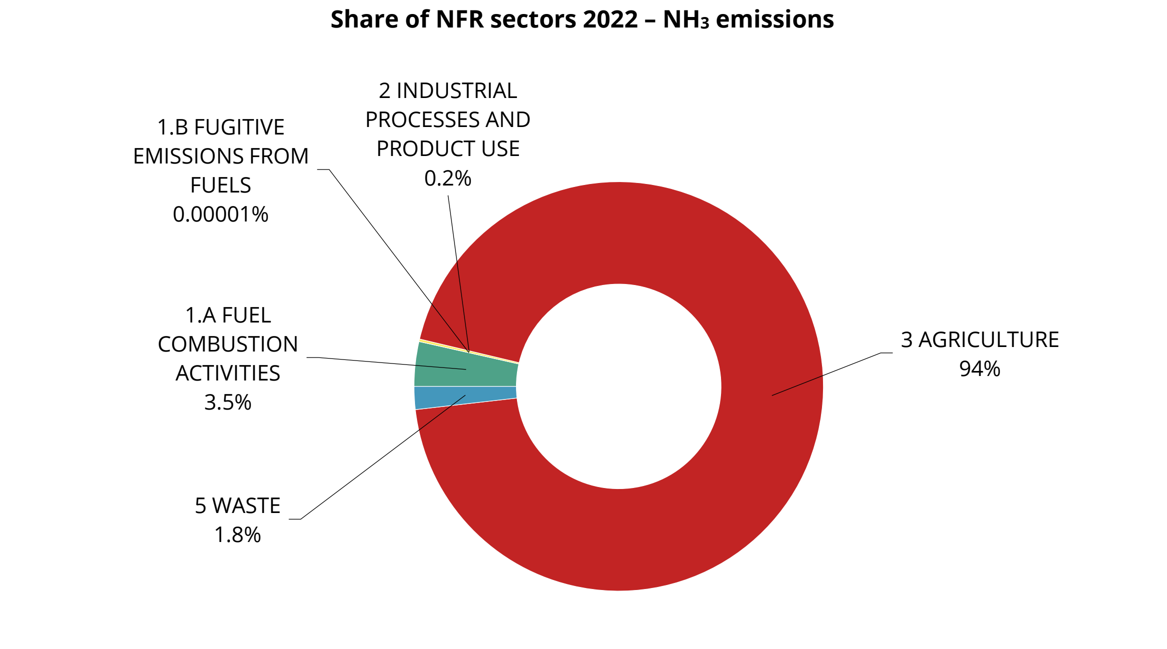
In 1990, national total NH_3 emissions amounted to 74 kt; emissions have decreased over the period from 1990 to 2022. In 2022, emissions were 8.2% under 1990 levels and amounted to 68 kt. NH_3 in Austria is almost exclusively emitted in the agricultural sector. The lower NH_3 emissions can be explained by decreasing cattle numbers, more efficient feeding and an increased application of low emission spreading techniques (e.g. band spreading, trailing shoe, rapid incorporation of manure). Compared to the previous year 2021, total emissions decreased by 1.2 kt (-1.7%). The main reason for this reduction were falling emissions from mineral fertilizer application as a result of lower sales volumes due to the significant increase in energy and raw material prices, which led to higher prices on the fertilizer market. Furthermore, ammonia emissions decreased due to reductions in manure spreading because of the increased use of band spreading techniques in Austria.

Main sources and emission trends in Austria

As it is illustrated in Figure 12 and in Table 48, NH_3 emissions in Austria are almost exclusively emitted by the agricultural sector. The share in national total NH_3 emissions is about 94% for 2022. Sector *1.A Fuel Combustion Activities* contributes with 3.5% in national total emissions.

NH_3 emissions resulting from NFR sectors *2 Industrial Processes and Product Use* and *5 Waste* are minor sources. These sectors contribute to national total NH_3 emissions in 2021 with 0.2% and 1.8%, respectively.

Figure 12: Share of NFR sectors 2022 in NH_3 emissions.



Source: Umweltbundesamt

NFR 3 Agriculture

In 1990 national NH_3 emissions from the sector *Agriculture* amounted to 71 kt. Since 1990, emissions from this sector have decreased by 10%. This reduction can be mainly explained by decreasing cattle numbers, more efficient feeding and an increased application of low emission spreading techniques (e.g. band spreading, trailing shoe, rapid incorporation of manure). Compared to the previous year, emissions decreased slightly in 2022 (-1.5%) as a result of lower mineral fertilizer application and increased band spreading (as described above).

- *NFR 3.B Manure Management* has a share of 47% in national total NH_3 emissions in 2022. The emissions result from animal husbandry and the storage of manure. Within this source category manure management of cattle has the highest contribution with 64%. Emissions are linked to livestock numbers but also to housing systems and manure treatment (e.g. NH_3 emissions from loose housing systems are considerable higher than those applied for tied systems). Since 1990 emissions from this sub sector are increasing by 6.7%, mainly due to higher emissions from cattle.

- *NFR 3.D Agricultural Soils* has a share of 48% in national total NH_3 emissions in 2022. These emissions result from fertilization with mineral N-fertilizers as well as organic fertilizers (including the application of animal manure, sewage sludge, energy crops and compost). Another source of NH_3 emissions is urine and dung deposited on pastures by grazing animals. Compared to the previous year, emissions in 2022 decreased by 2.7%.

NFR 1.A Fuel Combustion Activities

NH_3 emissions from *1.A Fuel Combustion Activities* are the second largest source category although it is only a small source of NH_3 emissions with a contribution to national total NH_3 emissions of 3.5% in 2022. NH_3 emissions from NFR sector *1.A* are increasing: in 1990, emissions amounted to about 2.0 kt. In the year 2022, they were about 22% higher than 1990 levels and amounted to about 2.4 kt. The rise is mainly due to an increase of biomass use in category *1.A.1.a Public Electricity and Heat.* Compared to the previous year, emissions in 2022 decreased by 4.3% mainly due to lower emissions from residential heating as a result of the reduced biomass consumption.

Figure 13: NH_3 emissions in Austria 1990–2022 by sectors in absolute terms.

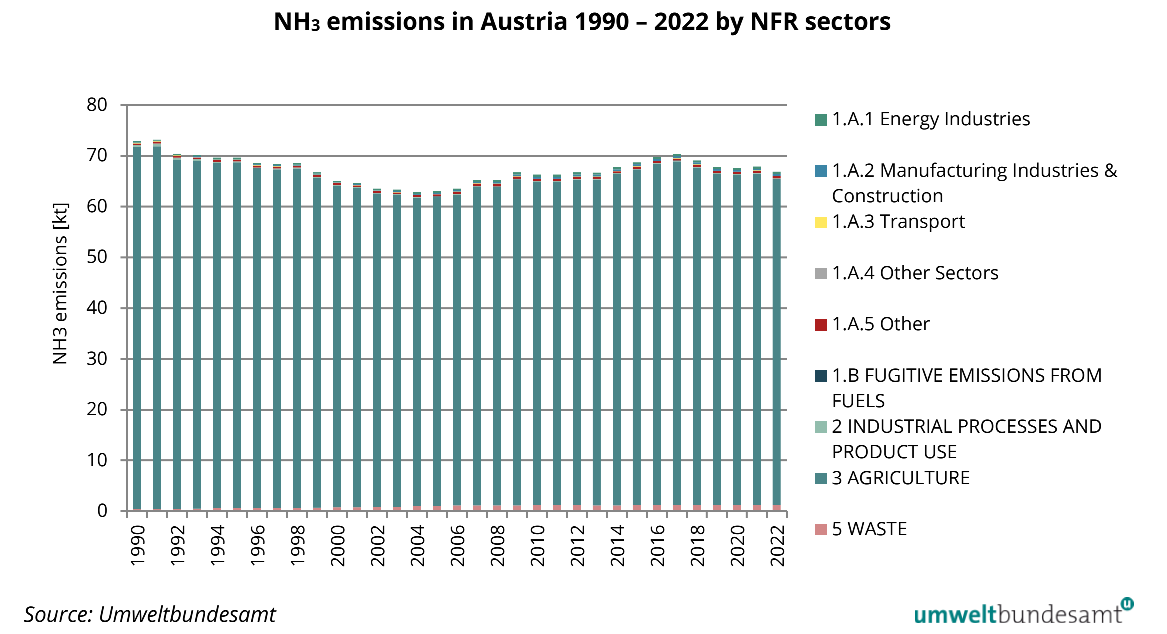


Table 48: NH_3 emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		NH_3 Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1	ENERGY	1.96	2.40	22.4%	-4.3%	3%	4%
1.A	FUEL COMBUSTION ACTIVITIES	1.96	2.40	22.3%	-4.3%	3%	4%
1.A.1	Energy Industries	0.20	0.43	119.2%	-3.0%	<1%	1%
1.A.2	Manufacturing Industries and Construction	0.33	0.43	30.1%	7.1%	<1%	1%
1.A.3	Transport	0.80	0.96	19.7%	1.0%	1%	1%
1.A.4	Other Sectors	0.63	0.57	-8.6%	-18.7%	1%	1%

NFR Category		NH_3 Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1.A.5	Other	0.00	0.00	-32.7%	-2.2%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	IE	0.00	IE	-93.0%	IE	<1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	0.34	0.13	-60.7%	-8.2%	<1%	<1%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.27	0.08	-71.2%	-11.4%	<1%	<1%
2.C	METAL PRODUCTION	IE	IE	IE	IE	IE	IE
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NA	NA	NA	NA	NA	NA
2.G	Other product manufacture and use	0.07	0.06	-22.1%	-3.3%	<1%	<1%
2.H	Other Processes	NA	NA	NA	NA	NA	NA
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	71.42	64.23	-10.1%	-1.5%	96%	94%
3.B	MANURE MANAGEMENT	29.66	31.64	6.7%	-0.3%	40%	47%
3.B.1	Cattle	16.01	20.15	25.9%	1.2%	22%	30%
3.B.2	Sheep	0.74	0.96	29.3%	-0.4%	1%	1%
3.B.3	Swine	9.97	5.67	-43.2%	-5.3%	13%	8%
3.B.4	Other livestock	2.94	4.86	65.2%	-0.1%	4%	7%
3.B.4.a	Buffalo	NO	NO	NO	NO	NO	NO
3.B.4.d	Goats	0.11	0.30	165.2%	-1.6%	<1%	<1%
3.B.4.e	Horses	0.65	1.72	164.2%	0.0%	1%	3%
3.B.4.f	Mules and asses	IE	IE	IE	IE	IE	IE
3.B.4.g	Poultry	2.15	2.81	30.7%	0.0%	3%	4%
3.B.4.h	Other animals	0.03	0.03	3.2%	0.0%	<1%	<1%
3.D	AGRICULTURAL SOILS	41.73	32.59	-21.9%	-2.7%	56%	48%
3.D.a	Direct Soil Emissions	41.73	32.59	-21.9%	-2.7%	56%	48%
3.D.b	Indirect emissions from managed soils	NO	NO	NO	NO	NO	NO
3.D.c	On-farm storage	NA	NA	NA	NA	NA	NA
3.D.d	Off-farm storage	NA	NA	NA	NA	NA	NA
3.D.e	Cultivated crops	NA	NA	NA	NA	NA	NA
3.D.f	Use of pesticides	NA	NA	NA	NA	NA	NA
3.F	FIELD BURNING OF AGRICULTURAL RES.	0.03	NO	NO	NO	<1%	NO
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.37	1.23	233.9%	-3.6%	<1%	2%
	Total without sinks	**74.09**	**67.99**	**-8.2%**	**-1.7%**		

2.1.5 Carbon monoxide (CO) Emissions

CO is a colourless and odourless gas, formed when carbon in fuel is not burned completely. It is a component of motor vehicle exhaust; other sources of CO emissions include industrial processes, non-transportation fuel combustion, and natural sources such as wildfires.

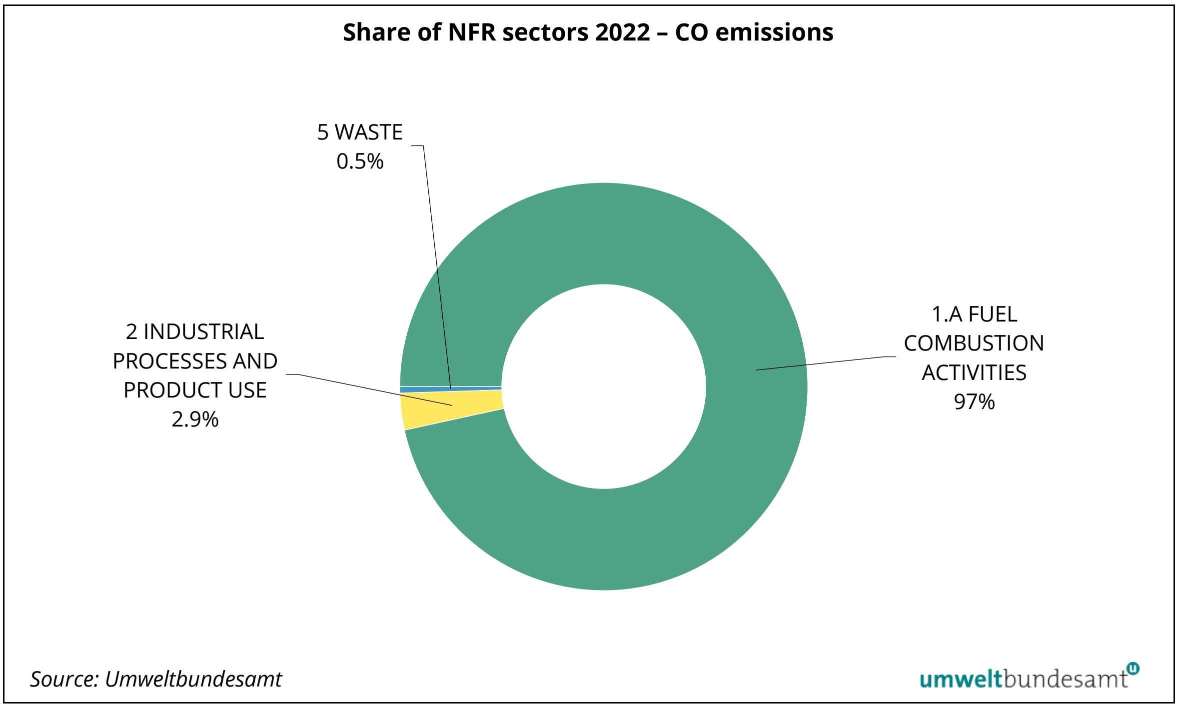
In 1990, national total CO emissions amounted to 1 248 kt. Emissions decreased considerably from 1990 to 2022. In 2022, emissions were 61% below 1990 levels and amounted to 481 kt. This reduction was mainly due to decreasing emissions from road transport (catalytic converters). The emissions decreased between 2021 and 2022 by 11%, mainly in the category *1.A.4.b.i Residential: stationary* as a consequence of the mild weather as well as changes of energy prices and the associated reduced use of biomass.

Main sources and emission trends in Austria

As can be seen in Figure 14 and Table 49, CO emissions in Austria are almost exclusively emitted by the Energy sector, and more specifically, *1.A.2.a Iron and steel* and *1.A.4.b.i Residential: stationary*. The share of *1.A Fuel combustion activities* in national total CO emissions is about 97% for 2022.

CO emissions resulting from NFR sectors *2 Industrial Processes and Product Use* and *5 Waste* are minor sources. These sectors contribute to national total CO emissions with 2.9% and 0.5%, respectively. In 2022, no CO emissions were emitted from *3 Agriculture* ("not occurring").

Figure 14: Share of NFR sectors 2022 in CO emissions.



Note: CO emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as IE.

NFR 1.A Fuel Combustion Activities

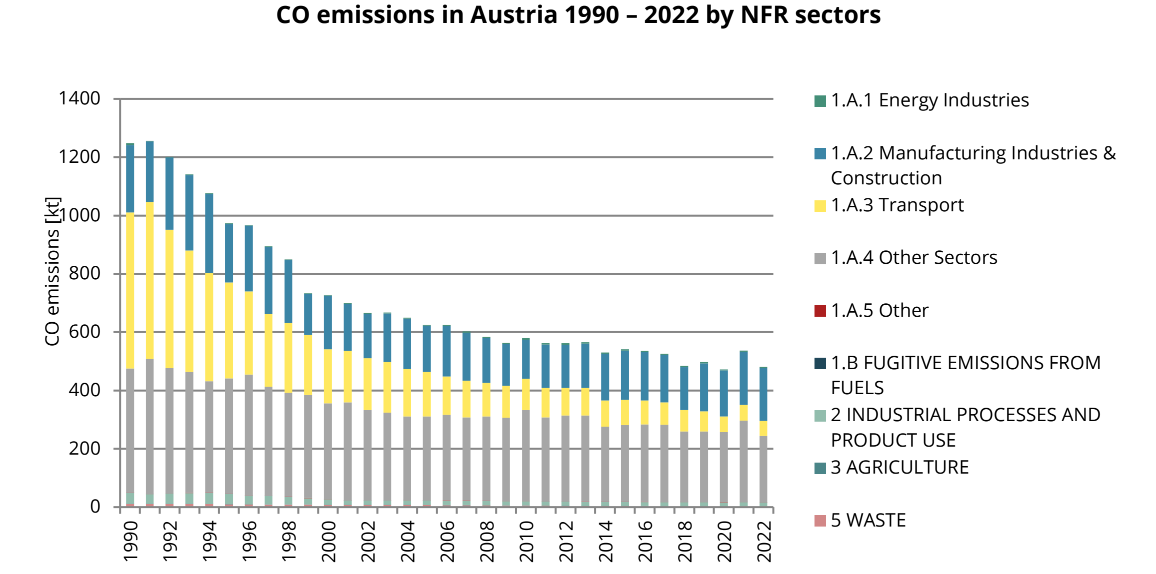
In the period 1990–2022 the share of CO emissions from *1.A Fuel Combustion Activities* in national total CO emissions has been quite stable in spite of growing activities because of considerable efforts regarding abatement techniques and improved combustion efficiency in all sub-sectors.

The main contributors of CO emissions within sector *1.A Fuel Combustion Activities* are:

- *NFR 1.A.4 Other Sectors:* CO emissions decreased since 1990 by 47% due to the switch-over to improved technologies and decreased use of coke. Between 2021 and 2022 emissions decreased by 19% mainly because of falling emissions from residential heating as a result of the decreased biomass consumption due to milder weather and price changes on the energy market.

- *NFR 1.A.2 Manufacturing Industries and Construction:* Compared to 1990 emissions decreased by 22%. The trend is dominated by fuel combustion from iron and steel industry. The emissions 2022 decreased by 1.2% compared to the previous year due to lower emissions from the sector iron and steel.
- *NFR 1.A.3 Transport:* The significant emission reduction of 90% from *1.A.3 Transport* compared to 1990 was mainly possible due to optimized combustion processes in the engine and the introduction of the catalytic converters. Compared to the previous year, emissions in 2022 decreased by 3.2% due to reductions in category *1.A.3.b.3 Heavy duty vehicles* due to improved exhaust emissions per vehice kilometer.

Figure 15: CO emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 49: CO emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		CO Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1	ENERGY	1199.50	464.15	-61.3%	-10.9%	96%	97%
1.A	FUEL COMBUSTION ACTIVITIES	1199.50	464.15	-61.3%	-10.9%	96%	97%
1.A.1	Energy Industries	6.10	4.49	-26.5%	-5.3%	<1%	1%
1.A.2	Manufacturing Industries and Construction	231.22	180.49	-21.9%	-1.2%	19%	38%
1.A.2.a	Iron and Steel	210.72	168.46	-20.1%	-1.2%	17%	35%
1.A.2.b	Non-ferrous Metals	0.05	0.05	8.0%	17.5%	<1%	<1%
1.A.2.c	Chemicals	0.46	0.45	-3.6%	14.9%	<1%	<1%
1.A.2.d	Pulp, Paper and Print	4.15	1.69	-59.3%	0.2%	<1%	<1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.20	0.15	-24.0%	43.9%	<1%	<1%
1.A.2.f	Non-metallic Minerals	11.03	3.90	-64.7%	-14.0%	1%	1%
1.A.2.g	Manufacturing Industries and Constr. - other	4.61	5.79	25.6%	7.4%	<1%	1%
1.A.3	Transport	535.16	51.75	-90.3%	-3.2%	43%	11%
1.A.3.a	Civil Aviation	2.56	3.13	22.2%	-0.9%	<1%	1%

NFR Category		CO Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1.A.3.b	Road Transportation	527.27	45.82	-91.3%	-3.8%	42%	10%
1.A.3.c	Railways	2.04	0.41	-80.1%	-2.2%	<1%	<1%
1.A.3.d	Navigation	3.12	2.36	-24.4%	8.6%	<1%	<1%
1.A.3.e	Other transportation	0.18	0.04	-77.9%	-63.6%	<1%	<1%
1.A.4	Other Sectors	426.78	227.26	-46.7%	-18.8%	34%	47%
1.A.4.a	Commercial/Institutional	11.42	3.79	-66.8%	-22.8%	1%	1%
1.A.4.b	Residential	382.21	206.81	-45.9%	-19.1%	31%	43%
1.A.4.c	Agriculture/Forestry/Fisheries	33.15	16.66	-49.7%	-12.6%	3%	3%
1.A.5	Other	0.25	0.16	-34.8%	-2.0%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	IE	IE	IE	IE	IE	IE
2	INDUSTRIAL PROCESSES AND PRODUCT USE	37.19	14.03	-62.3%	-0.3%	3%	3%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	12.67	11.09	-12.4%	0.1%	1%	2%
2.C	METAL PRODUCTION	23.32	1.90	-91.9%	-1.7%	2%	<1%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.27	0.31	17.3%	0.0%	<1%	<1%
2.G	Other product manufacture and use	0.94	0.73	-22.7%	-2.8%	<1%	<1%
2.H	Other Processes	NA	NA	NA	NA	NA	NA
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	0.95	NA	NA	NA	<1%	NA
3.B	MANURE MANAGEMENT	NA	NA	NA	NA	NA	NA
3.D	AGRICULTURAL SOILS	NA	NA	NA	NA	NA	NA
3.F	FIELD BURNING OF AGRICULT. RESIDUES	0.95	NO	NO	NO	<1%	NO
3.I	AGRICULTURE OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	10.59	2.43	-77.0%	-5.6%	1%	1%
5.A	SOLID WASTE DISPOSAL ON LAND	10.26	2.34	-77.2%	-5.8%	1%	<1%
5.B	BIOLOGICAL TREATMENT OF WASTE	NA	NA	NA	NA	NA	NA
5.C	INCINERATION/BURNING OF WASTE	0.33	0.09	-71.3%	0.9%	<1%	<1%
5.D	WASTEWATER TREATMENT	NA	NA	NA	NA	NA	NA
5.E	OTHER WASTE	NE	NE	NE	NE	NE	NE
	Total without sinks	**1248.24**	**480.62**	**-61.5%**	**-10.6%**		

2.2 Emission Trends for Particulate matter (PM)

Particulate matter (PM) is a complex mixture consisting of both directly emitted and secondarily formed components of both natural and anthropogenic origin (e.g. geological material, combustion by-products and biological material). It has an inhomogeneous composition of sulphate, nitrate, ammonium, organic carbon, heavy metals, PAH and dioxins/furans (PCDD/F). Anthropogenic PM is formed during industrial production and combustion processes as well as during mechanical processes such as abrasion of surface materials. In addition, PM originates from secondary formation from SO_2, NO_x, NMVOC or NH_3.

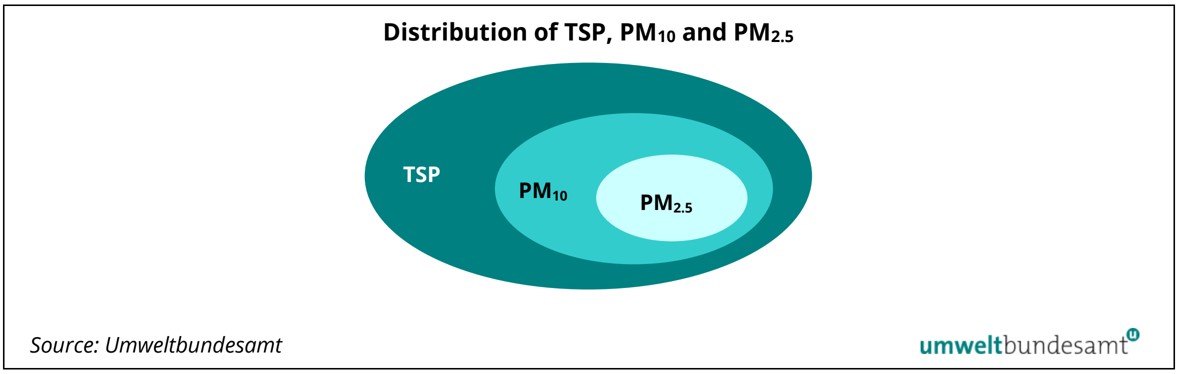
PM does not only have effects on the chemical composition and reactivity of the atmosphere but also affects human and animal health and welfare. When breathed in, a particle-loaded atmosphere impacts on the respiratory tract. The observable effects are dependent on the particle size, therefore for legislative issues particulate matter is classified according to its size (see Figure 16).

PM_{10} is the fraction of suspended particulate matter in the air with an aerodynamic diameter of less than 10 µm. These particles are small enough to be breathable and could be deposited in lungs, which may cause deteriorated lung functions.

The size fraction **$PM_{2.5}$** refers to particles with an aerodynamic diameter of less 2.5 µm. Studies link long-term exposure to $PM_{2.5}$ with cardiovascular and respiratory deaths, as well as increased sickness, such as childhood respiratory diseases. $PM_{2.5}$ also causes reductions in visibility and solar radiation due to enhanced scattering of light. Aerosol precursors such as ammonia (the source of which is mainly agriculture) form $PM_{2.5}$ as secondary particles through chemical reactions in the atmosphere.

Total suspended particulate matter (TSP) refers to the entire range of ambient air matter that can be collected from the sub-micron level up to 100 µm in aerodynamic diameter (d_{ae}). Particles with a d_{ae} larger than 100 µm will not remain suspended in the atmosphere for a significant length of time. Compared to PM_{10} and $PM_{2.5}$, TSP remains in the air for shorter periods and is therefore generally not carried over long distances. As a result, TSP pollution tends to be a local rather than a regional problem, occurring close to industrial sources, such as metal processing plants and mining operations, along roads because of the re-suspension, and close to stables and agricultural cropland.

Figure 16: Distribution of TSP, PM_{10} and $PM_{2.5}$ (schematic).

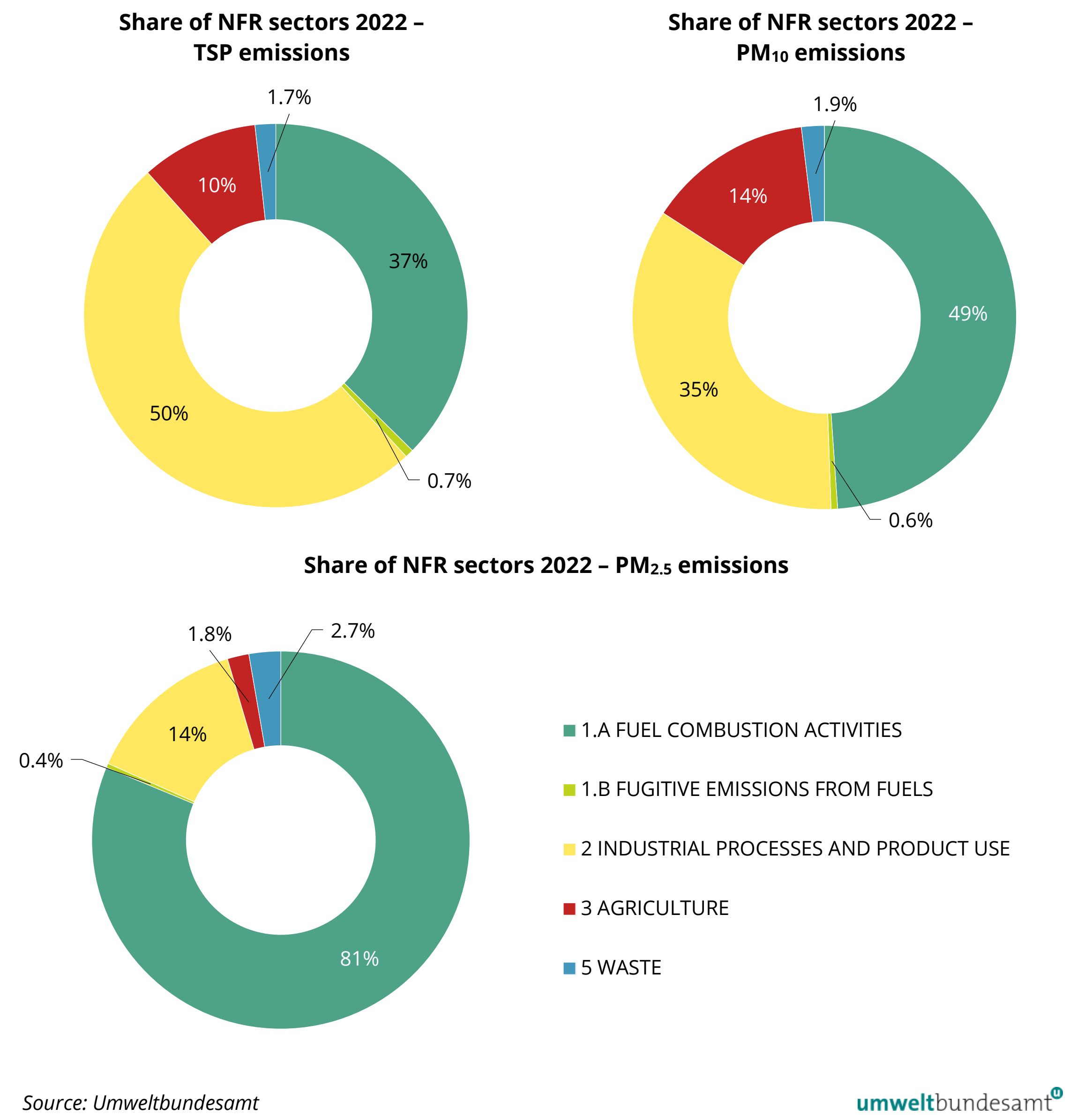


Main sources and emission trends in Austria

Particulate matter emissions in Austria mainly arise from *1.A Fuel Combustion Activities* (1.A.3 Road transport, 1.A.4 Other sectors – residential heating), *2 Industrial Processes and Product Use* and *3 Agriculture*. Where for TSP the most important source is the sector *2.A.5 Mining, construction/demolition and handling of products*, small heating installations are the highest contributor for $PM_{2,5}$ emissions.

NFR sectors *1.B Fugitive Emissions* and *5 Waste* are minor sources regarding PM emissions.

Figure 17: Share of NFR sectors 2022 in PM emissions (TSP, PM_{10} and $PM_{2.5}$).



Source: Umweltbundesamt

Table 50: National total emissions and emission trends for particulate matter (PM) 1990–2022.

Year	Emissions [kt]		
	TSP	PM_{10}	$PM_{2.5}$
1990	62.69	43.35	27.33
1995	61.45	41.88	25.94
2000	59.50	40.06	24.22
2005	59.27	39.10	23.42
2010	52.64	34.95	20.68
2011	50.91	33.59	19.50
2012	49.93	32.88	18.97
2013	49.15	32.20	18.35
2014	48.38	30.86	16.78

Year	Emissions [kt]		
	TSP	PM_{10}	$PM_{2.5}$
2015	48.40	30.79	16.68
2016	48.20	30.50	16.38
2017	49.11	30.73	16.22
2018	47.86	29.54	15.20
2019	48.39	29.43	14.94
2020	45.22	27.45	13.70
2021	48.33	29.36	14.88
2022	45.16	27.37	13.45
Trend 1990–2022	**-28%**	**-37%**	**-51%**

Particulate matter (PM) emissions show a decreasing trend over the period 1990 to 2022: TSP emissions decreased by 28%, PM_{10} emissions were about 37% below the level of 1990, and $PM_{2.5}$ emissions dropped by about 51%. In the transport sector PM emissions show a general decrease since several years as a result of improved technology. In the NFR sectors *1.A.4 Other* and *2 Industrial Processes*, PM emissions also fell since 1990.

Between 2021 and 2022 TSP, PM_{10} and $PM_{2.5}$ emissions decreased by 6.6% (TSP), 6.8% (PM_{10}) and 9.6% ($PM_{2.5}$). The short-term decrease of PM emissions was largely influenced by sector residential heating (*1.A.4.b.i*) as a consequence of the mild weather as well as changes in energy prices and the associated reduced use of biomass. In sector *2.A.5 Mining, construction/demolition and handling of products* the PM emission levels have also decreased in 2022 compared to the previous year due to less construction activities.

NFR 1.A Fuel Combustion Activities

One of the main sources of PM emissions is NFR sector 1.A Fuel Combustion Activities. Within this source the largest contributors are NFR 1.A.4 Other Sectors, NFR 1.A.3 Transport, NFR 1.A.1 Energy Industries and NFR 1.A.2 Manufacturing Industries and Construction.

- *NFR 1.A.4 Other Sectors*: small combustion plants, residential heating, household ovens and stoves (NFR 1.A.4.b.i) are large sources of TSP, PM_{10} and $PM_{2.5}$, as well as Off Road Vehicles and Other Machinery (included in NFR 1.A.4.c) which are important sources of $PM_{2.5}$. Emission reduction could be achieved through:
  - substitution of old installations with modern technology,
  - reduction of biomass consumption in household ovens and stoves due to less use as a main heating system,
  - installation of energy-saving boilers,
  - connection to the district-heating networks or other public energy- and heating networks,
  - substitution from high-emission fuels to low-emission (low-ash) fuels (wood pellets),
  - raising awareness for energy saving.
- *NFR 1.A.3 Transport* includes transportation activities, mechanical abrasion from tyres, brakes and road surfaces and has a contribution of 16% TSP, 17% PM_{10} and 21% $PM_{2.5}$ emissions of the respective national totals. The reduction of PM emissions since 2005 is due to improvements in the drive and exhaust gas after treatment technologies and the integration of particulate filter systems in the fuel consumption based taxation for passenger cars in Austria

(NOVA). PM emissions from automobile tyre and break wear (NFR sector *1.A.3.b.6*) and road abrasion (NFR *1.A.3.b.7*) are increasing as a function of travelled vehicles kilometres, which have shown an increasing trend since 1990.

- *NFR 1.A.1 Energy Industries* and *NFR 1.A.2 Manufacturing Industries and Construction*: *NFR 1.A.2 Manufacturing Industries and Construction* is responsible for 2.2% of the national total TSP emissions, 3.2% of PM_{10} emissions and 5.6% of $PM_{2.5}$ emissions. *1.A.1 Energy Industries* contributes in 2022 with 2.8% of TSP, 4.1% of PM_{10} and 7.1% of $PM_{2.5}$ to the respective national totals. Achievements for reducing emissions in both subcategories were made by several appropriate measures in this category:
  - application of abatement techniques such as flue gas collection and flue gas cleaning systems (already in the 1980),
  - installation of energy- and resource-saving production processes (already in the 1980),
  - substitution from high-emission fuels to low-emission (low-ash) fuels (already in the 1980),
  - raising awareness for environmental protection.
  - closure of coal plants

While emissions in category 1.A.2 have decreased due to these measures, they have increased in 1.A.1 by the increases in energy consumption. A reason for rising PM emissions in these source categories is the increasing use of CO_2-neutral fuels such as biomass (wood, pellets etc.) in district-heating plants. Even with modern combustion technology, solid biomass causes considerable higher emissions than liquid or gaseous fuels.

NFR 2 Industrial Processes and Product Use

Overall PM emissions from this sector decreased from 1990 to 2010, following the decrease in emissions from *2.C Metal Production*, since then emissions are relatively stable.

- *NFR 2.A Mineral Products*: Mining, construction/demolition and handling of mineral products is the main source of PM emissions of sector *2 Industrial Processes and Product Use*. The increase of PM emissions of subcategory NFR *2.A Mineral products* from 1990 to 2008 is mainly due to a doubling of gravel use, which is the most important contribution to total PM emissions from this subcategory. From 2008 onwards emissions follow the trend in construction activities, which show a dip due to the economic crisis from 2008 to 2010 and are subsequent slowly increasing.
- *NFR 2.C Metal Production*, emissions decreased by over 91% from1990 to 2022 due to the introduction of low-PM technologies, abatement measures such as flue gas collection and flue gas cleaning systems etc. In 2022, this subcategory is only a minor source of PM emissions.

NFR 3 Agriculture

- *NFR 3.D Agricultural Soils*, which considers tillage operations and harvesting activities, is the main source of PM emissions within sector Agriculture. The decrease in agricultural production (soil cultivation, harvesting etc.) is responsible for the decrease since 1990 of about 5.2% of the agricultural $PM_{2.5}$ emissions from this source category. TSP and PM_{10} emissions from *3.D Agricultural Soils* decreased by 7.3% and 7.7% over the period 1990 to 2022.
- *NFR 3.B Manure Management* comprises PM emissions from animal husbandry, primary connected with the manipulation of forage and a smaller part arises from dispersed excrements

and litter. Between 1990 and 2022 emissions decreased by 12% for all PM fractions due to falling livestock numbers. Compared to the previous year emissions decreased by 1.4%.

2.2.1 PM_{10} emissions and emission trends in Austria

National total PM_{10} emissions amounted to 43 kt in 1990 and have decreased steadily so that by the year 2022 emissions were reduced by 37% (to 27 kt) – see Table 51.

As shown in Figure 17 and Table 51, the main sources for PM_{10} emissions in 2022 in Austria are combustion processes in the NFR category 1.A *Fuel Combustion Activities* (49% in national total emissions) as well as the handling of bulk materials like mineral products and the activities in the field of civil engineering of category 2 *Industrial Processes and Product Use* (35% in national total emissions). Sector *3 Agriculture* contributes with a share of 14% in national total PM_{10} emissions.

Figure 18: PM_{10} emissions in Austria 1990–2022 by sectors in absolute terms.

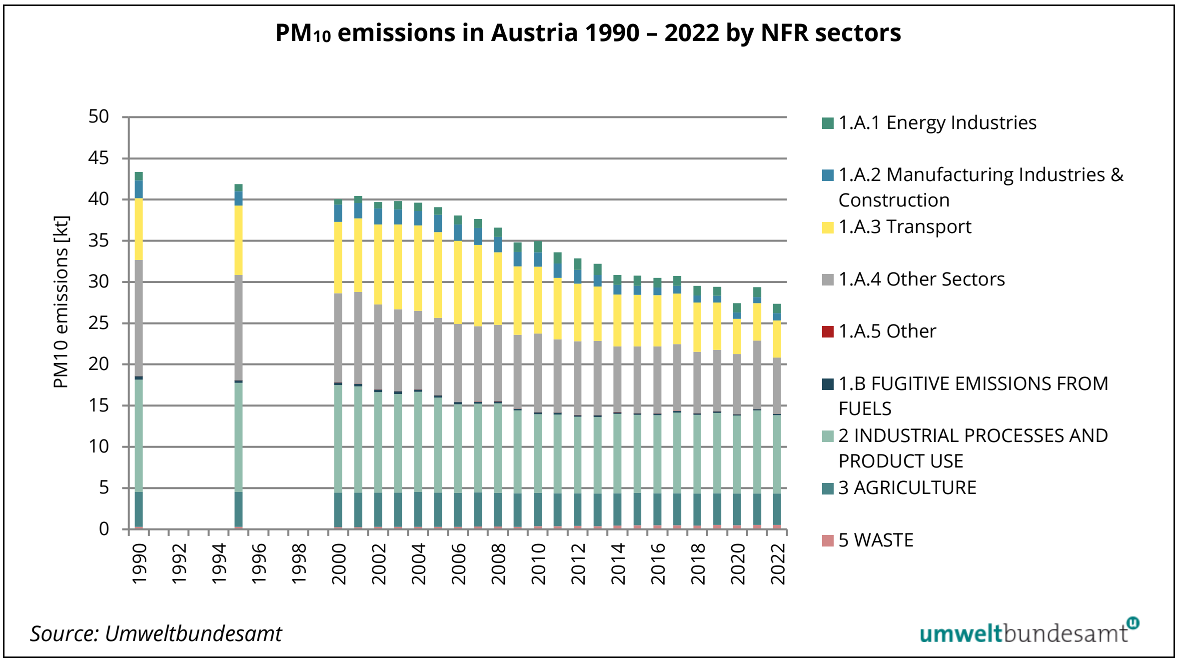


Table 51: PM_{10} emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		PM_{10} Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1	ENERGY	25.19	13.53	-46.3%	-9.4%	58%	49%
1.A	FUEL COMBUSTION ACTIVITIES	24.79	13.38	-46.0%	-9.4%	57%	49%
1.A.1	Energy Industries	1.00	1.13	13.3%	-5.1%	2%	4.1%
1.A.2	Manufacturing Industries and Construction	2.18	0.89	-59.5%	18.0%	5%	3.2%
1.A.2.a	Iron and Steel	0.05	0.01	-77.4%	60.1%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.01	0.01	-7.0%	27.8%	<1%	<1%
1.A.2.c	Chemicals	0.21	0.20	-2.8%	18.6%	<1%	1%
1.A.2.d	Pulp, Paper and Print	0.95	0.19	-80.2%	1.2%	2%	1%

NFR Category		PM_{10} Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1.A.2.e	Food Processing, Beverages and Tobacco	0.11	0.05	-58.3%	115.1%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.07	0.10	38.3%	20.0%	<1%	<1%
1.A.2.g	Manufacturing Ind. and Constr. - other	0.78	0.33	-57.8%	19.5%	2%	1%
1.A.3	Transport	7.48	4.53	-39.4%	0.1%	17%	17%
1.A.3.a	Civil Aviation	0.04	0.10	128.8%	58.6%	<1%	<1%
1.A.3.b	Road Transportation	6.41	3.84	-40.1%	-1.7%	15%	14%
1.A.3.c	Railways	0.96	0.54	-43.8%	3.9%	2%	2%
1.A.3.d	Navigation	0.06	0.05	-7.7%	45.6%	<1%	<1%
1.A.3.e	Other transportation	0.01	0.00	-80.5%	-53.9%	<1%	<1%
1.A.4	Other Sectors	14.10	6.82	-51.6%	-17.7%	33%	25%
1.A.4.a	Commercial/Institutional	0.85	0.32	-62.6%	-12.0%	2%	1%
1.A.4.b	Residential	10.71	5.74	-46.4%	-18.6%	25%	21%
1.A.4.c	Agriculture/Forestry/Fisheries	2.55	0.76	-70.0%	-13.5%	6%	3%
1.A.5	Other	0.02	0.01	-56.2%	-2.7%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	0.40	0.15	-62.3%	-8.2%	1%	1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	13.63	9.50	-30.3%	-5.8%	31%	35%
2.A	MINERAL PRODUCTS	7.40	7.67	3.7%	-7.1%	17%	28%
2.A.1	Cement Production	0.16	0.04	-77.3%	-4.8%	<1%	<1%
2.A.2	Lime Production	0.06	0.09	55.1%	-5.9%	<1%	<1%
2.A.3	Glass production	0.03	0.01	-83.6%	7.1%	<1%	<1%
2.A.5	Mining, construction, handling of products	7.15	7.54	5.4%	-7.1%	16%	28%
2.A.6	Other Mineral products	NO	NO	NO	NO	NO	NO
2.B	CHEMICAL INDUSTRY	0.42	0.26	-37.8%	-11.2%	1%	1%
2.C	METAL PRODUCTION	4.68	0.41	-91.3%	5.4%	11%	1%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.24	0.29	23.7%	0.0%	1%	1%
2.G	Other product manufacture and use	0.54	0.41	-23.4%	5.4%	1%	2%
2.H	Other Processes	0.00	0.00	-28.0%	2.2%	<1%	<1%
2.I	Wood processing	0.37	0.46	26.3%	-0.6%	1%	2%
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	"Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage,...	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	4.23	3.81	-10.0%	-0.5%	10%	14%
3.B	MANURE MANAGEMENT	0.58	0.51	-12.0%	-1.4%	1%	2%
3.D	AGRICULTURAL SOILS	3.58	3.30	-7.7%	-0.3%	8%	12%
3.F	FIELD BURNING OF AGRICUL. RESIDUES	0.08	NO	NO	NO	<1%	NO
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.30	0.53	76.9%	1.8%	1%	2%
	Total without sinks	**43.35**	**27.37**	**-36.9%**	**-6.8%**		

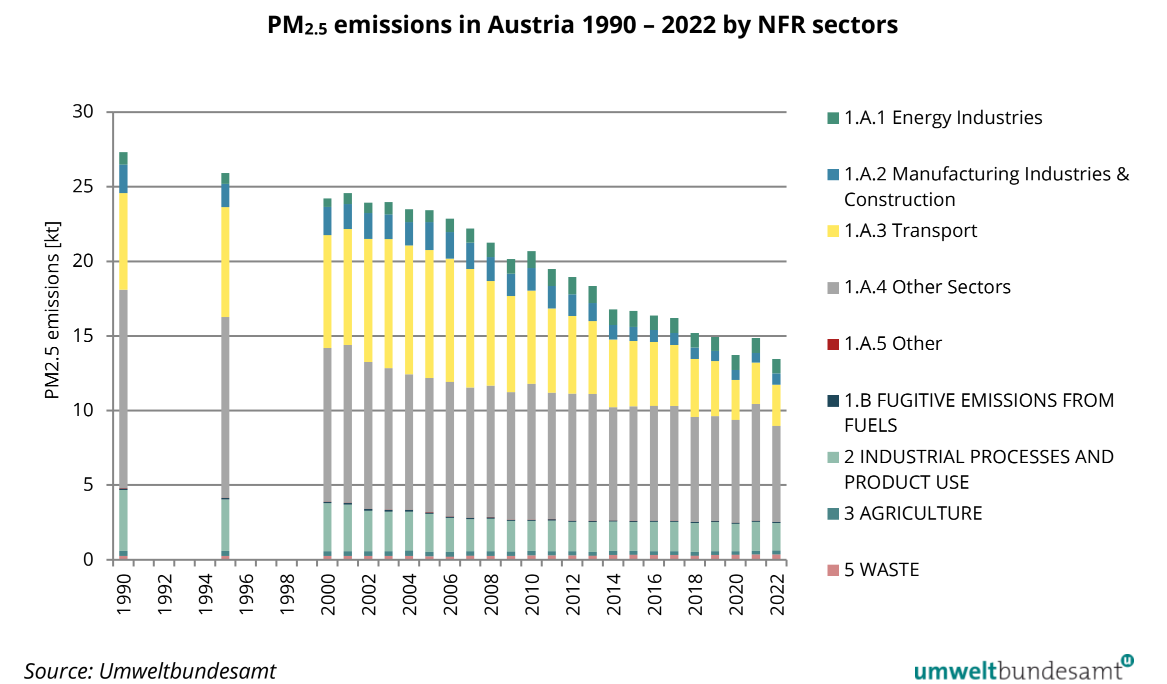
2.2.2 $PM_{2.5}$ emissions and emission trends in Austria

National total $PM_{2.5}$ emissions amounted to 27 kt in 1990 and have decreased steadily so that by the year 2022 emissions were reduced by 51% (to 13 kt) – see Table 52.

As shown in Figure 17 and Table 52, $PM_{2.5}$ emissions in Austria mainly arose from combustion processes in the energy sector with a share of 81% in the total emissions in 2022. A further emission source is NFR sector *2 Industrial Processes and Product Use,* which had a share of 14% in national total emissions.

In general, the reduction of $PM_{2.5}$ emission is due to the installation of flue gas collection and modern flue gas cleaning technologies in several branches. Compared to the previous year, emissions in 2022 decreased by 9.6%, due to lower biomass consumption from residential heating (*1.A.4.b.i*) because of the milder weather as well as changes in energy prices and the associated reduced use of biomass.

Figure 19: $PM_{2.5}$ emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 52: $PM_{2.5}$ emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		$PM_{2.5}$ Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1	ENERGY	22.67	10.98	-51.6%	-10.9%	83%	82%
1.A	FUEL COMBUSTION ACTIVITIES	22.56	10.93	-51.5%	-10.9%	83%	81%
1.A.1	Energy Industries	0.85	0.96	12.2%	-5.4%	3%	7.1%
1.A.2	Manufacturing Industries and Construction	1.90	0.75	-60.6%	17.4%	7%	5.6%
1.A.2.a	Iron and Steel	0.04	0.01	-77.4%	60.1%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.01	0.01	-7.0%	27.8%	<1%	<1%
1.A.2.c	Chemicals	0.17	0.17	-2.8%	18.6%	1%	1%
1.A.2.d	Pulp, Paper and Print	0.78	0.15	-80.2%	1.2%	3%	1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.09	0.04	-58.3%	115.1%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.06	0.08	38.3%	20.0%	<1%	1%
1 A 2 g	Manufacturing Industries and Constr. – other	0.74	0.29	-61.1%	17.8%	3%	2%
1.A.3	Transport	6.48	2.77	-57.3%	-0.9%	24%	21%

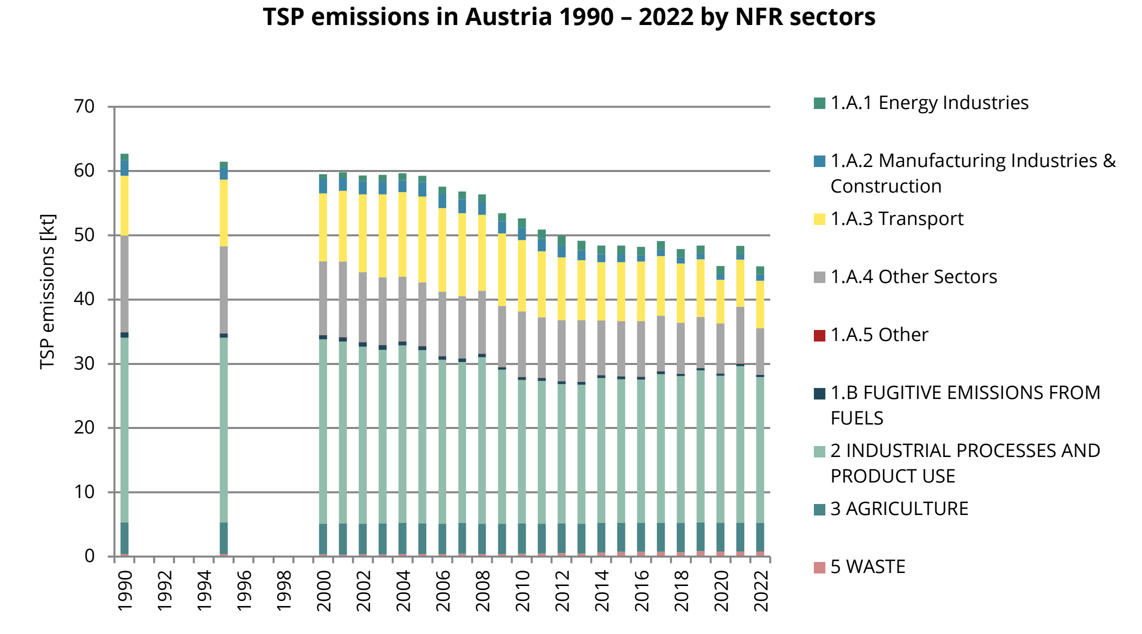
NFR Category		$PM_{2.5}$ Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1.A.3.a	Civil Aviation	0.04	0.10	128.8%	58.6%	<1%	1%
1.A.3.b	Road Transportation	5.78	2.43	-58.0%	-3.3%	21%	18%
1.A.3.c	Railways	0.60	0.19	-68.3%	2.7%	2%	1%
1.A.3.d	Navigation	0.06	0.05	-7.7%	45.6%	<1%	<1%
1.A.3.e	Other transportation	0.01	0.00	-82.5%	-52.9%	<1%	<1%
1.A.4	Other Sectors	13.30	6.45	-51.5%	-17.5%	49%	48%
1.A.4.a	Commercial/Institutional	0.77	0.30	-61.0%	-11.4%	3%	2%
1.A.4.b	Residential	10.03	5.43	-45.9%	-18.3%	37%	40%
1.A.4.c	Agriculture/Forestry/Fisheries	2.50	0.72	-71.2%	-13.2%	9%	5%
1.A.5	Other	0.02	0.01	-56.2%	-2.7%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	0.11	0.05	-55.9%	-8.1%	<1%	<1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	4.07	1.86	-54.3%	-5.1%	15%	14%
2.A	MINERAL PRODUCTS	0.98	0.93	-4.9%	-6.6%	4%	7%
2.A.1	Cement Production	0.14	0.03	-77.3%	-4.8%	1%	<1%
2.A.2	Lime Production	0.04	0.06	55.1%	-5.9%	<1%	<1%
2.A.3	Glass production	0.03	0.00	-83.6%	7.1%	<1%	<1%
2.A.5	Mining, construction, handling of products	0.77	0.84	8.0%	-6.8%	3%	6%
2.A.6	Other Mineral products	NO	NO	NO	NO	NO	NO
2.B	CHEMICAL INDUSTRY	0.28	0.14	-48.6%	-17.9%	1%	1%
2.C	METAL PRODUCTION	2.13	0.18	-91.5%	-8.4%	8%	1%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.01	0.01	23.7%	0.0%	<1%	<1%
2.G	Other product manufacture and use	0.52	0.40	-23.3%	3.9%	2%	3%
2.H	Other Processes	0.00	0.00	-47.2%	2.2%	<1%	<1%
2.I	Wood processing	0.15	0.18	26.6%	-0.6%	1%	1%
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	0.34	0.25	-28.2%	-1.0%	1%	2%
3.B	MANURE MANAGEMENT	0.13	0.11	-12.0%	-1.4%	<1%	1%
3.D	AGRICULTURAL SOILS	0.14	0.13	-5.2%	-0.6%	1%	1%
3.F	FIELD BURNING OF AGRICULT. RES.	0.07	NO	NO	NO	<1%	NO
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.25	0.36	46.6%	4.2%	1%	3%
	Total without sinks	**27.33**	**13.45**	**-50.8%**	**-9.6%**		

2.2.3 Total suspended particulate matter (TSP) emissions and emission trends in Austria

National total TSP emissions amounted to 63 kt in 1990, decreased over the period 1990 to 2022 by 28% and amounted to 45 kt in 2022, as can be seen in Table 53. TSP emissions in Austria mainly derive from *1.A Fuel Combustion Activities* and *2 Industrial Processes and Product Use* with shares of 37% and 50%, respectively, in national total emissions in 2022. Important subcategories of *1.A Fuel Combustion Activities* are *1.A.4 Other Sectors* (mainly small heating installations) with a share of 16%, 1.*A.3 Transport* contributing with 16% as well as *1.A.1 Energy Industries* with 2.8% and *1.A.2 Manufacturing*

Industries and Construction with 2.2% in national total emissions. NFR sector *3 Agriculture* also participates with 10%.

Figure 20: TSP emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 53: TSP emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		**TSP Emission in [kt]**		**Trend**		**Share in National Total**	
		1990	**2022**	**1990–2022**	**2021–2022**	**1990**	**2022**
1	ENERGY	28.64	17.22	-39.9%	-7.9%	46%	38%
1.A	FUEL COMBUSTION ACTIVITIES	27.79	16.90	-39.2%	-7.9%	44%	37%
1.A.1	Energy Industries	1.06	1.25	18.1%	-4.9%	2%	3%
1.A.2	Manufacturing Industries and Construction	2.37	0.98	-58.8%	18.3%	4%	2%
1.A.2.a	Iron and Steel	0.06	0.01	-77.4%	60.1%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.01	0.01	-7.0%	27.8%	<1%	<1%
1.A.2.c	Chemicals	0.23	0.23	-2.8%	18.6%	<1%	1%
1.A.2.d	Pulp, Paper and Print	1.06	0.21	-80.2%	1.2%	2%	<1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.12	0.05	-58.3%	115.1%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.08	0.11	38.3%	20.0%	<1%	<1%
1 A 2 g	Manufacturing Industries and Constr. – other	0.81	0.36	-55.8%	20.5%	1%	1%
1.A.3	Transport	9.30	7.38	-20.7%	1.0%	15%	16%
1.A.3.a	Civil Aviation	0.04	0.10	128.8%	58.6%	<1%	<1%
1.A.3.b	Road Transportation	7.20	5.69	-21.0%	-0.8%	11%	13%
1.A.3.c	Railways	2.00	1.54	-23.0%	4.4%	3%	3%
1.A.3.d	Navigation	0.06	0.05	-7.7%	45.6%	<1%	<1%
1.A.3.e	Other transportation	0.01	0.00	-79.3%	-54.5%	<1%	<1%
1.A.4	Other Sectors	15.04	7.28	-51.6%	-18.0%	24%	16%

NFR Category		TSP Emission in [kt]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1.A.4.a	Commercial/Institutional	0.92	0.33	-63.7%	-12.6%	1%	1%
1.A.4.b	Residential	11.53	6.14	-46.7%	-18.8%	18%	14%
1.A.4.c	Agriculture/Forestry/Fisheries	2.59	0.81	-68.8%	-13.9%	4%	2%
1.A.5	Other	0.02	0.01	-56.2%	-2.7%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	0.85	0.32	-62.5%	-8.2%	1%	1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	28.72	22.70	-21.0%	-6.9%	46%	50%
2.A	MINERAL PRODUCTS	19.50	19.74	1.3%	-7.5%	31%	44%
2.A.1	Cement Production	0.17	0.04	-77.3%	-4.8%	<1%	<1%
2.A.2	Lime Production	0.06	0.10	55.1%	-5.9%	<1%	<1%
2.A.3	Glass production	0.04	0.01	-83.6%	7.1%	<1%	<1%
2.A.5	Mining, construction, handling of products	19.22	19.60	2.0%	-7.5%	31%	43%
2.A.6	Other Mineral products	NO	NO	NO	NO	NO	NO
2.B	CHEMICAL INDUSTRY	0.83	0.42	-48.8%	-7.0%	1%	1%
2.C	METAL PRODUCTION	6.60	0.54	-91.9%	-9.2%	11%	1%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.35	0.44	23.7%	0.0%	1%	1%
2.G	Other product manufacture and use	0.54	0.41	-23.4%	5.4%	1%	1%
2.H	Other Processes	0.00	0.00	-24.0%	2.2%	<1%	<1%
2.I	Wood processing	0.90	1.15	26.7%	-0.6%	1%	3%
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	4.96	4.46	-10.0%	-0.6%	8%	10%
3.B	MANURE MANAGEMENT	1.28	1.13	-12.0%	-1.4%	2%	3%
3.D	AGRICULTURAL SOILS	3.59	3.33	-7.3%	-0.4%	6%	7%
3.F	FIELD BURNING OF AGRICULTURAL RES.	0.08	NO	NO	NO	<1%	NO
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.37	0.79	110.4%	0.0%	1%	2%
	Total without sinks	**62.69**	**45.16**	**-28.0%**	**-6.6%**		

2.2.4 Black Carbon emissions

Black carbon' or 'BC' means carbonaceous particulate matter that absorbs light.

In accordance with the NEC Directive (EU) 2016/2284, Table A (*Annual emission reporting requirements*) and Table C (*Reporting requirements on emissions and projections*), Austria does not report emissions of BC (notation key NR is used).

In response to an encouragement of the TERT in the framework of the NEC Review 2021 (EC, 2021a), Austria will continue to observe the situation with regard to the high uncertainties of BC emission data and decide accordingly on the calculation of a BC inventory.

2.3 Emission Trends for Heavy Metals

In general emissions of heavy metals decreased remarkably from 1990 to 2022. Emission trends for heavy metals from 1990 to 2022 are presented in Table 54. Emissions for all three priority heavy metals (Cd, Pb, Hg) are well below their 1985 level, which is the obligation for Austria as a Party to the Heavy Metals Protocol. From submission 2015 onwards Austria reported all mandatory pollutants in the NFR19 reporting format from 1990 to the latest inventory year.

Table 54: National total emissions and emission trends for heavy metals 1990–2022.

Year	**Emissions [t]**		
	Cd	**Hg**	**Pb**
1990	1.76	2.52	232.89
1995	1.11	1.59	26.06
2000	1.03	1.40	23.30
2005	1.09	1.61	27.23
2010	0.96	1.11	15.89
2011	0.94	1.10	15.87
2012	0.96	1.11	15.85
2013	0.98	1.17	16.16
2014	0.91	1.12	15.42
2015	0.94	1.10	15.19
2016	0.92	1.04	15.59
2017	0.94	1.07	15.72
2018	0.90	1.03	15.26
2019	0.88	1.05	14.84
2020	0.86	1.07	12.96
2021	0.94	1.05	13.76
2022	0.89	0.99	13.67
Trend 1990–2022	**-49%**	**-61%**	**-94%**

2.3.1 Cadmium (Cd) Emissions

Cadmium (Cd) has been ubiquitously distributed in the natural environment for millions of years. It occurs in the earth’s crust with a content estimated to be between 0.08 and 0.5 ppm. Unlike some other heavy metals, such as lead or mercury, which have been used since ancient times, Cd has been refined and utilized only since 100 years, but it was already discovered in 1817. The production and consumption of Cd has risen distinctly only since the 1940’s. The primary uses are electroplated cadmium coatings, nickel-cadmium storage batteries, pigments, and stabilizers for plastics. Publicity about the toxicity of cadmium has affected the consumption significantly.

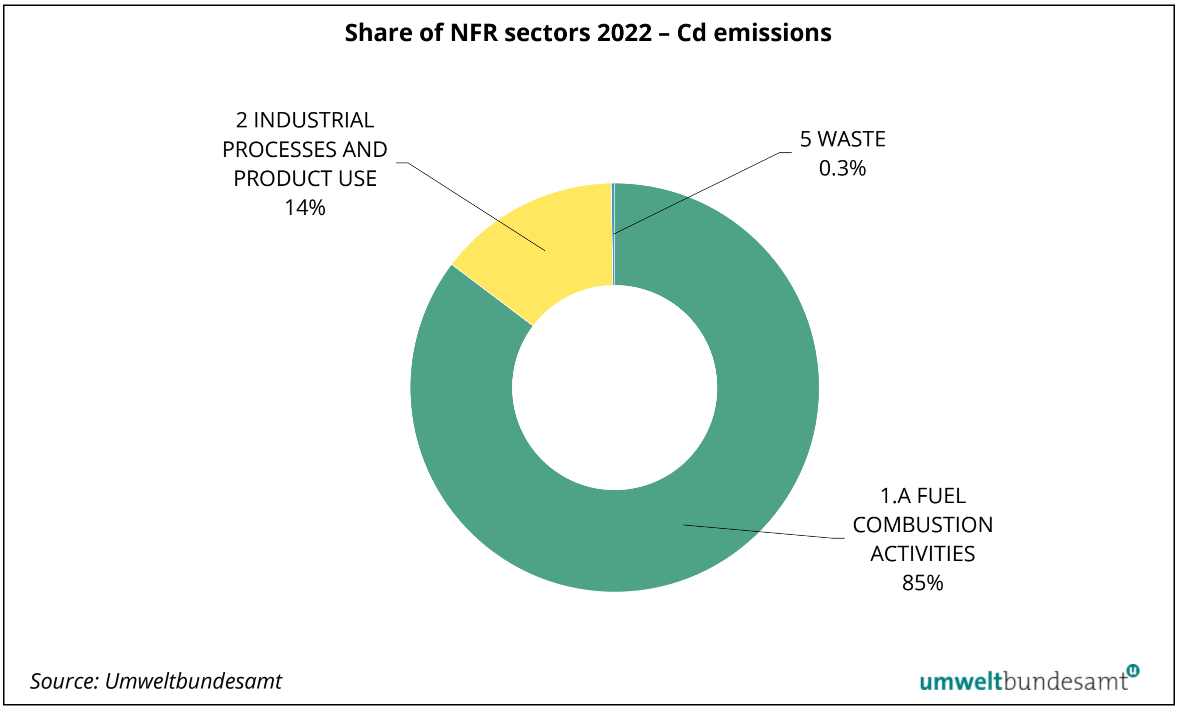
For human beings Cd does not have a biological function unlike many other elements. The smoking (of tobacco) stands for an important exposure to Cd: smokers generally have about twice as high cadmium concentrations in the renal cortex compared to non-smokers. For the non-smoking population food is an important source of exposure because Cd is accumulated in the human and animal bodies due to its long half-life. Cd compounds and complexes are classified as an unambiguous carcinogenic working material.

Main sources and emission trends in Austria

The most important source for Cd emissions is the combustion of solid fuels (fossil and biomass), *1.A. Fuel Combustion Activities*, contributing with a share of 85% to national total Cd emissions in 2022. The second important source is 2 *Industrial Processes and Product Use* with 14% in national total (see Figure 21 and Table 55).

Cd emissions resulting from NFR sectors *5 Waste* is a minor source. This sector contributes to national total Cd emissions with about 0.3%. In sector *3 Agriculture* no emissions occurred in 2022.

Figure 21: Share of NFR sectors 2022 in Cd emissions.



Note: Cd emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as NA.

National total Cd emissions amounted to 1.76 t in 1990; emissions have decreased and by the year 2022 emissions were reduced by 49% to 0.89 t in the period 1990–2022. However, the most significant reduction of national total Cd emissions could be achieved in the period 1985–1990. For further information see Austria´s Informative Inventory Report 2014 (Umweltbundesamt, 2014c).

Between 1990 and 1998 emissions were still decreasing, mainly due a decline in the use of heavy fuel oil and lower process emissions from iron and steel production. From 2000 to 2006 Cd emissions were increasing again, which was due to the growing activities in the industrial processes sector and energy sector. After a sharp decline between 2006 and 2007 due to falling activities in iron and steel production, emissions remained on this low level due to the economic crises. In 2010 emissions increased, partly as a result of the economic recovery, but also due to higher emissions from residential heating. Since then emissions remained quite stable with slightly falling tendency from 2010 onwards. The decrease in 2022 compared to the previous year was mainly due to lower emissions from *1.A.4.b.i Residential: stationary*.

NFR 1.A Fuel Combustion Activities

In the period from 1990 to 2022 Cd emissions of *1.A Fuel Combustion Activities* decreased by 28% to 0.76 t. The main sources of Cd emission within NFR sector *1.A. Fuel Combustion Activities* are *1.A.1 Energy Industries, 1.A.4 Other Sectors*, *1.A.2 Manufacturing Industries and Construction.*

- *NFR 1.A.1 Energy* Industries: The increasing Cd emissions since 2001 were due to increasing use of wood and wooden litter in small combustion plants, the combustion of heavy fuel oil and residues from the petroleum processing in the refinery as well as the thermal utilisation of industrial residues and residential waste.
- *NFR 1.A.4 Other Sectors*: Cd emissions decreased by 28% since 1990 to 0.29 t, representing a share of 32% in national total emissions in 2022. The reduction is mainly due to a decreased use of coal. The significant fall of emissions in 2022 (-21%) compared to the previous year is a result of the warmer weather and and price changes on the energy market leading to a reduced biomass consumption.
- *NFR 1.A.2 Manufacturing Industries and Construction*: Between 1990 and 2022 Cd emissions decreased by 53% which was mainly due to measures (reduction of PM) in pulp and paper, cement and glass manufacturing industries in the early 1990s. In 2022 emissions rose by 9.0% as a result of the increased use of solid biomass and black liquor in *1.A.2.d pulp and paper industries* and the increased use of solid biomass in wood processing industries (*1.A.2.g.viii*).
- *NFR 1.A.3 Transport*: The increase of Cd emission is due to the enormous increasing activity of the transport sector in passenger and freight transport. Cd emissions arise for the most part from tyre and brake abrasion. Emissions from tyre and brake wear are increasing as a function of travelled vehicles kilometres, which have shown an increasing trend since 1990.

In all mentioned subcategories, except for NFR sector *1.A.3*, Cd emissions have decreased since 1990, mainly due to an increase in efficiency, the implementation and installation of flue gas treatment system as well as due to dust removal systems.

NFR 2 Industrial Processes and Product Use

Within sector *2 Industrial Processes and Product Use* the main source for Cd emissions are:

- *NFR 2.C Metal Production*: As shown in Table 55 from 1990 to 2022 Cd emissions decreased by 90% to 0.06 t, which is a share of 6.3% to national total Cd emissions. Emissions from the main subcategory NFR *2.C.1 Iron and steel* decreased significantly due to extensive abatement measures but also by production and product substitution.
- *NFR 2.G Other Product Manufacture and Use*: As shown in Table 55 in the period from 1990 to 2022 the Cd emissions decreased by 23% to 0.07 t, which is a share of 8.1% to the total Cd emission. Cd emissions from this category almost exclusively derive from tobacco use. Tobacco use has been declining since the 1990 due to health campaigns and increasing prices for tobacco products.

Figure 22: Cd emissions in Austria 1990–2022 by sectors in absolute terms.

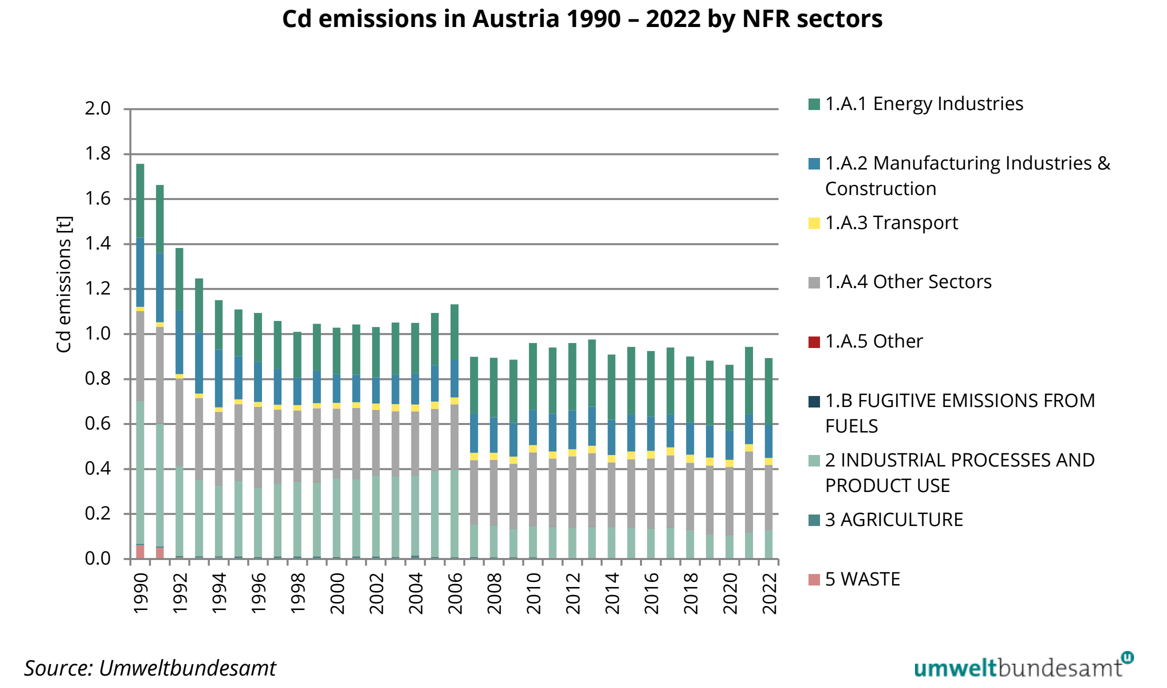


Table 55: Cd emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		Cd Emission in [t]		Trend		Share in National Total	
		1990	2021	1990–2021	2020–2021	1990	2021
1	ENERGY	1.05	0.76	-27.7%	-7.7%	60%	85%
1.A	FUEL COMBUSTION ACTIVITIES	1.05	0.76	-27.7%	-7.7%	60%	85%
1.A.1	Energy Industries	0.33	0.30	-9.1%	-0.2%	19%	33%
1.A.1.a	Public Electricity and Heat Production	0.18	0.15	-14.4%	-1.7%	10%	17%
1.A.1.b	Petroleum refining	0.15	0.14	-2.5%	1.6%	8%	16%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-32.2%	-8.1%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	0.31	0.15	-52.6%	9.0%	18%	16%
1.A.2.a	Iron and Steel	0.01	0.00	-49.2%	2.8%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	-86.5%	-31.0%	<1%	<1%
1.A.2.c	Chemicals	0.03	0.02	-37.6%	27.0%	2%	2%
1.A.2.d	Pulp, Paper and Print	0.15	0.05	-67.1%	11.4%	9%	6%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.00	-27.9%	229.3%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.10	0.02	-78.5%	-17.5%	6%	2%
1.A 2.g	Manufacturing Industries and Constr. - other	0.02	0.05	143.4%	14.4%	1%	6%
1.A.3	Transport	0.02	0.03	76.6%	-3.0%	1%	4%
1.A.3.a	Civil Aviation	0.00	0.00	121.1%	56.5%	<1%	<1%
1.A.3.b	Road Transportation	0.02	0.03	80.6%	-3.2%	1%	3%
1.A.3.c	Railways	0.00	0.00	-90.7%	-5.9%	<1%	<1%
1.A.3.d	Navigation	0.00	0.00	36.3%	35.8%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	57.2%	-0.1%	<1%	<1%

NFR Category		Cd Emission in [t]		Trend		Share in National Total	
		1990	2021	1990–2021	2020–2021	1990	2021
1.A.4	Other Sectors	0.40	0.29	-28.4%	-20.5%	23%	32%
1.A.4.a	Commercial/Institutional	0.06	0.02	-63.4%	-22.5%	3%	2%
1.A.4.b	Residential	0.31	0.22	-28.6%	-20.7%	18%	25%
1.A.4.c	Agriculture/Forestry/Fisheries	0.03	0.04	37.2%	-18.6%	2%	5%
1.A.5	Other	0.00	0.00	-27.4%	-2.0%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	0.63	0.13	-79.7%	11.9%	36%	14%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.00	0.00	-43.6%	-14.7%	<1%	<1%
2.C	METAL PRODUCTION	0.54	0.06	-89.6%	37.5%	31%	6%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.00	0.00	0.0%	0.0%	<1%	<1%
2.G	Other product manufacture and use	0.09	0.07	-22.8%	-2.1%	5%	8%
2.H	Other Processes	NA	NA	NA	NA	NA	NA
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	"Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	0.01	NA	NA	NA	<1%	NA
5	WASTE	0.06	0.00	-96.0%	3.9%	3%	<1%
	Total without sinks	**1.76**	**0.89**	**-49.1%**	**-5.3%**		

2.3.2 Mercury (Hg) Emissions

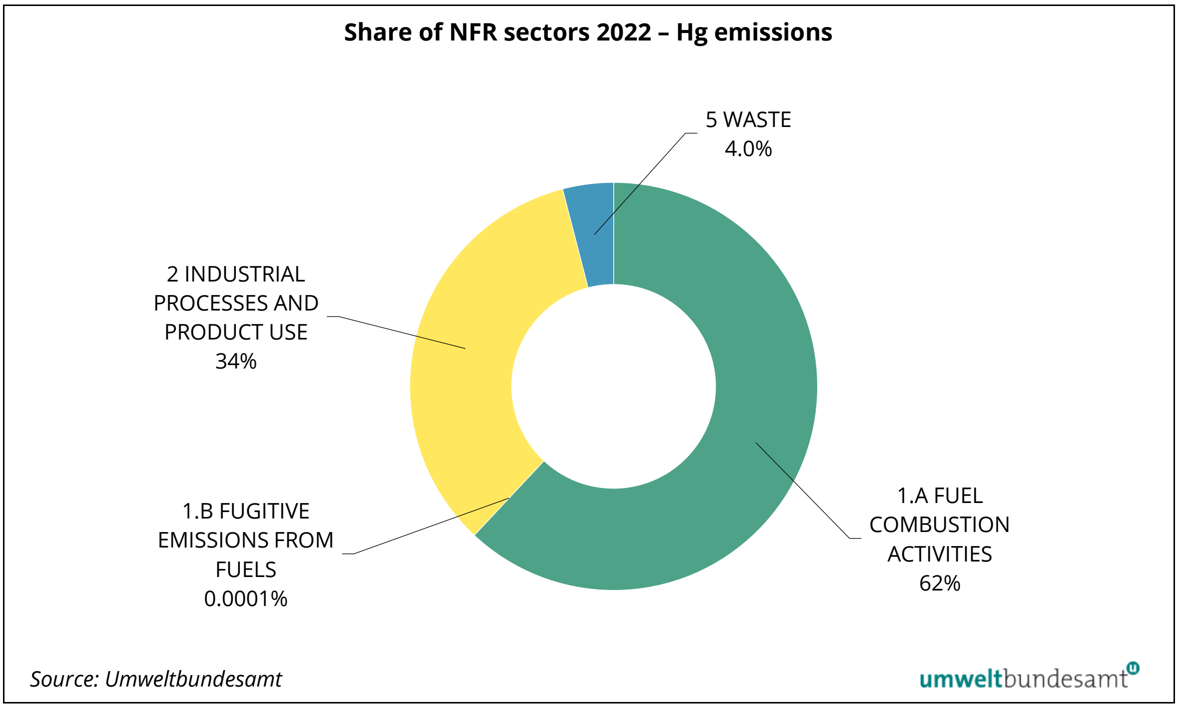
Mercury (Hg) has been ubiquitously distributed in the natural environment for millions of years. It occurs in the earth's crust with a content estimated to be about $4 \cdot 10^{-5}$%. Because of its special properties, mercury has had a number of uses for a long time: the conventional application is the thermometer, barometer, and hydrometer; other important areas of use are the lighting industry and for electrical components. Mercury forms alloys with a large number of metals, these alloys also have a wide range of applications.

Main sources and emission trends in Austria

As can be seen in Figure 23 and Table 56 the two most important Hg emission sources are NFR sectors *1.A Fuel Combustion Activities* and *2 Industrial Processes and Product Use* with shares in national totals in 2022 of 62% and 34%, respectively.

NFR sectors *1.B Fugitive Emissions from fuels* and *5 Waste* are only minor Hg sources. These sectors contribute to national total Hg emissions with 0.0001% (*1.B*) and 4.0% (*Waste*), respectively. In 2022, no emissions resulted from sector *3 Agriculture* ("not occurring").

Figure 23: Share of NFR sectors 2022 in Hg emissions.



In 1990 national total Hg emissions amounted to 2.5 t; In the year 2022 national total Hg emissions were 61% below the level of 1990 (see Table 56). Between 2021 and 2022 emissions decreased by 5.3 % because of falling emissions from NFR *1.A.4.b Residential.* As a result of the warmer weather and and price changes the biomass consumption dropped significantly compared to the previous year.

The overall reduction of about 61% for the period 1990 to 2022 was due to decreasing emissions from cement industries and the industrial processes sector as well as due to reduced use of coal for residential heating and public electricity and heat production. Several bans in different industrial subsectors led to the sharp fall of total Hg emission in Austria, where the largest reduction was achieved in the early 90ies. Due to new data from the steel industry, Hg emissions from 1990–2005 had to be revised upwards, due to abatement measures emissions dropped from 2006 onwards.

The main sources of Hg emissions are described in the following.

NFR 1.A Fuel Combustion Activities

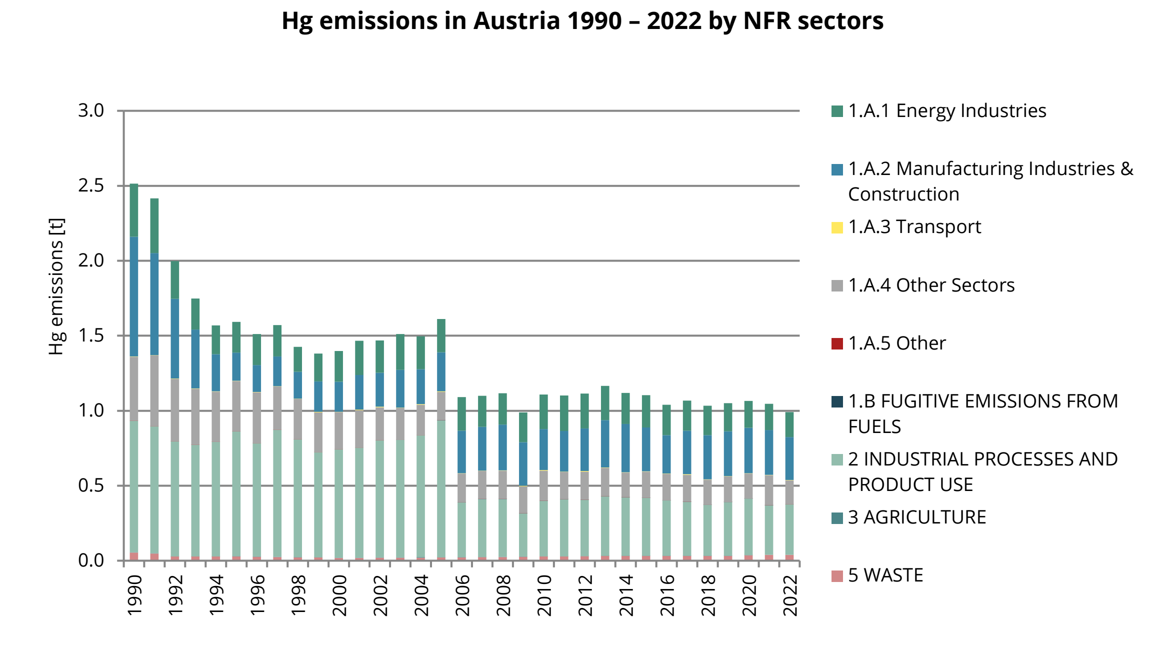
- *NFR 1.A Fuel Combustion (mainly 1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction, 1.A.4 Other Sectors):* Hg emissions are a result of combustion of coal, heavy fuel oil and waste in manufacturing industries and construction, the combustion of wood, wood waste and coal in residential plants and combustion of coal and heavy fuel oil in public electricity and heat production. Overall Hg emissions were reduced significantly by different abatement techniques such as filter installation and wet flue gas treatment in industry and due to decreasing coal consumption in the residential sector. Compared to the previous year, emissions from NFR *1.A* dropped by 9.2%, mainly due to lower emissions from residential heating (warmer winter and higher prices), but also from cement industries (*1.A.2.f non-metallic minerals)*.

NFR 2 Industrial Processes and Product Use

The major source of Hg emissions in the 90ties was *NFR 2.C Metal Production,* but also *NFR 2.B Chemical Industry* contributed significantly. Since 1999 only minor emissions arise from the latter subcategory, so now Hg emissions from *Industrial Processes and Product Use* almost exclusively arise from *Metal Production*.

- *NFR 2.C Metal Production:* Emissions from iron and steel production are the main source within this subcategory, they decreased by 44% since 1990 due to implemented abatement measures.
- *NFR 2.B Chemical Industry:* Hg emissions from this source were significant in 1990 but dropped due to a change of chlorine production to a non Hg emissive process in 1999, which had been the by far most important souce of Hg emissions in chemical industry until then.

Figure 24: Hg emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 56: Hg emissions per NFR Category 1990 and 2021, trend 1990–2021 and share in total emissions.

NFR Category		Hg Emission in [t]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1	ENERGY	1.58	0.61	-61.2%	-9.2%	63%	62%
1.A	FUEL COMBUSTION ACTIVITIES	1.58	0.61	-61.2%	-9.2%	63%	62%
1.A.1	Energy Industries	0.36	0.17	-52.8%	-4.9%	14%	17%
1.A.1.a	Public Electricity and Heat Production	0.35	0.16	-54.7%	-1.9%	14%	16%
1.A.1.b	Petroleum refining	0.01	0.01	37.5%	-36.3%	<1%	1%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-32.2%	-8.1%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	0.80	0.28	-64.3%	-4.4%	32%	29%
1.A.2.a	Iron and Steel	0.00	0.00	103.5%	49.6%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	1.2%	-7.1%	<1%	<1%

NFR Category		Hg Emission in [t]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1.A.2.c	Chemicals	0.01	0.01	-5.3%	21.0%	<1%	1%
1.A.2.d	Pulp, Paper and Print	0.07	0.08	16.5%	4.6%	3%	8%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.00	23.1%	45.3%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.70	0.16	-77.5%	-12.7%	28%	16%
1.A.2.g	Manufacturing Industries and Constr. - other	0.01	0.03	190.1%	13.1%	<1%	3%
1.A.3	Transport	0.00	0.00	-6.4%	-14.7%	<1%	<1%
1.A.3.a	Civil Aviation	0.00	0.00	121.1%	56.5%	<1%	<1%
1.A.3.b	Road Transportation	0.00	0.00	52.4%	-5.0%	<1%	<1%
1.A.3.c	Railways	0.00	0.00	-94.3%	-10.0%	<1%	<1%
1.A.3.d	Navigation	0.00	0.00	36.3%	35.8%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	-32.4%	-59.3%	<1%	<1%
1.A.4	Other Sectors	0.43	0.16	-62.6%	-20.1%	17%	16%
1.A.4.a	Commercial/Institutional	0.02	0.01	-67.9%	-22.6%	1%	1%
1.A.4.b	Residential	0.39	0.14	-64.0%	-20.1%	16%	14%
1.A.4.c	Agriculture/Forestry/Fisheries	0.01	0.01	-12.0%	-18.6%	1%	1%
1.A.5	Other	0.00	0.00	-27.4%	-2.0%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	0.00	NA	-93.0%	NA	<1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	0.88	0.34	-61.5%	1.5%	35%	34%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.27	0.00	-100.0%	-14.7%	11%	0%
2.C	METAL PRODUCTION	0.61	0.34	-44.4%	1.5%	24%	34%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NA	NA	NA	NA	NA	NA
2.G	Other product manufacture and use	0.00	0.00	-27.2%	133.5%	<1%	<1%
2.H	Other Processes	NA	NA	NA	NA	NA	NA
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	0.00	NA	NA	NA	<1%	NA
5	WASTE	0.05	0.04	-27.3%	4.5%	2%	4.0%
	Total without sinks	**2.52**	**0.99**	**-60.6%**	**-5.3%**		

2.3.3 Lead (Pb) Emissions

In the past, automotive sources were the major contributor of lead emissions to the atmosphere. Due to Austrian regulatory efforts to reduce the content of lead in gasoline the contribution of air emissions of lead from the transportation sector has drastically declined over the past decades. Emissions from steel industry also show a significant reduction over time due to abatement measures. Today, although emissions have fallen so sharply, the Transport sector with its tyre and break wear is one of the major sources of lead emissions. Industrial processes, primarily metals processing, where highest air concentrations of lead are usually found in the vicinity of smelters and battery manufacturers, also contribute to national lead emissions. Exposure to lead occurs mainly through inhalation of air and ingestion of lead in food, water, soil, or dust. It accumulates in the blood, bones, and soft tissues and can adversely affect the kidneys, liver, nervous system, and other organs. Lead can also be deposited on the leaves of plants, which pose a hazard to grazing animals and humans through ingestion via food chain.

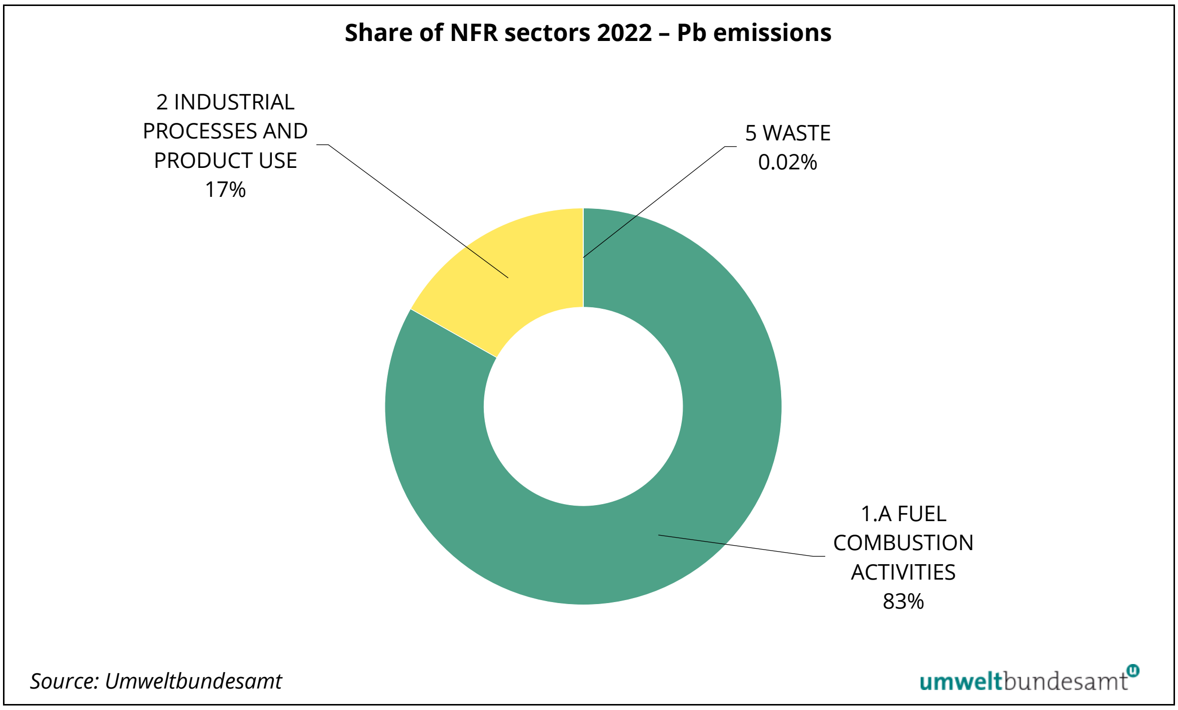
Main sources and emission trends in Austria

As it is shown in Figure 25 and

Table 57, today's Pb emissions mainly arise from the NFR *1.A Fuel Combustion Activities* and *2 Industrial Processes and Product Use* with shares in national total emissions of 83% and 17%, respectively.

Pb emissions resulting from NFR sector *5 Waste* is a minor source. This sector contributes to national total Pb emissions with about 0.02%.

Figure 25: Share of NFR sectors 2022 in Pb emissions



Note: Pb emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as NA.

In 1990 national total Pb emissions amounted to 233 t; emissions have decreased sharply until 1995 mainly due to enforced laws, while since the mid 90ies emissions remained quite stable. In the year 2022 emissions were 94% lower than in 1990 and amounted to 13.7 t. Compared to the previous year total Pb emissions show a decrease of 0.7% mainly because of the lower consumption of biomass in *1.A.4.b.i Residential: stationary*.

NFR 1.A Fuel Combustion Activities

- *NFR 1.A.2 Manufacturing Industries and Construction*: Pb emissions have decreased mainly due to an increase in efficiency, implementation and installation of flue gas treatment system as well as due to dust removal systems.
- *NFR 1.A.1 Energy Industries:* Increasing Pb emissions could be noted in the last decade due to increasing activities. In 2022, emissions fell sharply (-9.9%) compared to the previous year as a result of a decrease in crude oil refining (*1.A.1.b*).

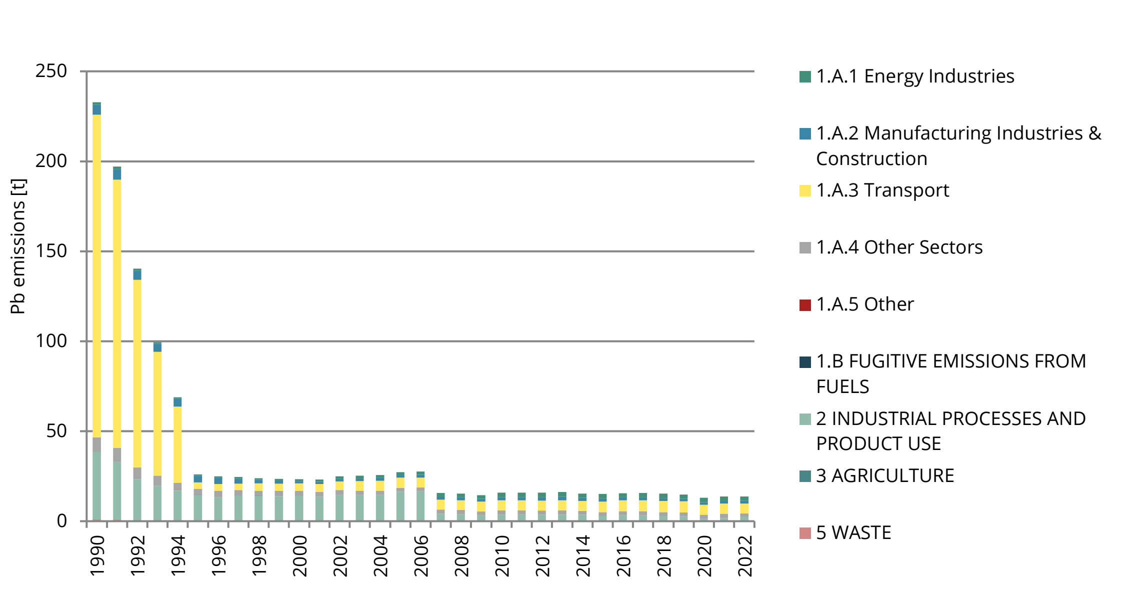
- *NFR 1.A.4 Other Sectors*: Between 1990 and 2022 emissions decreased due to a decreased use of coal and a reduced content of Pb in the heating oil. From 2021 to 2022, Pb emissions significantly decreased by 21% as a result of lower biomass consumption due to the warmer weather and higher energy prices.
- *NFR 1.A.3 Transport*: By the conditions laid down in European directives, emission limits for cars and trucks as well as more stringent quality requirements for fuels lead to almost completely reduced Pb emissions from the transport sector. From 1990 to 1995 lead emissions from this sub-sector decreased by 98%.

NFR 2 Industrial Processes and Product Use

In 1990, 97% of Pb emissions from *NFR 2* arose from *2.C Metal Production.* Due to a drop in emissions from this souce between 2006 and 2007 also *2.G Other Processes* became important in terms of contribution to total Pb emissions, with a notable share of 39%.

- *NFR 2.C Metal Production*: Emissions from this subsector decreased significantly between 1990 and 2022 (-96%) due to extensive (dust) abatement measures but also due to improvements in the production process and product substitution.
- *NFR 2.*G *Other Product Manufacture and Use*: Pb emissions from this category almost exclusively derive from tobacco use. Tobacco use has been declining since 1990 due to health campaigns and increasing prices for tobacco products resulting in an emission reduction of 27% in 2022.

Figure 26: Pb emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 57: Pb emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		Pb Emission in [t]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1	ENERGY	194.45	11.38	-94.1%	-6.4%	83%	83%
1.A	FUEL COMBUSTION ACTIVITIES	194.45	11.38	-94.1%	-6.4%	83%	83%
1.A.1	Energy Industries	1.45	2.25	55.6%	-9.9%	1%	16%
1.A.1.a	Public Electricity and Heat Production	1.27	2.00	57.4%	-5.0%	1%	15%
1.A.1.b	Petroleum refining	0.18	0.25	43.1%	-36.0%	<1%	2%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-32.2%	-8.1%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	5.59	1.59	-71.5%	8.2%	2%	12%
1.A.2.a	Iron and Steel	0.26	0.14	-46.4%	-0.9%	<1%	1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	35.8%	26.9%	<1%	<1%
1.A.2.c	Chemicals	0.21	0.37	80.4%	31.9%	<1%	3%
1.A.2.d	Pulp, Paper and Print	0.65	0.32	-51.2%	12.7%	<1%	2%
1.A.2.e	Food Processing, Beverages and Tobacco	0.01	0.01	170.9%	205.8%	<1%	<1%
1.A.2.f	Non-metallic Minerals	4.27	0.19	-95.5%	-38.0%	2%	1%
1.A.2.g	Manufacturing Industries and Constr. - other	0.20	0.55	178.5%	23.4%	<1%	4%
1.A.3	Transport	179.29	5.52	-96.9%	-2.2%	77%	40%
1.A.3.a	Civil Aviation	1.64	0.00	-100.0%	-5.9%	1%	<1%
1.A.3.b	Road Transportation	177.37	5.52	-96.9%	-2.2%	76%	40%
1.A.3.c	Railways	0.01	0.00	-94.9%	-11.2%	<1%	<1%
1.A.3.d	Navigation	0.26	0.00	-100.0%	26.1%	<1%	<1%
1.A.3.e	Other transportation	0.01	0.00	-99.9%	-36.7%	<1%	<1%
1.A.4	Other Sectors	8.12	2.01	-75.2%	-20.7%	3%	15%
1.A.4.a	Commercial/Institutional	0.36	0.15	-58.0%	-22.6%	<1%	1%
1.A.4.b	Residential	6.77	1.72	-74.5%	-20.7%	3%	13%
1.A.4.c	Agriculture/Forestry/Fisheries	0.99	0.14	-85.9%	-18.6%	<1%	1%
1.A.5	Other	0.00	0.00	-27.4%	-2.0%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	37.42	2.29	-93.9%	42.7%	16%	17%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.00	0.00	-43.6%	-14.7%	<1%	<1%
2.C	METAL PRODUCTION	36.17	1.38	-96.2%	14.7%	16%	10%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.02	0.02	0.0%	0.0%	<1%	<1%
2.G	Other product manufacture and use	1.23	0.89	-27.2%	133.5%	1%	7%
2.H	Other Processes	NA	NA	NA	NA	NA	NA
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	0.00	NA	NA	NA	<1%	NA
5	WASTE	1.02	0.00	-99.7%	0.9%	<1%	<1%
	Total without sinks	**232.89**	**13.67**	**-94.1%**	**-0.7%**		

2.4 Emission Trends for POPs

In submission 2020 Austria reports for the first time all mandatory pollutants in the NFR19 reporting format from 1990 to the latest inventory year. Emissions of the years before 1990 were last updated and published in submission 2014[75]. PCB emissions are reported from submission 2016 onwards.

Emissions of all POPs decreased remarkably from 1990 to 2022 (HCB -87%, PAH -69%, PCDD/F -74% and PCBs -92%), where the highest achievement was made until 1994. The significant increase of HCB emissions in the years 2012, 2013 and 2014 was due to unintentional releases of HCB by an Austrian cement plant.

In 2022 PCDD/F emissions decreased by 15 % compared to the previous year 2021, HCB emissions decreased by 18% and PAH emissions by 21% in the same time. The reductions of HCB and PCDD/F emissions were mainly due to lower emissions from sectors *1.A.4.b Residential* and to a lesser extent *from 2.C Metal Production (*2*.C.1 Iron and Steel Production* and *2.C.3 Aluminium Production)*. PAH emissions fell because of lower emissions from *1.A.4.b Residential.* Decreasing HCB and PCDD/F emissions from *Iron and steel production* were due to changes in the production process and from *aluminium production* emissions followed production figures. In the residential sector emissions fell due to the lower heating demand because of the the warmer weather but also due to the higher prices on the energy market.

The most important source for PAH, PCDD/F and HCB emissions in Austria is residential heating. In the 80s industry and waste incineration were still important sources regarding POP emissions. Due to legal regulations concerning air quality emissions from industry and waste incineration decreased remarkably from 1990 to 1993.

PAH emissions from NFR subcategory *2.D.*3 *Solvent Use* stopped in 1997, emissions of dioxin/furan (PCDD/F) stopped in 1993 and emissions of HCB from this sector stopped in 2001.

In 2022 PCB emissions decreased by 9.8% compared to the previous year 2021 due to lower emissions from 2*.C.1 Iron and Steel Production* as a result of changes in the production process and reduced hard coal consumption *in 1.A.2.d Pulp, Paper and Print*.

For PCB emissions the most important source category is *2.C Metal Production*.

Table 58: Emissions and emission trends for POPs 1990–2022.

Year	**Emission**			
	PAH [t]	**PCDD/F [g]**	**HCB [kg]**	**PCB [kg]**
1990	18.47	121.68	81.66	36.41
1995	10.98	57.80	42.83	10.44
2000	8.79	50.78	20.26	9.18
2005	7.11	35.09	13.64	5.87
2010	7.85	40.50	15.22	4.45
2011	7.20	37.67	13.60	4.16
2012	7.52	38.77	38.02	4.01

[75] Austria´s submission 2014 under the Convention on Long-range Transboundary Air Pollution covering the years 1980–2012: https://cdr.eionet.europa.eu/at/un/CLRTAP_AT/envuvyara/

Year	Emission			
	PAH [t]	PCDD/F [g]	HCB [kg]	PCB [kg]
2013	7.69	38.78	116.45	4.05
2014	6.81	35.85	120.58	4.14
2015	7.07	36.70	12.45	4.05
2016	7.17	36.20	13.17	4.12
2017	7.19	36.67	14.24	4.23
2018	6.73	33.42	12.76	3.69
2019	6.88	33.86	13.63	3.52
2020	6.54	33.15	11.16	3.24
2021	7.20	37.29	12.66	3.08
2022	5.68	31.72	10.40	2.77
Trend 1990–2022	**-69%**	**-74%**	**-87%**	**-92%**

2.4.1 Polycyclic Aromatic Hydrocarbons (PAH) Emissions total

The polycyclic aromatic hydrocarbons (PAH) are molecules built up of benzene rings, which resemble fragments of single layers of graphite. PAHs are a group of approximately 100 compounds. Most PAHs in the environment arise from incomplete burning of carbon-containing materials like oil, wood, garbage or coal. Fires are able to produce fine PAH particles, they bind to ash particles and sometimes move long distances through the air. Thus, PAHs have been ubiquitously distributed in the natural environment since thousands of years.

Out of all different compounds of the pollutant group of PAHs, the four compounds benz(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene are used as indicators for the purposes of emission inventories, which has been specified in the UNECE POPs Protocol mentioned above.

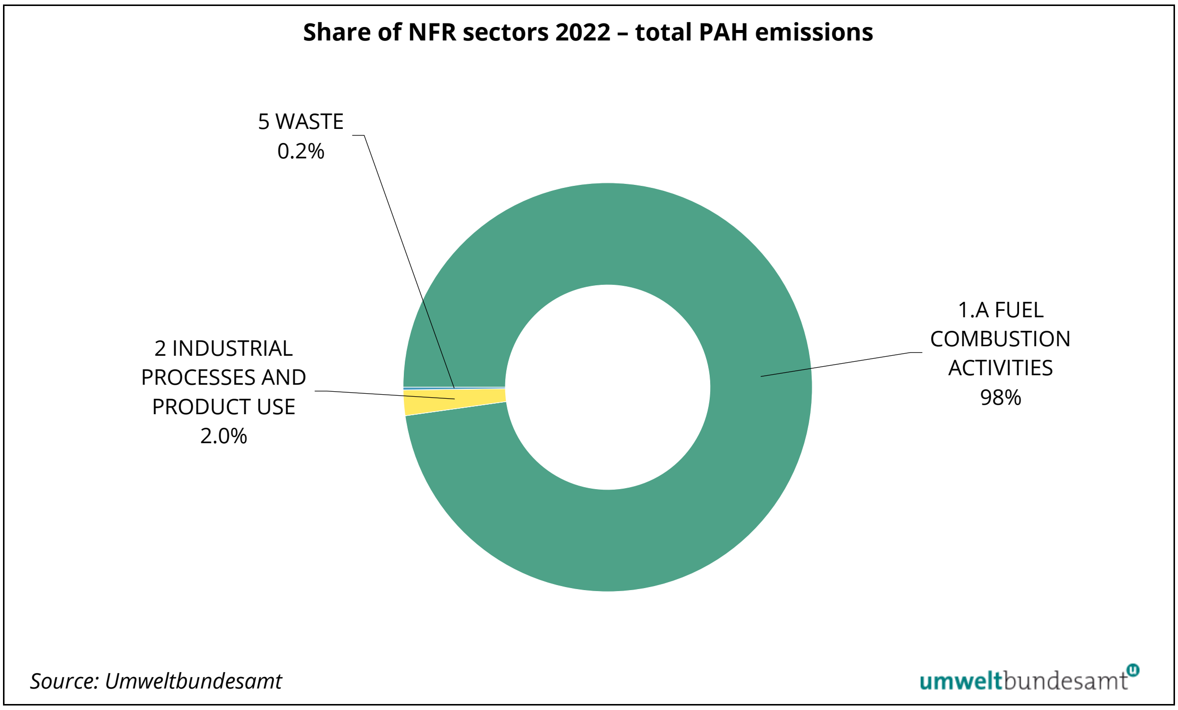
In response to a recommendation of the NEC Review 2020 (EC 2020) Austria reports benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene emissions for all sectors across all years from submission 2021 onwards.

Main sources and emission trends in Austria

In 1990 the main emission sources for PAH emissions were NFR 1.A *Fuel Combustion Activities* (62%) and *2 Industrial Processes and Product Use* (38%). In 2022 emissions are almost exclusively emitted by source category *1.A Fuel Combustion* Activities with 98% of national total PAH emissions as it is illustrated in Figure 27. NFR sector *Industrial Processes and Product Use* contributes in 2022 with 2.0% of national total emissions.

From 1990 to 2022 PAH emissions from Agriculture decreased continuously due to the prohibition of open field burning activities. In 2022, no emissions resulted from NFR sector *3 Agriculture* (“not occurring”) and sector *5 Waste* (0.2%) is a minor source.

Figure 27: Share of NFR sectors 2022 in PAH emissions.



Note: PAH emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as NA.

In 1990 national total PAH emissions amounted to 18.5 t; emissions have decreased since then, where the main achievement was made until 1993, by the year 2022 emissions were reduced by about 69% (to 5.7 t in 2022).

NFR 1.A Fuel Combustion Activities

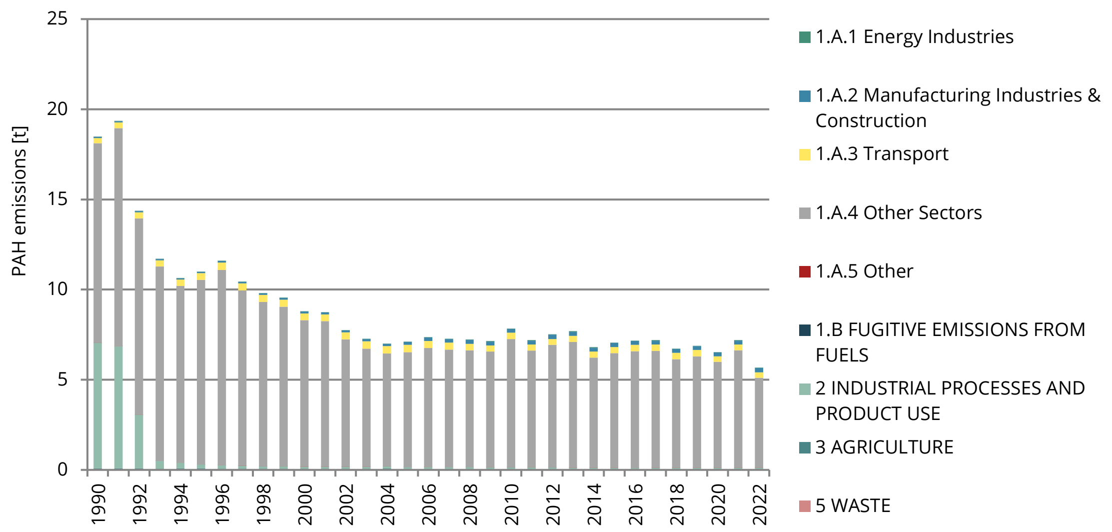
In 2022, PAH emissions are largely emitted by *1.A Fuel Combustion Activities* with a share of 98% in national total emissions. Within this source, PAH emissions mainly result from sector *1.A.4.b Residential (stationary),* and to a much smaller extent from NFR sectors *1.A.4.c Agriculture/Forestry/Fisheries (stationary)* and *1.A.3 Transport*.

- *NFR 1.A.4.b.i Residential (stationary):* Emissions have decreased since 1990 by 58% because of a decreased use of coal and an increased share of efficient biomass boilers with lower specific emissions. Compared to the previous year 2021 emissions decreased in 2022 by 24% because of falling emissions from residential heating. Due to the milder weather and price changes on the energy market, biomass use in households decreased.
- *NFR 1.A.4.c Agriculture/Forestry/Fisheries (stationary):* Compared to 1990 emissions have increased by 15% as a result of a higher biomass consumption. Between 2021 and 2022 emissions decreased by 18%, that was due to decreased fuel wood use.
- *NFR 1.A.3 Transport:* Emissions have increased by 3.2% since 1990 due to increased activities (emissions here result from exhaust and non-exhaust (tyre and brake wear) activities). A reduction potential results in the future by reducing the soot emissions of diesel-powered vehicles because the PAHs are mostly attached to the microparticles. From 2021 to 2022 emissions decreased by 5.0% due to redcued mileage of heavy duty vehicles.

NFR 2 Industrial Processes and Product Use

PAH emissions from the sector *Industrial processes and Product Use* decreased by 98% since 1990 due to the shutdown of the main subcategory primary aluminium production. Since then (1993), emissions remained quite stable on a low level.

Figure 28: Total PAH emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 59: Total PAH emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		**PAH Emission in [t]**		**Trend**		**Share in National Total**	
		1990	**2022**	**1990–2022**	**2021–2022**	**1990**	**2022**
1	ENERGY	11.43	5.55	-51.4%	-21.6%	62%	98%
1.A	FUEL COMBUSTION ACTIVITIES	11.43	5.55	-51.4%	-21.6%	62%	98%
1.A.1	Energy Industries	0.01	0.03	422.8%	-7.8%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	0.06	0.25	289.6%	12.1%	<1%	4%
1.A.2.a	Iron and Steel	0.00	0.00	15.1%	56.1%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	-2.0%	36.9%	<1%	<1%
1.A.2.c	Chemicals	0.02	0.03	47.3%	27.8%	<1%	<1%
1.A.2.d	Pulp, Paper and Print	0.00	0.00	17.8%	-1.9%	<1%	<1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.00	42.5%	172.4%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.00	0.01	155.0%	14.6%	<1%	<1%
1.A.2.g	Manufacturing Industries and Constr. - other	0.04	0.21	459.6%	9.6%	<1%	4%
1.A.3	Transport	0.29	0.30	3.2%	-5.0%	2%	5%
1.A.3.a	Civil Aviation	NE	NE	NE	NE	NE	NE

NFR Category		PAH Emission in [t]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1.A.3.b	Road Transportation	0.27	0.29	7.2%	-6.2%	1%	5%
1.A.3.c	Railways	0.02	0.01	-64.0%	-0.8%	<1%	<1%
1.A.3.d	Navigation	0.01	0.01	42.1%	37.5%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	120.9%	40.7%	<1%	<1%
1.A.4	Other Sectors	11.07	4.97	-55.1%	-23.6%	60%	88%
1.A.4.a	Commercial/Institutional	0.32	0.07	-78.4%	-22.8%	2%	1%
1.A.4.b	Residential	10.18	4.26	-58.2%	-24.4%	55%	75%
1.A.4.c	Agriculture/Forestry/Fisheries	0.56	0.65	15.2%	-18.1%	3%	11%
1.A.5	Other	0.00	0.00	-65.3%	-0.2%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	6.96	0.11	-98.4%	2.5%	38%	2%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	NE	NE	NE	NE	NE	NE
2.C	METAL PRODUCTION	6.26	0.07	-98.8%	4.0%	34%	1%
2.C.1	Iron and Steel Production	6.26	0.07	-98.8%	4.1%	34%	1%
2.C.2	Ferroalloys Production	NE	NE	NE	NE	NE	NE
2.C.3	Aluminium production	NE	NE	NE	NE	NE	NE
2.C.4	Magnesium production	NO	NO	NO	NO	NO	NO
2.C.5	Lead Production	NA	NA	NA	NA	NA	NA
2.C.6	Zinc production	NO	NO	NO	NO	NO	NO
2.C.7	Other metal production	0.00	0.00	67.4%	0.0%	<1%	<1%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.15	NA	NA	NA	1%	NA
2.G	Other product manufacture and use	0.00	0.00	-22.7%	-3.5%	<1%	<1%
2.H	Other Processes	0.55	0.04	-93.2%	0.0%	3%	1%
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	"Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, ...	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	0.04	NA	NA	NA	<1%	NA
5	WASTE	0.05	0.01	-73.7%	0.0%	<1%	<1%
	Total without sinks	**18.47**	**5.68**	**-69.2%**	**-21.1%**		

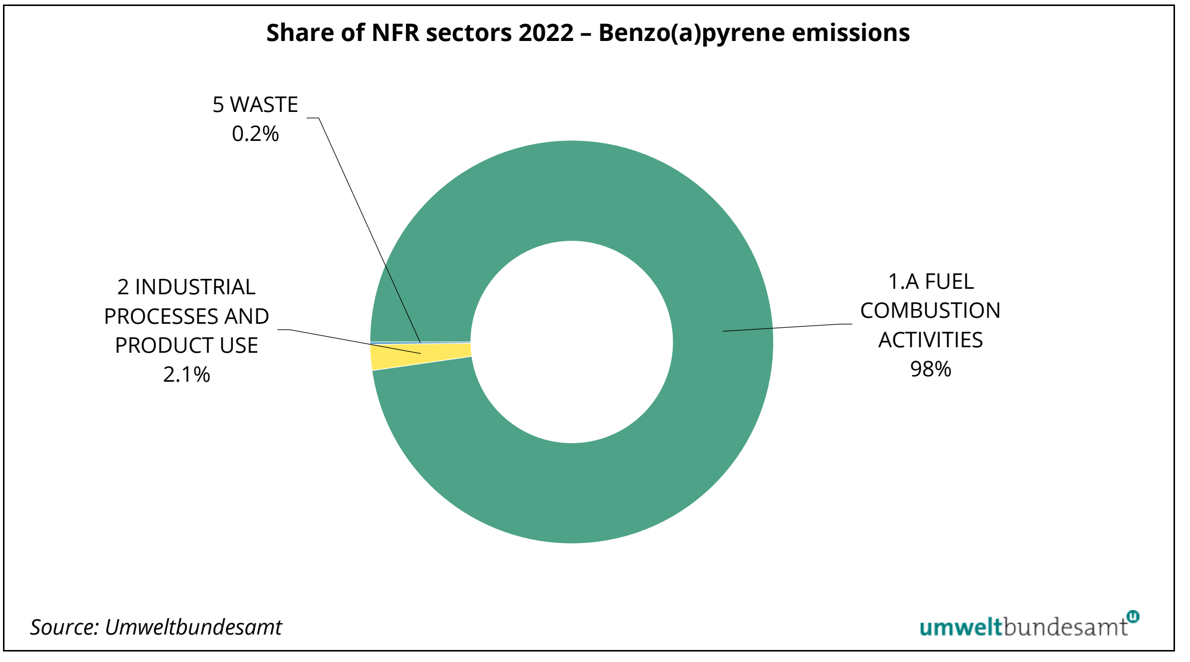
2.4.1.1 Benzo(a)pyrene

In 1990 the main emission sources for Benzo(a)pyrene emissions were NFR 1.A *Fuel Combustion Activities* (62%) and 2 *Industrial Processes and Product Use* (37%). In 2022 emissions are almost exclusively emitted by source category *1.A Fuel Combustion* Activities with 98% of national total Benzo(a)pyrene emissions as illustrated in Figure 29. NFR sector 2 *Industrial Processes and Product Use* contributes with 2.1% of national total emissions in 2022.

From 1990 to 2020 Benzo(a)pyrene emissions from Agriculture decreased continuously due to prohibition of open field burning. In 2022, no emissions occurred from *3 Agriculture* and the NFR sector *5 Waste* (0.2%) is a minor source.

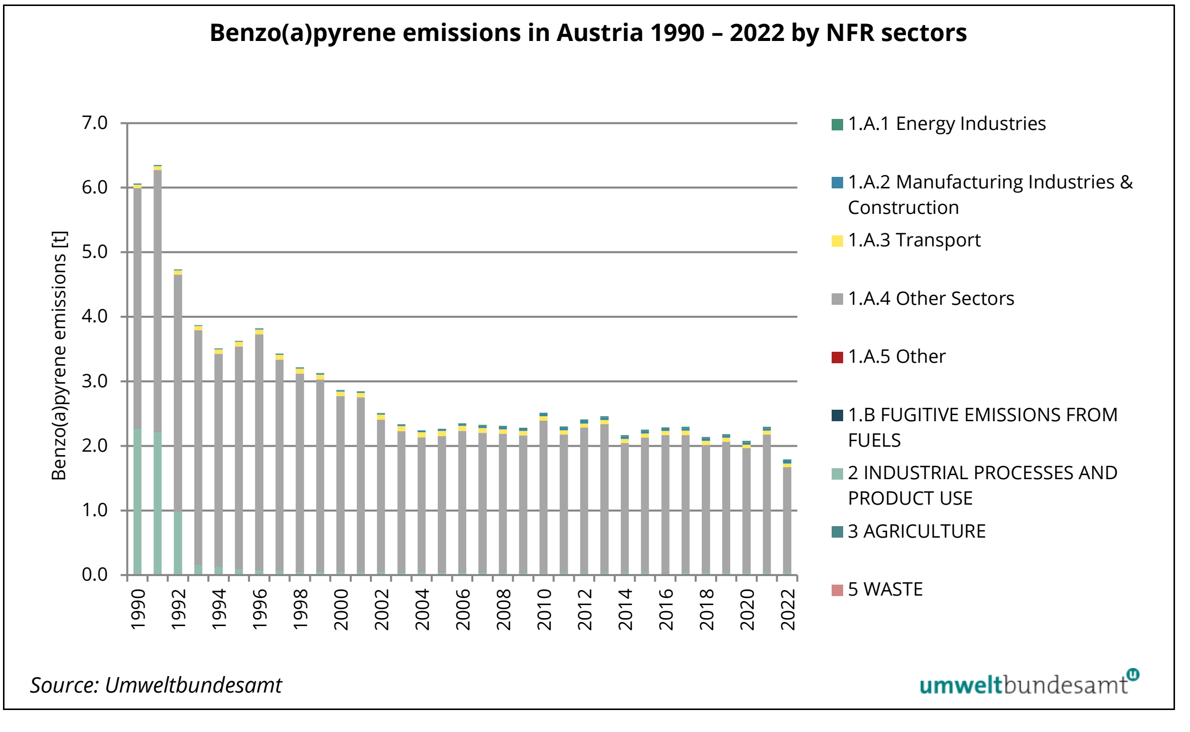
In 1990 national total Benzo(a)pyrene emissions amounted to 6.1 t; emissions have decreased between 1990 and 2022 by about 70% (to 1.8 t in 2022). The greatest reductions were made until 1993.

Figure 29: Share of NFR sectors 2022 in Benzo(a)pyrene emissions.



Note: Benzo(a)pyrene emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as NA.

Figure 30: Benzo(a)pyrene emissions in Austria 1990–2022 by sectors in absolute terms.

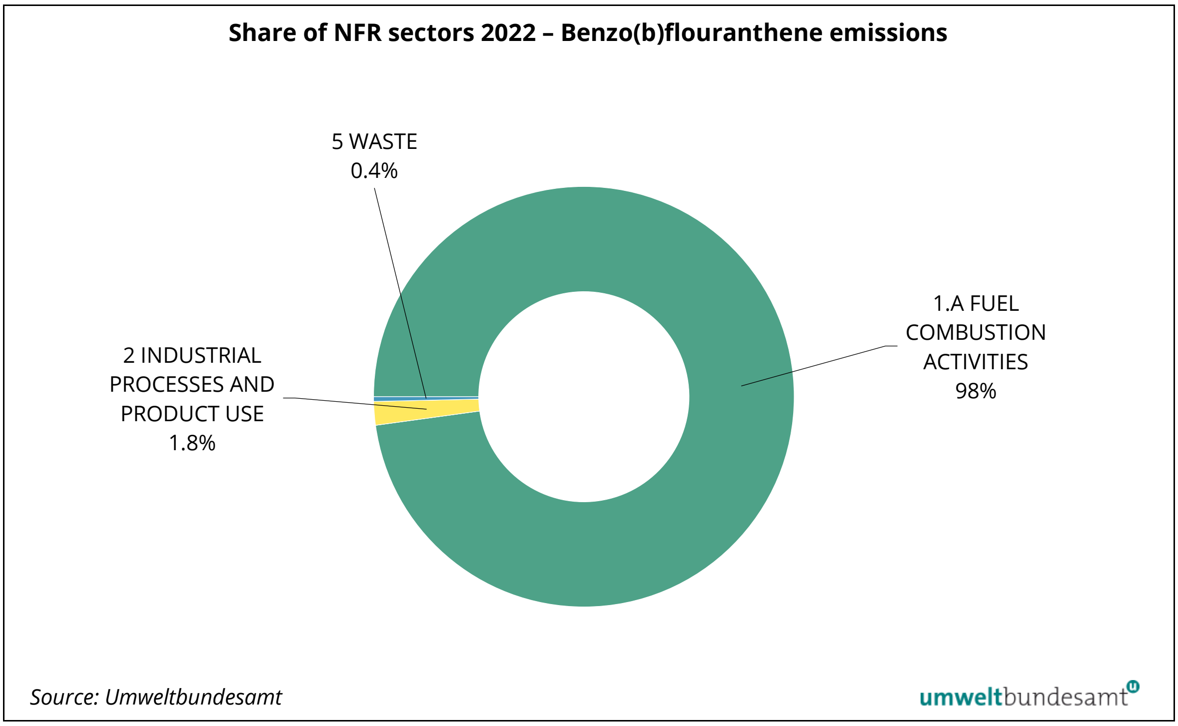


2.4.1.2 Benzo(b)floranthene

The most important emission sources for Benzo(b)floranthene emissions were NFR *1.A Fuel Combustion Activities* (64%) and *2 Industrial Processes and Product Use* (35%) in 1990. In 2022 emissions are arising almost solely from source category *1.A Fuel Combustion Activities* with 98% of national total Benzo(b)floranthene emissions as it is indicated in Figure 31. NFR sector *2 Industrial Processes and Product Use* contributes with 1.8% of national total emissions in 2022.

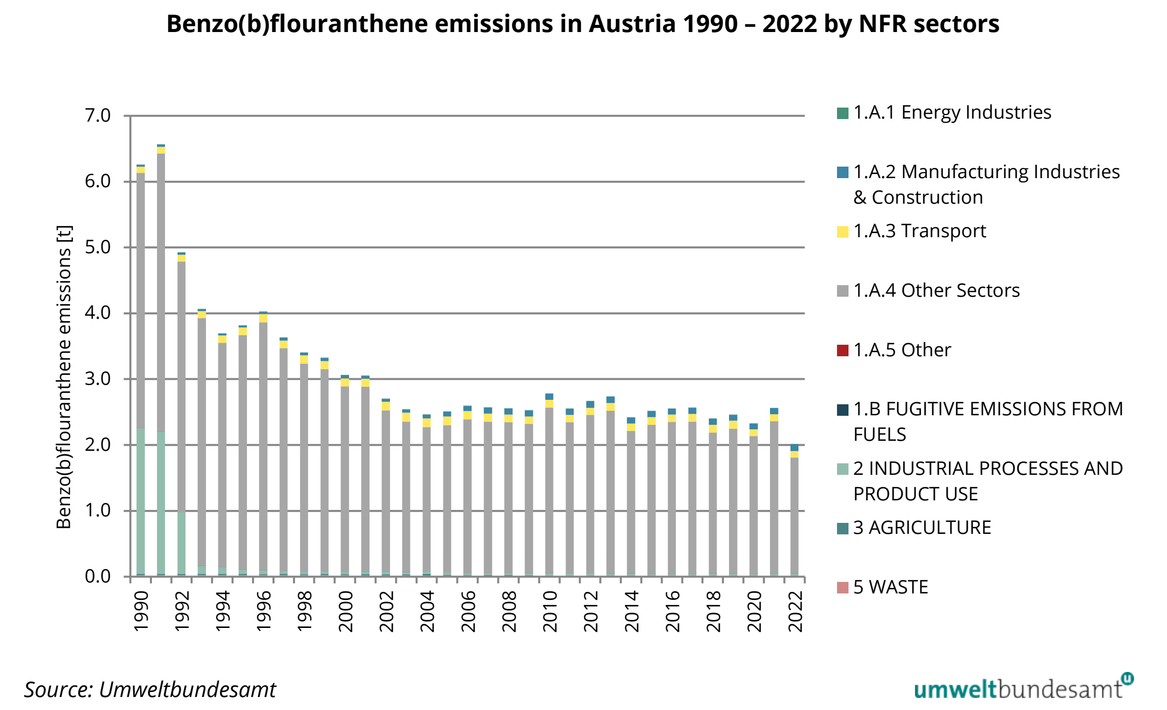
From 1990 to 2020 Benzo(b)floranthene emissions from Agriculture decreased continuously due to prohibition of open field burning and since 2021, no emissions occurred from this source. NFR sector 5 Waste (0.4%) is a minor source in 2022. In 1990 national total Benzo(b)flouranthene emissions amounted to 6.3 t; emissions have decreased between 1990 and 2022 by about 68% (to 2.0 t in 2022), where the largest reductions were made until 1993.

Figure 31: Share of NFR sectors 2022 in Benzo(b)flouranthene emissions.



Note: Benzo(b)flouranthene emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as NA.

Figure 32: Benzo(b)flouranthene emissions in Austria 1990–2022 by sectors in absolute terms.



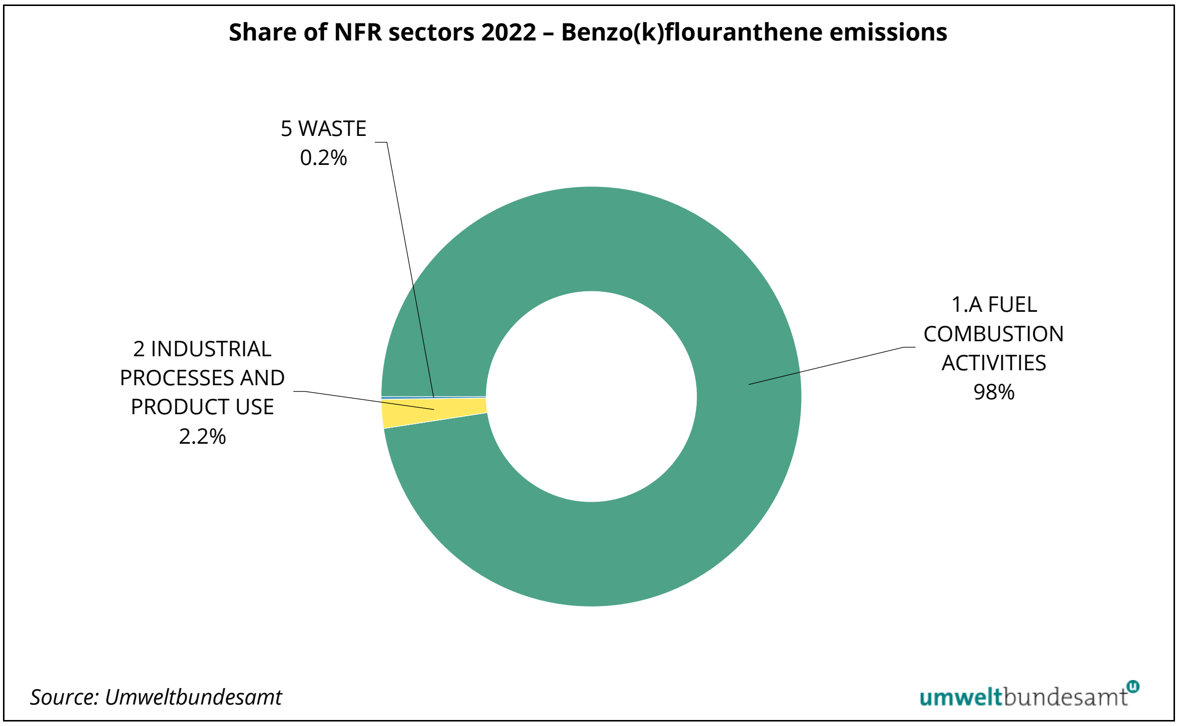
2.4.1.3 Benzo(k)fluoranthene

In 1990 the two main emission sources for Benzo(k)floranthene emissions were NFR *1.A Fuel Combustion Activities* (42%) and *2 Industrial Processes and Product Use* (57%). In 2022 emissions are stemming almost exclusively from source category *1.A Fuel Combustion Activities* with 98% of national total Benzo(k)floranthene emissions (please refer to Figure 33). NFR sector *2 Industrial Processes and Product Use* contributes in 2022 with 2.2% of national total emissions.

Benzo(k)floranthene emissions from Agriculture decreased continuously between 1990 and 2020 as a result of the prohibition of open field burning. Finally, emissions from this source are not occurring since 2021. NFR sector 5 Waste (0.2%) is a minor source in 2022.

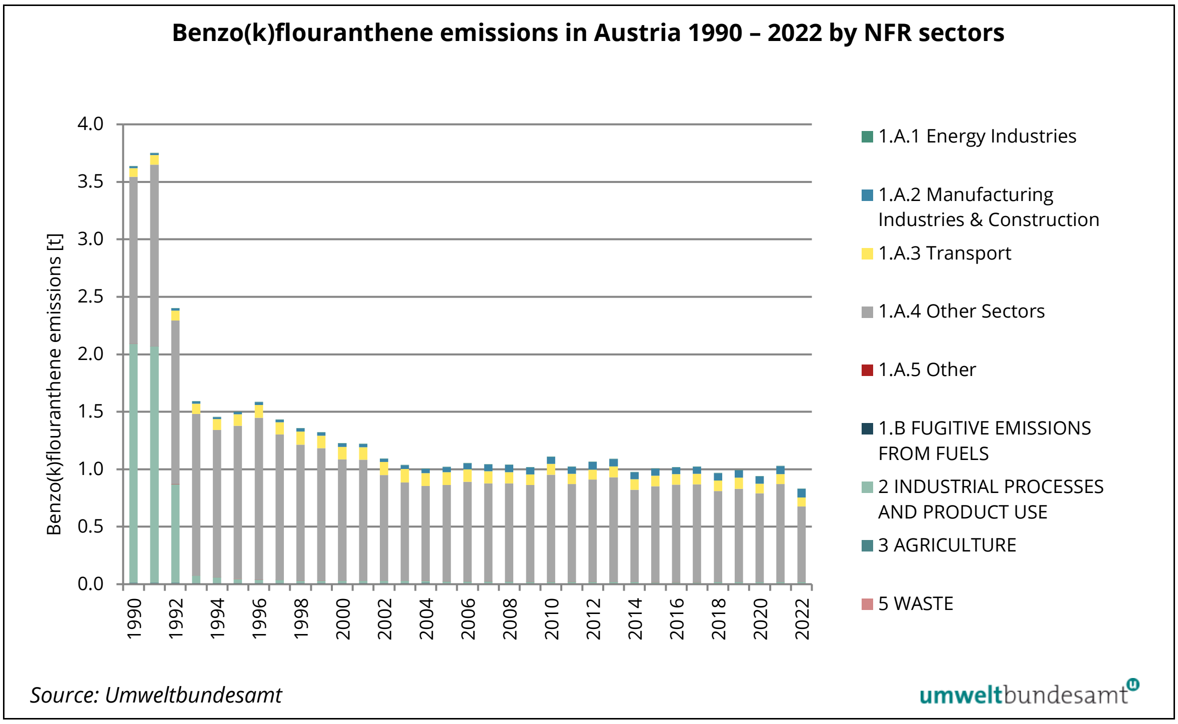
In 1990 national total Benzo(k)flouranthene emissions amounted to 3.6 t; emissions have decreased between 1990 and 2022 by about 77% (to 0.8 t in 2022). The largest reductions took place until 1993.

Figure 33: Share of NFR sectors 2022 in Benzo(k)flouranthene emissions.



Note: Benzo(k)flouranthene emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as NA.

Figure 34: Benzo(k)flouranthene emissions in Austria 1990–2022 by sectors in absolute terms.



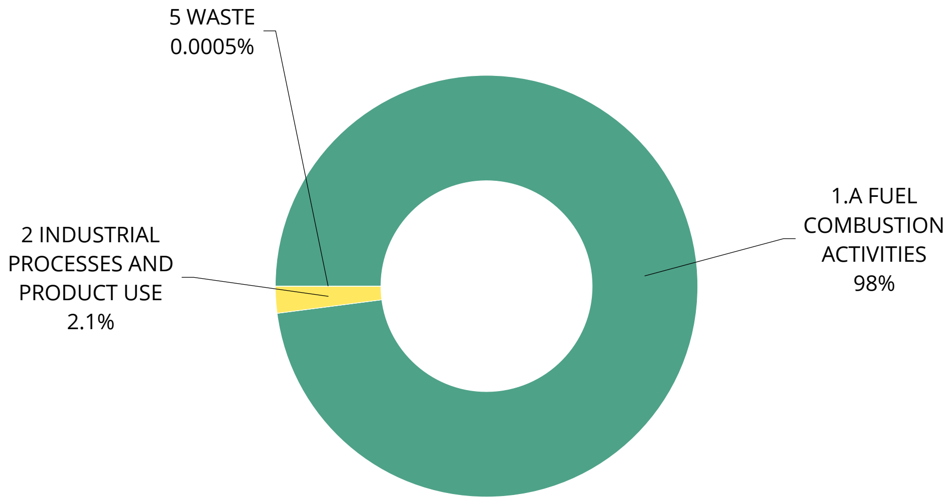
2.4.1.4 Indeno (1,2,3-cd) pyrene

In 1990 the most important emission sources for Indeno (1,2,3-cd) pyrene emissions were NFR *1.A Fuel Combustion Activities* (83%) and *2 Industrial Processes and Product Use* (16%). In 2022 emissions are almost exclusively emitted from source category *1.A Fuel Combustion Activities* with 98% of national total Indeno (1,2,3-cd) pyrene emissions as indicated in Figure 35. NFR sector *2 Industrial Processes and Product Use* contributes in 2022 with 2.1% of national total emissions.

Due to prohibition of open field burning Indeno (1,2,3-cd) pyrene emissions from Agriculture fell by 100% between 1990 and 2020; since 2021 emissions are "not occurring". In 2022 NFR sector *5 Waste* (0.0005%) is a minor source.

Figure 35: Share of NFR sectors 2022 in Indeno (1,2,3-cd) pyrene emissions.

Share of NFR sectors 2022 – Indeno(1,2,3-c,d)pyrene emissions

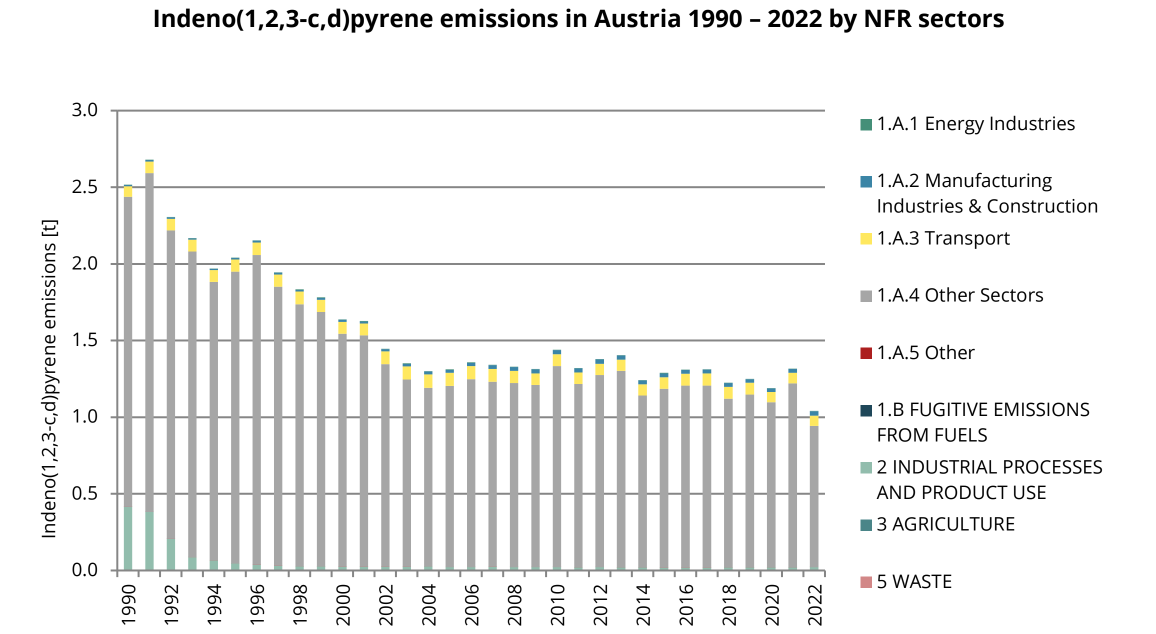


Source: Umweltbundesamt

Note: Indeno (1,2,3-cd) pyrene emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as NA.

In 1990 national total Indeno (1,2,3-cd) pyrene emissions amounted to 2.5 t; emissions have decreased between 1990 and 2022 by about 59% (to 1.0 t in 2022). The largest reductions could be achieved until 1993.

Figure 36: Indeno (1,2,3-cd) pyrene emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

2.4.2 Dioxins and Furan (PCDD/F)

Dioxins form a family of toxic chlorinated organic compounds that share certain chemical structures and biological characteristics. Several hundred of these compounds exist and are members of three closely related families: the chlorinated dibenzo(p)dioxins (CDDs), chlorinated dibenzofurans (CDFs) and certain polychlorinated biphenyls (PCBs). Dioxins bio-accumulate in humans and wildlife due to their fat solubility and 17 of these compounds are especially toxic.

Dioxins are formed as a result of combustion processes such as commercial or municipal waste incineration and from burning fuels like wood, coal or oil as a main source of dioxins. Dioxins can also be formed when household trash is burned and as a result of natural processes such as forest fires. Dioxins enter the environment also through the production and use of organ chlorinated compounds: chlorine bleaching of pulp and paper, certain types of chemical manufacturing and processing, and other industrial processes are able to create small quantities of dioxins. Cigarette smoke also contains small amounts of dioxins.

Due to stringent legislation and modern technology, dioxin emissions from combustion and incineration as well as from chemical manufacturing and processes have been reduced dramatically. Nowadays domestic combustion as well as thermal processes in metals extraction and processing have become more significant.

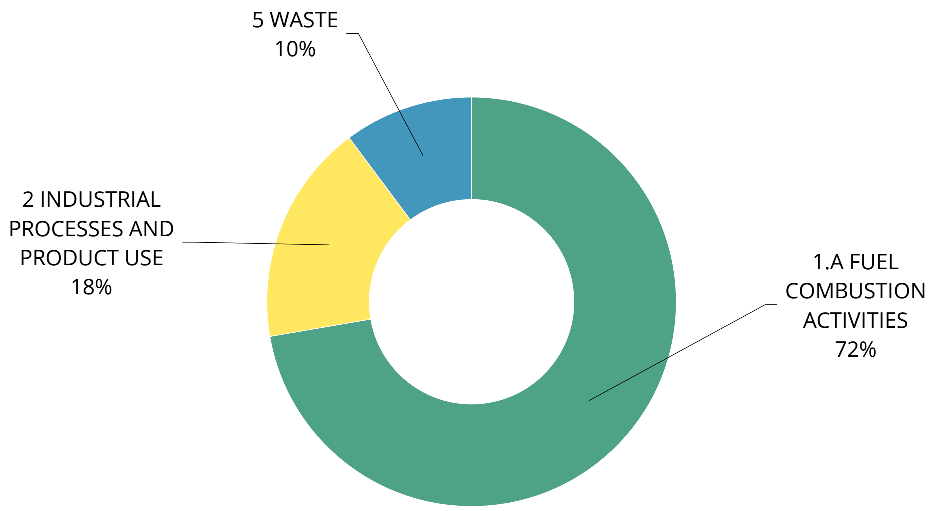
Main sources and emission trend in Austria

The main source for dioxin and furan emissions in Austria, with a share of 72% in 2022, is category *1.A Fuel Combustion Activities* (see Figure 37 and Table 60). Sector *2 Industrial Processes and Product Use* contributes with 18% in national total emissions.

In 2022, no PCDD/F emissions occurred from sectors *3 Agriculture* (*3.F Field burning of agricultural residues* is "not occurring"). NFR sector *5 Waste* contributes with 10% to national total emissions (mainly due to *5.E Other Waste* comprising unwanted fires in cars and various types of houses).

Figure 37: Share of NFR sectors 2022 in Dioxin/furan emissions.

Share of NFR sectors 2022 – Dioxin/furan emissions



Source: Umweltbundesamt

umweltbundesamt

Note: Dioxin/furan emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as NA.

In 1990 national total dioxin/furan (PCDD/F) emissions amounted to about 122 g; emissions have decreased since then, where the main achievement was made until 1993, by the year 2022 emissions were reduced by about 74% (to 32 g in 2022). In 2022, emissions fell by 15% compared to the previous year due to remarkably lower emissions from residential heating.

NFR 1.A Fuel Combustion Activities

In more detail within sector *1.A Fuel Combustion Activities*, the main sources of dioxin and furan emissions are:

- *NFR 1.A.4 Other Sectors:* This sector has the highest contribution (51%) to national total dioxin/furan (PCDD/F) emissions in 2022 within source *1.A Fuel Combustion Activities* due to biomass heating. The emission reduction of 22% in 2022 compared to 2021 is due to the warmer weather and higher energy prices resulting in reduced consumption of biomass.
- *NFR 1.A.2 Manufacturing Industries and Construction:* Emissions increased significantly since 1990 due to increased use of biomass and contribute with 12% to national dioxin/furan (PCDD/F) emissions in 2022.
- *NFR 1.A.1 Energy Industries:* Emissions decreased significantly since 1990 due to improved flue gas cleaning of waste incineration plants.

NFR 2 Industrial Processes and Product Use

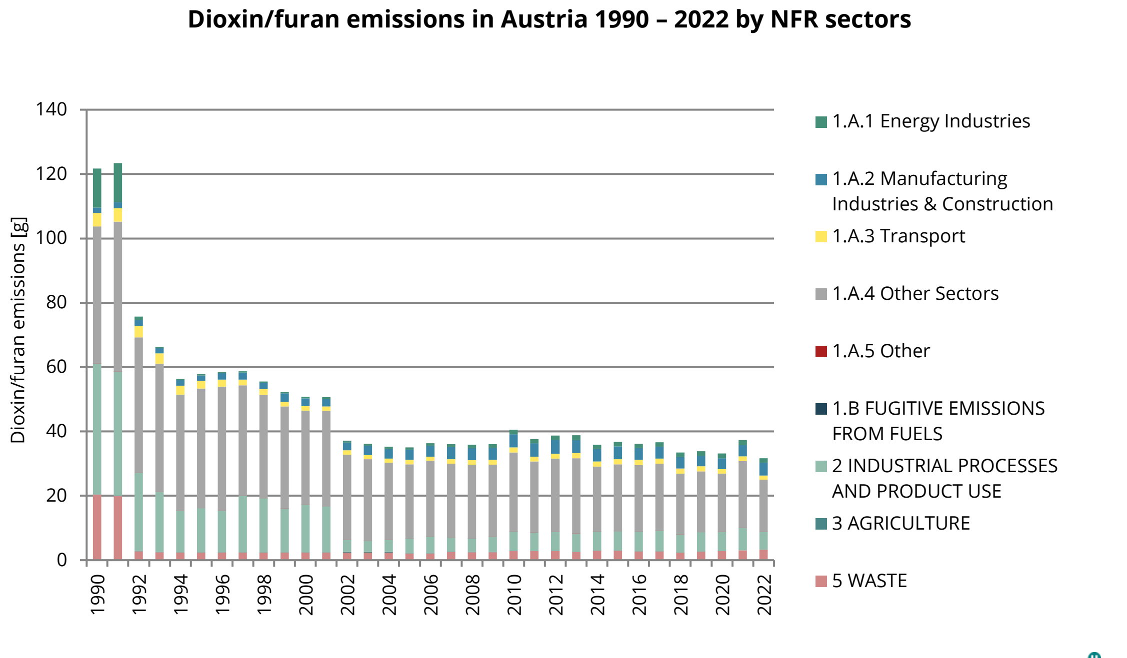
The second largest sector is *2 Industrial Processes and Product Use* (18% in national total emissions in 2022), where emissions are almost exclusively emitted by one subcategory:

- *NFR 2.C Metal Production:* Dioxin/furan (PCDD/F) emissions decreased remarkably due to extensive abatement measures since 1990 (-86%). Within this sector emissions are emitted by subcategories *2.C.1 Iron and Steel Production, 2.C.3 Aluminium Production, 2.C.5 Lead Production* and *2.C.7 Other metal production* (copper production). Between 2021 and 2022, emissions from subcategory *2.C.1 Iron and Steel Production* fell significantly by 61% due to changes in the production process.

NFR 5 Waste

- *5 Waste:* From 1990 to 2022 dioxin/furan (PCDD/F) emissions from sector *Waste* decreased by 84% due to stringent legislation and modern technology. As shown in Table 60 in the period from 1990 to 2022 dioxin/furan emissions decreased to 3.2 g, which is a share of 10% in total dioxin/furan emissions, whereas in 1990 dioxin/furan (PCDD/F) emissions contributed 17% to the total dioxin/furan emissions. Within sector *Waste* the main emission source is *5.E Other Waste* comprising emissions from unintential fires, which is rated as a key source for dioxin/furan (PCDD/F) emissions in 2022.

Figure 38: Dioxin/Furan emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 60: Dioxin/Furan (PCDD/F) emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		Dioxin Emission in [g]		Trend		Share in National Total	
		1990	**2022**	**1990–2022**	**2021–2022**	**1990**	**2022**
1	ENERGY	60.58	22.93	-62.2%	-15.9%	50%	72%
1.A	FUEL COMBUSTION ACTIVITIES	60.58	22.93	-62.2%	-15.9%	50%	72%
1.A.1	Energy Industries	12.14	1.46	-88.0%	-5.6%	10%	5%
1.A.2	Manufacturing Industries and Construction	1.68	3.91	132.6%	12.1%	1%	12%
1.A.2.a	Iron and Steel	0.03	0.03	-9.5%	27.5%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.02	0.04	98.9%	8.4%	<1%	<1%
1.A.2.c	Chemicals	0.44	0.65	50.0%	26.4%	<1%	2%
1.A.2.d	Pulp, Paper and Print	0.50	0.59	17.8%	-1.9%	<1%	2%
1.A.2.e	Food Processing, Beverages and Tobacco	0.03	0.07	131.2%	126.9%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.29	0.48	65.3%	0.5%	<1%	2%
1.A.2.g	Manufacturing Industries and Constr. - other	0.37	2.04	453.5%	13.7%	<1%	6%
1.A.3	Transport	4.15	1.36	-67.2%	-8.4%	3%	4%
1.A.3.a	Civil Aviation	NE	NE	NE	NE	NE	NE
1.A.3.b	Road Transportation	4.10	1.33	-67.5%	-8.8%	3%	4%
1.A.3.c	Railways	0.04	0.01	-75.2%	-2.1%	<1%	<1%
1.A.3.d	Navigation	0.01	0.01	25.6%	29.1%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	82.9%	-4.7%	<1%	<1%
1.A.4	Other Sectors	42.62	16.20	-62.0%	-21.9%	35%	51%
1.A.4.a	Commercial/Institutional	1.73	0.56	-67.6%	-22.6%	1%	2%
1.A.4.b	Residential	39.36	14.30	-63.7%	-22.3%	32%	45%
1.A.4.c	Agriculture/Forestry/Fisheries	1.53	1.34	-12.2%	-17.7%	1%	4%
1.A.5	Other	0.00	0.00	-52.3%	-0.3%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	40.63	5.55	-86.3%	-20.4%	33%	18%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	NA	NA	NA	NA	NA	NA
2.C	METAL PRODUCTION	37.78	5.42	-85.6%	-20.8%	31%	17%
2.C.1	Iron and Steel Production	34.51	0.53	-98.5%	-61.0%	28%	2%
2.C.2	Ferroalloys Production	NE	NE	NE	NE	NE	NE
2.C.3	Aluminium production	2.40	3.48	44.9%	-14.6%	2%	11%
2.C.4	Magnesium production	NO	NO	NO	NO	NO	NO
2.C.5	Lead Production	0.07	0.08	14.8%	0.0%	<1%	<1%
2.C.6	Zinc production	NO	NO	NO	NO	NO	NO
2.C.7	Other metal production	0.80	1.34	67.4%	0.0%	1%	4%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	1.06	NA	NA	NA	1%	NA
2.G	Other product manufacture and use	0.00	0.00	-22.7%	-3.5%	<1%	<1%
2.H	Other Processes	1.79	0.13	-92.7%	0.0%	1%	<1%
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	"Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	0.13	NA	NA	NA	<1%	NA
5	WASTE	20.34	3.23	-84.1%	6.2%	17%	10%
	Total without sinks	**121.68**	**31.72**	**-73.9%**	**-15.0%**		

2.4.3 Hexachlorobenzene (HCB) Emissions

Hexachlorobenzene (HCB) has been widely employed as a fungicide on seeds, especially against the fungal disease 'bunt' that affects some cereal crops. The marketing and use of hexachlorobenzene as a plant protection product was banned in the European Union in 1988.

As there is no more hexachlorobenzene production in the EU, the only man-made releases of hexachlorobenzene are as unintentional by-product; it is emitted from the same chemical and thermal processes as Dioxins/Furans (PCDD/F) and formed via a similar mechanism.

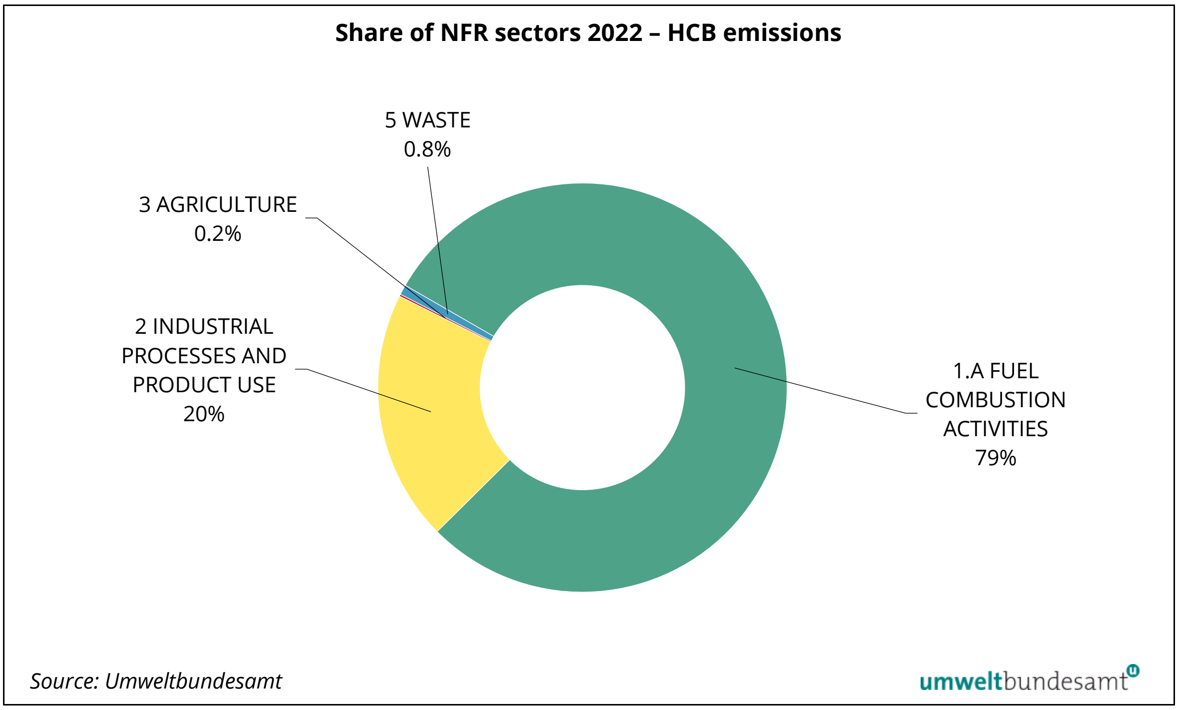
It is released to the environment as an unintentional by-product in chemical industry (production of several chlorinated hydrocarbons such as drugs, pesticides or solvents) and in metal industries and is formed in combustion processes in the presence of chlorine.

Main sources and emission trends in Austria

As can be seen in Figure 39 and Table 61 the main HCB emission source in 2022 is NFR sector *1.A Fuel Combustion Activities* with 79% in national total emissions. Sector *2 Industrial Processes and Product Use* has a share of 20% in national total emissions and sectors NFR *3 Agriculture* has a share of 0.2%.

From 1990 to 2022 HCB emissions from the sector NFR *5 Waste* decreased remarkably by 80%, respectively, due to stringent legislation and modern technology. This sector is a minor source of HCB emissions in 2022 with a share 0.8% in national total emissions.

Figure 39: Share of NFR sectors 2022 in HCB emissions.



Note: HCB emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as NA.

Total emissions of HCB are decreasing over the period 1990–2022 by 87%. However, due to unintentional HCB releases in 2012, 2013 and 2014 emissions rose to a very high level: HCB contaminated material (lime) was co-incinerated in a cement plant at too low temperatures, that's why the

HCB was not destroyed as planned. The sharp decrease of total emissions between 2014 and 2015 can therefore be explained as emissions in 2015 were at the usual level again. Between 2021 and 2022 HCB emissions decreased by 18% mainly due to falling emissions from residential heating (*1.A.4.b.i*) and to a lesser extent also from 2*.C.1 Iron and Steel Production* and *2.C.3 Aluminium Production*.

NFR 1.A Fuel Combustion Activities

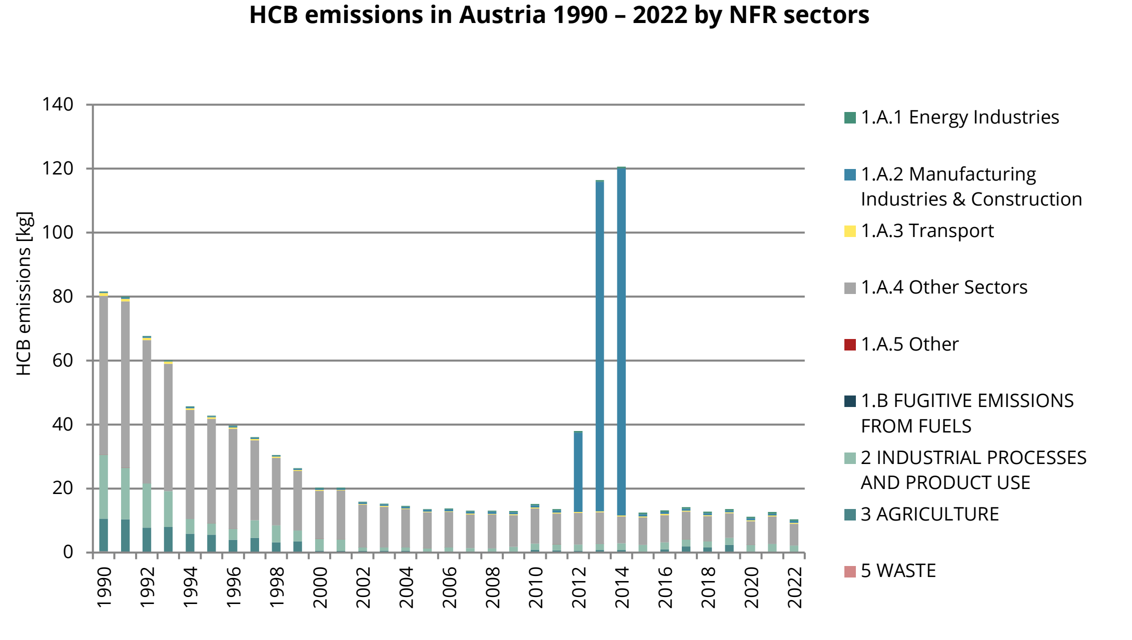
Within this source category the small combustion sector (i.e. residential heating) is the most important sector. HCB emissions of sector 1.A decreased by 84% since 1990.

- *NFR 1.A.4 Other Sectors:* This subcategory had a share of 61% in 1990 and 66% in 2022 and is the highest contributor within sector *1.A Fuel Combustion Activities* due to the high amounts of biomass used in the residential sector. Since 1990 emissions decreased by 86%. Compared to the previous year a significant decrease of 21% can be observed in 2022 due to the lower heating demand because of the the warmer weather but also due to the higher prices on the energy market.

NFR 2 Industrial Processes and Product Use

The second largest sector for HCB emissions in 2022 was *2 Industrial Processes and Product Use* with a share of 20% in national total emissions. HCB emissions of this sector decreased by 90% between 1990 and 2022. HCB was a by-product of chlorinated pesticides, which production was the main souce of HCB emissions in Austria. It was banned step-by-step in the beginning of the 1990s, leaving *2.C Metal Production* as now the almost exclusive emitting subcategory.

Figure 40: HCB emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 61: Hexachlorbenzene (HCB) emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		HCB Emission in [kg]		Trend		Share in National Total	
		1990	**2022**	**1990–2022**	**2021–2022**	**1990**	**2022**
1	ENERGY	51.04	8.24	-83.9%	-17.7%	63%	79%
1.A	FUEL COMBUSTION ACTIVITIES	51.04	8.24	-83.9%	-17.7%	63%	79%
1.A.1	Energy Industries	0.28	0.51	83.8%	-3.8%	<1%	5%
1.A.2	Manufacturing Industries and Construction	0.29	0.64	120.9%	10.9%	<1%	6%
1.A.2.a	Iron and Steel	0.01	0.00	-19.4%	23.6%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	-38.5%	26.0%	<1%	<1%
1.A.2.c	Chemicals	0.07	0.10	53.7%	26.5%	<1%	1%
1.A.2.d	Pulp, Paper and Print	0.10	0.12	17.8%	-1.9%	<1%	1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.01	157.7%	144.6%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.06	0.08	42.0%	-2.6%	<1%	1%
1.A.2.g	Manufacturing Industries and Constr. - other	0.06	0.33	484.4%	13.6%	<1%	3%
1.A.3	Transport	0.83	0.27	-67.2%	-8.4%	1%	3%
1.A.3.a	Civil Aviation	NA	NA	NA	NA	NA	NA
1.A.3.b	Road Transportation	0.82	0.27	-67.5%	-8.8%	1%	3%
1.A.3.c	Railways	0.01	0.00	-75.2%	-2.1%	<1%	<1%
1.A.3.d	Navigation	0.00	0.00	25.6%	29.1%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	82.9%	-4.7%	<1%	<1%
1.A.4	Other Sectors	49.64	6.82	-86.3%	-20.8%	61%	66%
1.A.4.a	Commercial/Institutional	1.17	0.26	-78.1%	-22.5%	1%	2%
1.A.4.b	Residential	47.57	6.06	-87.3%	-20.9%	58%	58%
1.A.4.c	Agriculture/Forestry/Fisheries	0.90	0.50	-43.7%	-18.6%	1%	5%
1.A.5	Other	0.00	0.00	-52.3%	-0.3%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	20.07	2.06	-89.7%	-19.3%	25%	20%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	1.26	NA	NA	NA	2%	NA
2.C	METAL PRODUCTION	9.40	2.03	-78.3%	-19.5%	12%	20%
2.C.1	Iron and Steel Production	8.09	0.12	-98.5%	-61.4%	10%	1%
2.C.2	Ferroalloys Production	NE	NE	NE	NE	NE	NE
2.C.3	Aluminium production	1.20	1.74	44.9%	-14.6%	1%	17%
2.C.4	Magnesium production	NO	NO	NO	NO	NO	NO
2.C.5	Lead Production	NA	NA	NA	NA	NA	NA
2.C.6	Zinc production	NO	NO	NO	NO	NO	NO
2.C.7	Other metal production	0.10	0.17	67.4%	0.0%	<1%	2%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	9.05	NA	NA	NA	11%	NA
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE
2.H	Other Processes	0.36	0.03	-92.7%	0.0%	<1%	<1%
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	"Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	10.14	0.02	-99.8%	22.1%	12%	<1%
5	WASTE	0.40	0.08	-79.7%	4.3%	<1%	1%
	Total without sinks	**81.66**	**10.40**	**-87.3%**	**-17.9%**		

2.4.4 Polychlorinated biphenyl (PCB) Emissions

Polychlorinated Biphenyls are a class of synthetic organic chemicals and there are 209 configurations. Since 1930 until the beginning of the 1980´s PCBs were used for a variety of industrial uses (mainly as dielectric fluids in capacitors and transformers but also as flame retardants, ink solvents, plasticizers etc.) because of their chemical stability (fire resistance, low electrical conductivity, high resistance to thermal breakdown and a high resistance to oxidants and other chemicals)[76].

PCBs have entered the environment through both use and disposal. PCBs can be easily carried along from the place of contamination and are distributed in all global ecosystems (Umweltbundesamt, 1996). Because of its substantial characteristics PCB is persistent. As it is also liposoluble it is easily accumulated in the food chain (Bayerisches Landesamt für Umwelt, 2008).

PCB production was banned by the United States Congress in 1979 and by the Stockholm Convention on Persistent Organic Pollutants[77] in 2001 because of its environmental toxicity and classification as a persistent organic pollutant. As PCB is no longer produced in the EU, the only man-made release of PCB is as unintentionally produced pollutant (Umweltbundesamt, 2012).

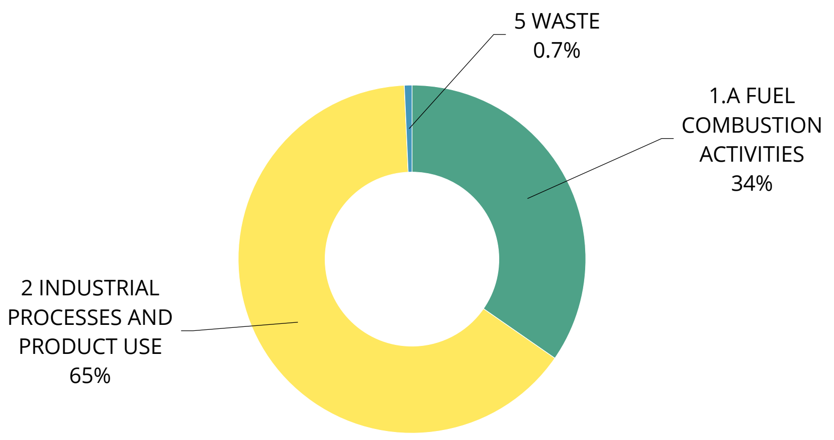
Main sources and emission trends in Austria

Austrian PCB emissions are largely emitted in NFR sector *2 Industrial Processes and Product Use* with a share of 65% in national total PCB emissions in 2022 (see Figure 41 and Table 62).

NFR 1.A Fuel Combustion Activities, both from stationary and mobile sources (*NFR 1.A.3 Transport*), is also a source of PCB emissions with a share of 35% in total emissions in 2022. PCB emissions from this sector are decreasing since 1990, mainly due to a reduced consumption of coal and bunker oil. Emissions from subcategory *Transport* are a minor source and do not influence the emission trend.

Figure 41: Share of NFR sectors 2022 in PCB emissions.

Share of NFR sectors 2022 – PCB emissions



Source: Umweltbundesamt

umweltbundesamt

Note: PCB emissions from NFR sector 1.B Fugitive Emissions from fuels are reported as NA.

[76] http://chm.pops.int/Implementation/PCBs/Overview/tabid/273/Default.aspx

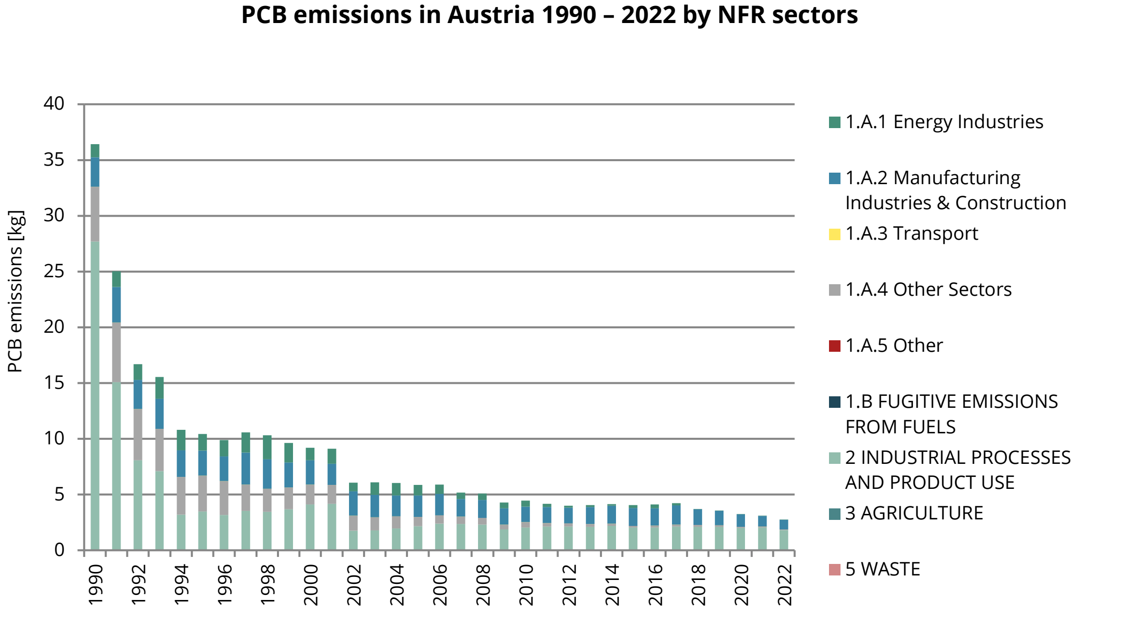
[77] http://chm.pops.int/default.aspx

In 1990 national total PCB emissions amounted to about 36 kg; emissions have decreased by 92% and in 2022 emissions were at the level of 2.8 kg. The emission trend is largely influenced by metal production. Between 2021 and 2022 total emissions decreased by 9.8% because of falling emissions from *sectors 2.C.1 Iron and Steel Production* (change in production process*)* and *1.A 2.d Pulp, Paper and Print* (lower hard coal consumption).

NFR 2 Industrial Processes and Product Use

This sector is the main souce for PCB emissions in Austria. In the beginning of the 90ies *2.C.5 Lead Production* was the major emitting process, but with the shutdown of primary lead production in Austria in 1993, PCB is almost exclusively emitted by *2.C.1 Iron and Steel Production.* Due to abatement measures, emissions from this category decreased by 79% from 1990 to 2022.

Figure 42: PCB emissions in Austria 1990–2022 by sectors in absolute terms.



Source: Umweltbundesamt

Table 62: Polychlorinated biphenyl (PCB) emissions per NFR Category 1990 and 2022, trend 1990–2022 and share in total emissions.

NFR Category		PCB Emission in [kg]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1	ENERGY	8.73	0.96	-89.0%	-8.0%	24%	35%
1.A	FUEL COMBUSTION ACTIVITIES	8.73	0.96	-89.0%	-8.0%	24%	35%
1.A.1	Energy Industries	1.16	0.04	-96.4%	30580.2%	3%	2%
1.A.2	Manufacturing Industries and Construction	2.64	0.85	-67.6%	-10.8%	7%	31%
1.A.2.a	Iron and Steel	0.08	0.01	-82.5%	-0.9%	<1%	1%
1.A.2.b	Non-ferrous Metals	0.04	0.02	-39.1%	46.3%	<1%	1%
1.A.2.c	Chemicals	0.21	0.10	-51.1%	50.8%	1%	4%
1.A.2.d	Pulp, Paper and Print	1.49	0.26	-82.8%	-36.5%	4%	9%
1.A.2.e	Food Processing, Beverages and Tobacco	0.15	0.03	-82.3%	24.6%	<1%	1%

NFR Category		PCB Emission in [kg]		Trend		Share in National Total	
		1990	2022	1990–2022	2021–2022	1990	2022
1.A.2.f	Non-metallic Minerals	0.48	0.43	-10.1%	-0.4%	1%	15%
1.A.2.g	Manufacturing Industries and Constr. - other	0.19	0.00	-98.0%	-26.5%	1%	<1%
1.A.3	Transport	0.00	0.00	-47.3%	-8.6%	<1%	<1%
1.A.4	Other Sectors	4.92	0.06	-98.7%	-25.2%	14%	2%
1.A.4.a	Commercial/Institutional	0.30	0.00	-100.0%	-22.6%	1%	<1%
1.A.4.b	Residential	4.53	0.06	-98.6%	-25.1%	12%	2%
1.A.4.c	Agriculture/Forestry/Fisheries	0.09	0.00	-98.1%	-29.2%	<1%	<1%
1.A.5	Other	0.00	0.00	-78.5%	-7.0%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	27.68	1.79	-93.5%	-10.9%	76%	65%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	NA	NA	NA	NA	NA	NA
2.C	METAL PRODUCTION	27.68	1.79	-93.5%	-10.9%	76%	65%
2.C.1	Iron and Steel Production	8.52	1.79	-78.9%	-10.9%	23%	65%
2.C.2	Ferroalloys Production	NA	NA	NA	NA	NA	NA
2.C.3	Aluminium production	NA	NA	NA	NA	NA	NA
2.C.4	Magnesium production	NO	NO	NO	NO	NO	NO
2.C.5	Lead Production	19.16	0.00	-100.0%	0.0%	53%	<1%
2.C.6	Zinc production	NO	NO	NO	NO	NO	NO
2.C.7	Other metal production	0.00	0.00	67.4%	0.0%	<1%	<1%
2.C.7.a	Copper production	0.00	0.00	67.4%	0.0%	<1%	<1%
2.C.7.b	Nickel production	NO	NO	NO	NO	NO	NO
2.C.7.c	Other metals	NA	NA	NA	NA	NA	NA
2.C.7.d	Storage, handling and transport of metal prod-ucts	NA	NA	NA	NA	NA	NA
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NA	NA	NA	NA	NA	NA
2.G	Other product manufacture and use	NA	NA	NA	NA	NA	NA
2.H	Other Processes	NA	NA	NA	NA	NA	NA
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	"Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	NA	NA	NA	NA	NA	NA
5	WASTE	0.00	0.02	377.1%	4.5%	<1%	1%
	Total without sinks	**36.41**	**2.77**	**-92.4%**	**-9.8%**		

2.5 Fuel export

Emission calculations for sector road transport are based on the quantity of fuel sold in Austria. However, it is important to note that the fuel quantity, which is sold in Austria, is higher compared to the quantity of fuel that is used and consumed in Austria. This is referred to as “fuel export”. In Austria there is a net export of fuels in vehicle tanks that cross national borders, with subse-quent combustion and emissions taking place outside the national territory.

The dynamic is explained in part by structural conditions (Austria is a land-locked country with a high share of exports in the economy) and by differ-ences in fuel price levels between Austria and its neighboring countries.

The net quantities of fuel exported (and used) abroad can be determined from the difference between fuel sales in Austria and the calculated domestic consumption. Emissions from "fuel exports in motor vehicles" are derived from the associated mileage (car-km) of cars and heavy-duty vehicles outside the national territory.

The table below shows the emissions from fuel exports. In 2022, NOx emissions were estimated at 7.1 kt, which is around 6.2 % of Austria's national total NOx emissions.

From the end of the 1990s, there was an increase of these exported NOx emissions, mainly from heavy-duty vehicles. A peak was reached in 2005; since then, fuel exports have declined continually. In 2022, the share of fuel export is 14 % of emissions from *1.A.3.b. Road Transport* and 6.2 % of the national total NOx emissions.

Table 63: Emissions from fuel exports.

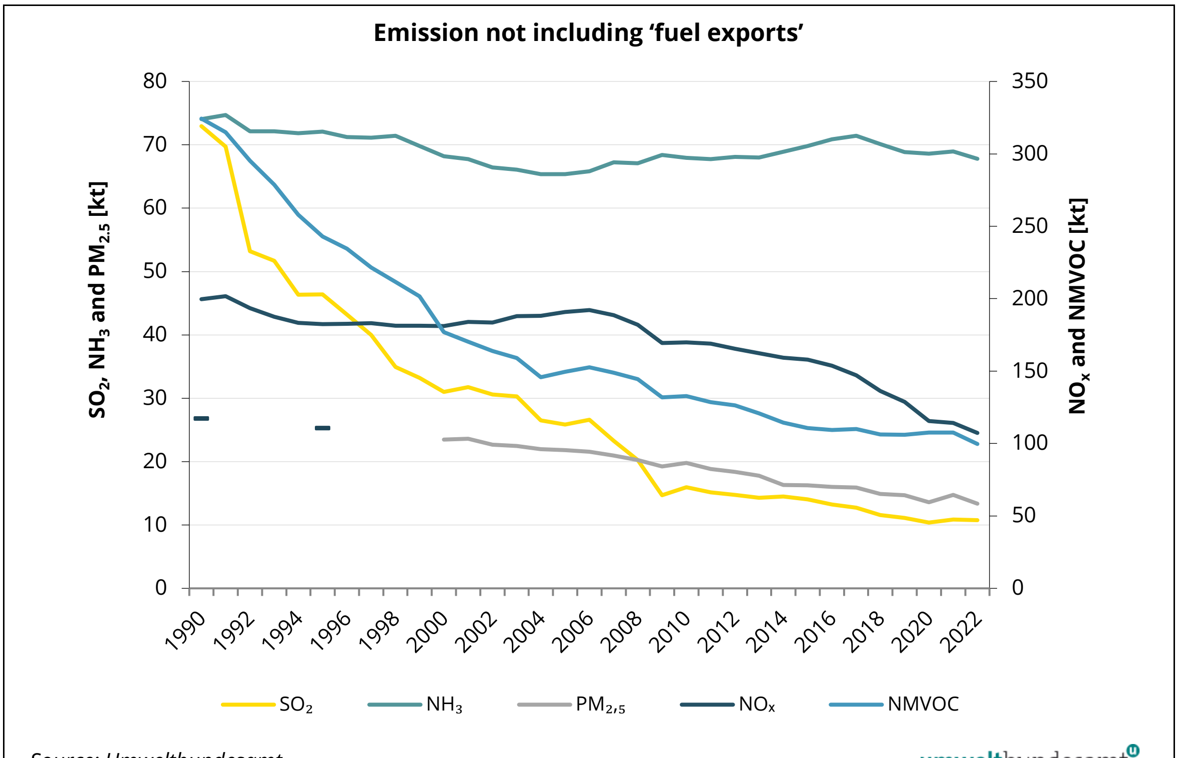
	Emissions in [kilotonnes]				
	SO_2	NO_x	NMVOC	NH_3	$PM_{2.5}$*
1990	0.76	16.44	4.43	0.05	0.54
1995	0.92	17.03	1.40	0.04	0.68
2000	0.52	31.57	0.27	-0.14	0.76
2005	0.05	56.94	4.49	0.63	1.58
2010	0.04	36.09	1.99	0.49	0.87
2011	0.03	29.02	1.53	0.40	0.67
2012	0.03	27.97	1.32	0.36	0.59
2013	0.04	31.40	1.21	0.32	0.58
2014	0.04	27.39	1.00	0.28	0.47
2015	0.04	26.19	0.97	0.29	0.44
2016	0.04	22.59	0.88	0.29	0.37
2017	0.04	20.25	0.78	0.28	0.32
2018	0.04	18.69	0.75	0.29	0.28
2019	0.04	17.00	0.67	0.29	0.24
2020	0.03	8.87	0.35	0.15	0.12
2021	0.03	9.12	0.41	0.19	0.12
2022	0.02	7.14	0.37	0.18	0.09

* *excluding emissions from tyre and break wear and road abrasion*

The national emissions without fuel exports were used to assess compliance with the emission ceilings under the NEC Directive for the years 2010 to 2019 (Directive 2001/81/EG on national emission ceilings for certain atmospheric pollutants, Annex I). However, from 2020 onwards the emissions based on fuels sold (i.e. including fuel exports) are used for assessing the compliance with the current national emission reduction commitments. This is justified in the inventory reporting guidelines[78]. It provides that the assessment of the achievement of the target is, in principle, based on the inventory data calculated on the basis of the quantity of fuel sold. However, those States whose obligations have been determined on the basis of the fuel consumed may also choose the inventory data calculated on the basis of the quantities of fuel used as the basis for assessing the achievement of the target. The emission ceilings applicable from 2010 onwards were established in the late 1990s; at that time, the problem of fuel export in the vehicle tank had not been adequately considered. However, the setting of emission reduction commitments for the years post-2020 and post-2030 is based on model calculations made on behalf of the European Commission, where fuel exports have been considered in the respective Member State targets.

The following figure shows the Austrian emissions of the pollutants SO_2, NO_x, NH_3, NMVOC and $PM_{2.5}$ without emissions from fuel exports. They are determined on the basis of the fuel used. The emission values in tabular form are listed in chapter 12.2.

Figure 43: SO_2, NO_x, NMVOC, NH_3 und $PM_{2.5}$-emissions without fuel exports.



Source: Umweltbundesamt

[78] 2023 Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution. These guidelines are also applicable under the NEC Directive.

3 ENERGY (NFR SECTOR 1)

Sector *1 Energy* considers emissions originating from fuel combustion activities (NFR 1.A)

- 1.A.1 Energy Industries
- 1.A.2 Manufacturing Industries and Construction
- 1.A.3 Transport
- 1.A.4 Other Sectors (commercial, residential and agriculture)
- 1.A.5 Other (Military)

as well as fugitive emissions from fuels (NFR 1.B)

- 1.B.1 Solid fuels
- 1.B.2 Oil and natural gas.

3.1 NFR 1.A Stationary Fuel Combustion Activities

3.1.1 General description

This chapter gives an overview of category *1.A Stationary Fuel Combustion Activities*. It includes information on completeness, QA/QC and planned improvements as well as on emissions, emission trends and methodologies applied (including emission factors).

Information is also provided in the Austrian National Inventory Report (Umweltbundesamt, 2024a) which is part of the submission under the UNFCCC.

- Additionally to information provided in this document, Annex 3.3 of (Umweltbundesamt, 2024a) includes further information on the underlying activity data used for emissions estimation. It describes the national energy balance (fuels and fuel categories, net calorific values) and the methodology of how activity data are extracted from the energy balance (correspondence of energy balance to SNAP and IPCC categories).
- National energy balance data is presented in Annex 4 of (Umweltbundesamt, 2024a) and available from Statistik Austria at: https://www.statistik.at/statistiken/energie-und-umwelt/energie

3.1.1.1 Completeness

Table 64 provides information on the status of emission estimates of all sub categories. A "✓" indicates that emissions from this sub category have been estimated.

Table 64: Completeness of "1.A Stationary Fuel Combustion Activities".

NFR Category	**NO_x**	**CO**	**NMVOC**	**SO_x**	**NH_3**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**Pb**	**Cd**	**Hg**	**DIOX**	**PAH**	**HCB**	**PCB**
1.A.1.a Public Electricity and Heat Production	✓	✓	✓	✓	✓ NE[3]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.1.b Petroleum refining	✓	✓	IE[1]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.1.c Manufacture of Solid fuels and Other Energy Industries	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]	✓ IE[4]
1.A.2.a Iron and Steel	✓	✓	✓	✓	✓	✓ IE[5]	✓ IE[5]	✓ IE[5]	✓ IE[5]	✓ IE[5]	✓ IE[5]	✓ IE[5]	✓ IE[5]	✓ IE[5]	✓ IE[5]
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	✓	✓	✓	✓	✓	✓[7]	✓[7]	✓[7]	✓	✓	✓	✓	✓	✓	✓
1.A.2.g Other Stationary combustion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.3.e.1 Pipeline compressors	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.4.a.1 Commercial/Institutional: stationary	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.4.b.1 Residential: stationary	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.4.c.1 Agriculture/ Forestry/Fishing, Stationary	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.5.a Other, Stationary (including Military)								IE[2]							

(1) NMVOC emissions from Petroleum Refining are included in 1.B.

(2) Emissions from military facilities are included in 1.A.4.a.

(3) NH_3 slip emissions from NO_x control are not estimated.

(4) Emissions from coke ovens are included in 1.A.2.a or 2.C.1. Emissions from final energy use of coal mines are included in 1.A.2.g.

(5) Heavy metals, POPs and PM emissions from integrated iron and steel plants are included in 2.C.1.

(7) PM emissions from cement kilns, lime kilns and glass furnaces are included in 2.A.1, 2.A.2 and 2.A.3.

Table 65 shows the correspondence of NFR and SNAP categories.

Table 65: NFR and SNAP categories of "1.A Stationary Fuel Combustion Activities".

NFR Category		SNAP	
1.A.1.a	Public Electricity and Heat Production	0101 0102	Public power District heating plants
1.A.1.b	Petroleum refining	0103	Petroleum refining plants
1.A.1.c	Manufacture of Solid fuels and Other Energy Industries	0104 010503 010504	Solid fuel transformation plants Oil/Gas Extraction plants Gas Turbines
1.A.2.a	Iron and Steel	0301 030302 030326	Comb. In boilers, gas turbines and stationary engines (Iron and Steel Industry) Reheating furnaces steel and iron Processes with Contact-Other(Iron and Steel Industry)
1.A.2.b	Non-ferrous Metals	0301 030324	Comb. In boilers, gas turbines and stationary engines (Non-ferrous Metals Industry) Nickel production (thermal process)
1.A.2.c	Chemicals	0301	Comb. in boilers, gas turbines and stationary engines (Chemicals Industry)
1.A.2.d	Pulp, Paper and Print	0301	Comb. in boilers, gas turbines and stationary engines (Pulp, Paper and Print Industry)
1.A.2.e	Food Processing, Beverages and Tobacco	0301	Comb. in boilers, gas turbines and stationary engines (Food Processing, Beverages and Tobacco Industry)
1.A.2.f	Non-metallic Minerals	030311 030312 030313 030317 030319 030320 030323	Cement Lime Asphalt concrete plants Glass Bricks and Tiles Fine ceramic materials Magnesium production (dolomite treatment)
1.A.2.g	Other Stationary Combustion	0301	Comb. in boilers, gas turbines and stationary engines (Industry not included in 1.A.2.a to 1.A.2.f)
1.A.3.e	Other transportation	010506	Pipeline Compressors
1.A.4.a.1	Commercial/Institutional: stationary	0201	Commercial and institutional plants Open Fire pits and Bonfires
1.A.4.b.1	Residential: stationary	0202	Residential plants Barbecue
1.A.4.c.1	Agriculture/ Forestry/Fishing: Stationary	0203	Plants in agriculture, forestry and aquaculture

3.1.1.2 Key Categories

Key category analysis is presented in Chapter 1.5. This chapter includes information on the Energy (stationary) sector. Key sources within this category are shown in Table 66.

Table 66: Key sources of sector Energy (stationary).

IPCC Category	Category Name	Pollutant	KS-Assessment
1.A.1.a	Public Electricity and Heat Production	SO_2, NO_x, Cd[2], Pb[2], Hg[2], PCDD/F, HCB[2], PM_{10}[2], $PM_{2.5}$[2]	LA, TA
1.A.1.b	Petroleum refining	SO_2[2], NO_x[1], Cd[2]	LA, TA

IPCC Category	Category Name	Pollutant	KS-Assessment
1.A.2.a	Iron and Steel	SO_2, CO	LA, TA
1.A.2.b	Non-ferrous Metals	-	-
1.A.2.c	Chemicals	-	-
1.A.2.d	Pulp, Paper and Print	SO_2[1)], NO_x[2)], Cd, Hg[2)], TSP[1)], PM_{10}[1)], $PM_{2.5}$[1)]	LA, TA
1.A.2.f	Non-metallic Minerals	SO_2[2)], NO_x, Cd[1)], Hg, PCB[2)]	LA, TA
1.A.2.g.viii	Other Stationary Combustion in Manufacturing Industries and Construction	SO, Cd, PCDD/F	LA
1.A.4.a.1	Commercial/Institutional: Stationary	SO_2[1)], TSP[1)], $PM_{2.5}$[2)]	LA, TA
1.A.4.b.1	Residential: stationary	SO_2, NO_x, NMVOC, CO, Cd, Pb[2)], Hg, PAH, PCDD/F, PCB[1)], HCB, TSP, PM_{10}, $PM_{2.5}$	LA, TA
1.A.4.c.1	Agriculture/Forestry/Fishing: Stationary	PAH, PCDD/F, HCB, $PM_{2.5}$	LA

LA = Level Assessment 2022

TA = Trend Assessment 1990–2022

Note: [1)]only TA, [2)]only LA

3.1.1.3 Uncertainty Assessment

The table below gives an overview of uncertainties for sector Energy (stationary) for selected pollutants. The method used for the assessment of uncertainty is according to the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA, 2019). Further information on the uncertainty assessment of activity data can be found in Austria`s National Inventory Report (Umweltbundesamt, 2022). Where no specific information on uncertainties of emission factors was available, an average of the default values, based on the definitions of the qualitative ratings given in the EMEP/EEA Emission Inventory Guidebook 2019 (EEA, 2019) is used (see chapter 1.7).

Table 67: Combined uncertainties for NO_x, SO_2, NMVOC, NH_3 and $PM_{2.5}$ for Energy (stationary).

NFR Categories		NO_x Emissions [%]	NH_3 Emissions [%]	NMVOC Emissions [%]	SO_2 Emissions [%]	$PM_{2.5}$ Emissions [%]
1.A.1.a	Public Electricity and Heat Production	22	750	200	22	61
1.A.1.b	Petroleum refining	10	750	-	10	40
1.A.1.c	Manufacture of Solid fuels and Other Energy Industries	40	750	200	125	40
1.A.2.a	Iron and Steel	11	750	200	11	125
1.A.2.b	Non-ferrous Metals	40	750	200	21	125
1.A.2.c	Chemicals	40	750	200	21	125
1.A.2.d	Pulp, Paper and Print	41	750	200	22	125
1.A.2.e	Food Processing, Beverages and Tobacco	40	750	200	21	125
1.A.2.f	Non-metallic Minerals	40	750	200	21	125

NFR Categories		NO_x Emissions [%]	NH_3 Emissions [%]	NMVOC Emissions [%]	SO_2 Emissions [%]	$PM_{2.5}$ Emissions [%]
1.A.2.g.7	Mobile Combustion in Manufacturing Industries and Construction	40	125	40	20	40
1.A.2.g.viii	Other Stationary Combustion in Manufacturing Industries and Construction	41	125	41	22	61
1.A.4.a	Commercial/Institutional	40	125	70	21	60
1.A.4.b	Residential	43	126	72	25	62
1.A.4.c	Agriculture/Forestry/ Fisheries	100	125	100	21	100
1.A.5	Other	125	200	125	40	125

3.1.2 Methodological issues

General Methodology for stationary sources of NFR categories 1.A.1 to 1.A.5

For large point sources in categories 1.A.1.a, 1.A.1.b, 1.A.2.a, 1.A.2.d and 1.A.2.f (cement industry) emission measurements of NO_x, SO_2, NMVOC, CO and TSP are the basis for the reported emissions.

The remaining sources (area sources), where measured (plant-specific) emission data and plant specific activity data is not available, were estimated by multiplying the fuel consumption of each sub category taken from the national energy balance with a fuel and technology dependent emission factor. Fuel specific emission factors are mainly country specific and taken from national studies.

Emission factors

Emission factors are expressed as: mass of released pollutant per TJ of burned fuel (e.g. [kg/TJ]).

Emission factors may vary over time for the following reasons:

- The chemical characteristics of a fuel category varies, e.g. sulphur content in residual oil.
- The mix of fuels of a fuel category changes over time. If the different fuels of a fuel category have different calorific values and their share in the fuel category changes, the calorific value of the fuel category might change over time. If emission factors are in the unit kg/t the transformation to kg/TJ induces a different emission factor due to varying net calorific values.
- The (abatement-) technology of a facility – or of facilities – changes over time.

Sources of NO_x, SO_2, VOC, CO, and TSP emission factors have been periodically published reports (BMWA, 1990), (BMWA, 1996), (Umweltbundesamt, 2001a), (Umweltbundesamt, 2004a). In these studies emission factors are provided for the years 1987, 1995 and 1996. Emission factors are mainly based on country specific measurements. NH_3 emission factors are taken from a national study (Umweltbundesamt, 1993) and (EEA, 2006, chapter B112). Details are included in the relevant chapters.

As there is no information on the average sulphur content of natural gas, a Tier 1 method has been used and a SO_2 emission factor of 0.3 kg/TJ has been applied for all categories of stationary combustion and natural gas in case that plant specific information was not reported. The emission factor has been selected from the EMEP/EEA 2019 Guidelines chapter 1.A.4, table 3.13.

PCB emission factors

PCB emission factors for coal and gasoil are selected from the EMEP/EEA 2019 Guidebook. The PCB emission factor of 3600 µg/t for residual fuel oil has been selected from (Kakareka et al., 2004) and converted to 85 µg/GJ.

The PCB emission factors for biofuels and waste have been derived from the ratio of Dioxin and PCB emission factors according to the measurements undertaken by (Hedman et al., 2006). A ratio of 0.09 g PCB per g Dioxin has been selected. The same ratio has also been selected for refinery fuels.

NH_3

Emission factors are constant for the whole time series.

SO_2, NO_x, NMVOC, CO

For the years 1990 to 1994, emission factors are linearly interpolated by using the emission factors from 1987 and 1995 taken from the studies mentioned above. From 1997 onwards, mainly the emission factors of 1996 are used.

In several national studies only emission factors for VOC are cited. NMVOC emissions are calculated by subtracting a certain share of CH_4 emissions from VOC emissions.

Characteristic of oil products

According to a national standard, residual fuel oil is classified into 3 groups with different sulphur content (heavy, medium, light). Consumption of special residual fuel oil with a sulphur content higher than 1% is limited to special power plants ≥ 50 MW and the oil refinery. Heating fuel oil is mainly used for space heating in small combustion plants. The following Table shows the sulphur contents of oil products which decreased strongly since 1980 due to legal measures. The years presented in the table are the years where legal measures came into force.

Table 68: Limited sulphur content of oil product classes according to the Austrian standard „ÖNORM".

Year	Residual fuel oil "Heavy"	Residual fuel oil "Medium"	Residual fuel oil "Light"	Heating fuel oil
1980	3.5%	2.5%	1.50%	0.8%
1981				0.5%
1982		1.5%	0.75%	
1983	3.0%			0.3%
1984	2.5%; 2.0%	1.0%	0.50%	
1985				
1987		0.6%		
1989			0.30%	0.2%
1990			0.20%	0.1%
1992	1.0%			
1994		0.4%		

Since the year 2008 a new gasoil product was introduced in Austria with a maximum sulphur content of 10 ppm (0.001%) which has the same quality as transport diesel. It is assumed that the new product has a 100% market share since 2009 because of its lower taxes.

Activity data

A description of methodology and activity data will be provided in (Umweltbundesamt, 2024a). If the energy balance reports fuel quantities by mass or volume units the fuel quantities must be converted into energy units [TJ] by means of net calorific values (NCV) which are provided by *Statistik Austria* along with the energy balance (IEA, 2023).

Not all categories of the gross inland fuel consumption are combusted or relevant for the inventory:

- Emissions from international bunker fuels are not included in the National Total but reported separately as *Memo Item*.
- Avoiding of activity data double counting: transformation and distribution losses and transformations of fuels to other fuels (like hard coal to coke oven coke or internal refinery processes which have been added to the transformation sector of the energy balance) is not considered as activity data.
- Non-energy use is also not considered for calculation of emissions in Sector *1.A Energy*. However, from these fuels fugitive emissions might occur which are considered in Sector *2.D.3 Solvents*. Emissions from fuel used as a feedstock are considered in Sector 2 *Industrial Processes*.

Measured emissions

In case that measured emissions are used for inventory preparation it is essential that the correspondent activity data be additionally reported to avoid double counting of emissions within the inventory. Plant or industrial branch specific emissions are mostly broken down to fuel specific emissions per NFR source category. In case that complete time series of measured emission data are not available implied emission factors are used for emission calculation. Implied emission factors may also be used for validation of measured emissions.

Specific note to the uncertainty as addressed in the EU large combustion plants directive (LCP-D)

According to the Austrian legislation, operators have to report monthly or yearly emission loads. The validated averaged values are only used for checking the compliance with the limits, which have been set by the authorities. It is not expected that operators are misunderstanding this in a way that operators subtract any uncertainty from the measured emission concentrations when calculating emission loads, which are not subject of any legislative limitation and not relevant for any permit. In case of waste incineration, plant operators have been informed during the law preparation process to report the measured concentrations. Therefore it is not expected that any systematic under estimation occurs when using yearly reported emission loads in the inventory.

3.1.3 NFR 1.A.1 Energy Industries

NFR Category *1.A.1* comprises emissions from fuel combustion for *public electricity and heat production* (NFR 1.A.1.a), in *petroleum refining* (NFR 1.A.1.b), and in manufacture of solid fuels and other energy industries (NFR 1.A.1.c).

General Methodology

The following Table 69 gives an overview of methodologies and data sources of sub category *1.A.1 Energy Industries*.

Table 69: Overview of 1.A.1 methodologies for main pollutants.

	Activity data	Reported/measured emissions	Emission factors
1.A.1.a boilers ≥ 50 MW_{th}	Reporting Obligation: fuel consumption (monthly). 2005–2022: ETS data	Reporting Obligation: NO_x, SO_2, TSP, CO (monthly) (About 130 boilers/60 facilities)	NMVOC, NH_3: national studies
1.A.1.a boilers < 50 MW_{th}	Energy balance 2005–2022: ETS data for plants ≥ 50 MW_{th}	Used for deriving emission factors	All pollutants: national studies
1.A.1.b (1 plant)	Reported by plant operator (yearly) 2005–2022: ETS data	Reported by plant operator: SO_2, NO_x, CO, NMVOC (yearly)	NH_3: national study
1.A.1.c	Energy balance 2005–2022: ETS data	–	Main pollutants and Dioxin: national studies Other Pollutants: EMEP/EEA 2019 GB

For 2005–2022, activity data from the emission trading system (ETS) are considered. ETS data fully covers category *1.A.1.b*, covers about 80% of category *1.A.1.a* fossil fuels and about 15% *(from 2013 onwards about 50%)* of category *1.A.1.c*.

3.1.3.1 NFR 1.A.1.a Public Electricity and Heat Production

In this category, large point sources are considered. Until the year 2007, the Umweltbundesamt operated a database called „Dampfkesseldatenbank" (DKDB) which stored plant specific monthly fuel consumption as well as measured CO, NO_x, SO_x and TSP emissions from boilers with a thermal capacity greater than 3 MW_{th} from 1990 to 2006. Since 2007 the reporting has been changed to an online system (EDM). To reach consistency with the GHG inventory all ETS plants and additionally 13 waste incineration boilers/kilns are considered as large point sources. These data are used to generate a split of the categories *Public Power* and *District Heating* into the two categories ≥ *300* MW_{th} and ≥ *50* MW_{th} *to 300* MW_{th}. Currently about 130 boilers at about 60 sites are considered in this approach. It turned out that this methodology is appropriate for most cases but overall fuel consumption has to be checked against the national energy balance or other available complete datasets/surveys (see section on QA/QC).

Fuel consumption in the public electricity sector varies strongly over time. The most important reason for this variation is the fact that in Austria up to 78% of yearly electricity production comes from hydropower. If production of electricity from hydropower is low, production from thermal power plants is high and vice versa. In addition, all coal-fired power plants were shut down by 2020 at the latest.

The following table shows the gross electricity and heat production of public power and district heating plants. Increasing district heat production is mainly generated by new biomass (local) heat plants and by waste incineration. The share of combined heat and power plants (CHP generation) is increasing and leads to higher efficiency of energy generation. The year 2010 shows a historic maximum of about 19 TWh of electricity production and the year 2017 shows a maximum of 76.6 PJ district heat production from fuel combustion.

Table 70: Public gross electricity and heat production.

	Public gross electricity production [GWh]						Public Heat Production [TJ] by Combustible Fuels
	Total	**Hydro[1)]**	**Combustible Fuels**	**Geothermal**	**Solar**	**Wind**	
1990	43 403	30 111	13 292	0.000	0	0	24 427
1995	47 580	35 431	12 147	0.000	1	1	34 426
2000	52 810	41 131	11 609	0.000	3	67	42 197
2005	58 518	38 205	18 958	2.302	21	1 331	54 424
2010	61 571	40 500	18 916	1.398	89	2 064	70 415
2011	56 270	36 815	17 344	1.053	174	1 936	70 399
2012	64 030	47 204	14 025	0.677	337	2 463	74 061
2013	60 239	45 226	11 234	0.306	626	3 152	75 274
2014	57 742	44 270	8 840	0.384	785	3 846	69 707
2015	57 455	40 102	11 575	0.061	937	4 840	72 314
2016	60 429	42 482	11 617	0.021	1 096	5 235	74 159
2017	63 114	41 697	13 576	0.091	1 269	6 572	76 620
2018	60 631	40 745	12 400	0.239	1 455	6 030	74 087
2019	66 268	43 669	13 446	0.200	1 702	7 450	73 573
2020	64 721	44 888	10 997	0.073	2 043	6 792	73 971
2021	62 669	42 133	11 009	0.031	2 783	6 740	80 992
2022	61 781	38 952	11 803	0.002	3 776	7 245	72 187

1) including pumped storage; Source: IEA JQ 2023

As shown in Table 71 electricity supply increased by 13.6 TWh since 2000 of which approx. 80% has been supplied by additional imports until 2008. The year 2009 shows falling electricity consumption (supply) but an increase of production, mainly by hydropower. The year 2015 shows an historical maximum of net imports which contribute to 15% of total electricity supply.

Table 71: Electricity supply, gross production imports, exports and net imports.

	Electricity [GWh]				
	Supply[1)]	**Gross production[2)]**	**Imports**	**Exports**	**Net Imports**
1990	46 489	50 294	6 839	7 298	-459
1995	50 979	56 225	7 287	9 757	-2 470
2000	55 750	61 257	13 824	15 192	-1 368
2005	62 948	66 833	20 355	17 732	2 623
2010	65 523	71 128	19 909	17 472	2 437
2011	65 702	65 813	24 977	16 777	8 199
2012	66 690	72 603	23 430	20 627	2 803
2013	67 048	68 357	24 960	17 689	7 270
2014	65 977	65 439	26 712	17 437	9 275
2015	67 021	65 299	29 389	19 328	10 062
2016	67 866	68 308	26 366	19 207	7 159
2017	69 029	71 324	29 362	22 817	6 546
2018	69 192	68 618	28 076	19 129	8 947
2019	69 332	74 234	26 047	22 918	3 129

	Electricity [GWh]				
	Supply[1)]	Gross production[2)]	Imports	Exports	Net Imports
2020	66 936	72 558	24 522	22 327	2 196
2021	70 108	73 644	26 436	18 893	7 543
2022	69 384	72 987	28 595	19 890	8 705

Source: IEA JQ, 2023

1) Excluding own use and heat pumps, boilers and pumped storage use. Including losses

2) Public and auto producer gross production

Total fuel consumption data is taken from the energy balance (IEA JQ, 2023) prepared by *Statistik Austria*. The remaining fuel consumption (= total consumption minus reported boiler consumption) is the activity data of plants < 20 MW_{th} used for emission calculation with a Tier 2 methodology using national emission factors. Table 72 shows activity data of category 1.A.1.a.

Table 72: Fuel consumption from NFR 1.A.1.a Public Electricity and Heat Production.

NFR	**1.A.1.a**	**1.A.1.a**	**1.A.1.a**	**1.A.1.a**	**1.A.1.a**	**1.A.1.a**
Fuel		**liquid**	**solid**	**gaseous**	**biomass**	**other**
				[PJ]		
1990	142.78	15.63	61.40	59.46	2.90	3.39
1995	136.44	19.74	45.49	62.07	6.08	3.06
2000	140.23	14.89	49.16	62.67	10.50	3.01
2005	201.69	14.05	61.63	95.25	25.11	5.65
2010	217.58	8.49	41.47	94.45	62.89	10.28
2011	209.46	4.78	45.64	83.93	63.83	11.28
2012	194.41	2.87	37.18	74.48	68.21	11.68
2013	176.76	2.35	35.78	60.21	66.91	11.51
2014	157.12	2.00	24.74	50.34	67.85	12.19
2015	177.59	3.23	24.98	65.46	71.55	12.37
2016	177.18	4.44	16.91	72.45	70.22	13.16
2017	195.05	2.81	14.55	92.59	72.70	12.40
2018	175.29	1.16	14.78	79.05	68.56	11.74
2019	175.45	0.55	12.49	84.88	65.89	11.64
2020	161.28	0.83	3.86	76.03	69.31	11.25
2021	163.51	1.57	NO	80.93	69.33	11.69
2022	163.59	3.11	NO	80.93	68.08	11.46
Trend 1990–2022	**14.6%**	**-80.1%**	**-100%**	**36.1%**	**2246.7%**	**238.4%**
Trend 2021–2022	**0.0%**	**97.8%**	**-**	**0.0%**	**-1.8%**	**-1.9%**

Boilers and gas turbines ≥ 50 MW_{th}

This category considers steam boilers and gas turbines with heat recovery. Due to national regulations, coal and residual fuel oil operated boilers are mostly equipped with NO_x controls, flue gas desulphurisation and dust control units. A high share (regarding fuel consumption) of natural gas operated boilers and gas turbines are equipped with NO_x controls. Emission data of boilers ≥ 50 MW_{th} is consistent with data used for the national report to the Large Combustion Plant Directive (LCP-D) 2001/80/EG (Umweltbundesamt, 2006a) except in the case where gap filling was performed. An overview about installed SO_2 and NO_x controls and emission trends is presented in (Umweltbundesamt 2006a).

Emissions by fuel type are essential for validation and review purposes. If boilers are operated with mixed fuels derivation of fuel specific emissions from measured emissions is not always appropriate. Fuel specific emissions were derived as following:

i Add up fuel consumption and emissions of the boiler size classes ≥ *300 MW_{th}* and ≥ *50 MW_{th}* < *300 MW_{th}*. Convert fuel consumption from mass or volume units to TJ by means of average heating values from the energy balance.

ii Derive default emission factors for each fuel type of the "most representative" plants by means of actual flue gas concentration measurements and/or legal emission limits. This work is done by the Umweltbundesamt. The national "default" emission factors have been periodically published in reports like (Umweltbundesamt, 2004a).

iii Calculate "default" emissions by fuel consumption and national "default" emission factors.

iv Calculate emission ratio of calculated emissions and measured emissions by boiler size class.

v Calculate emissions by fuel type and boiler size class by multiplying default emissions with emission ratio. Implied emission factors by fuel type may be calculated.

Table 73 shows emissions from LCP-D reporting and total 1.A.1.a emissions for selected years.

Table 73: 1.A.1.a total emissions, emissions from LCP-D reporting and share of LCP emissions for selected years

	NO_x (kt)			SO_2 (kt)			PM_{10} (kt)			CO (kt)		
	1A1a	**LCP**	**LCP %**	**1A1a**	**LCP**	**LCP %**	**1A1a**	**LCP**	**LCP %**	**1A1a**	**LCP**	**LCP %**
1990	12.09	10.98	91%	11.81	10.90	92%	0.78	0.69	88%	1.36	1.12	82%
1995	7.70	5.20	68%	5.95	3.03	51%	0.69	0.33	48%	1.72	1.18	68%
2000	7.07	5.29	75%	3.62	3.20	89%	0.49	0.24	48%	1.92	1.17	61%
2005	10.19	7.60	75%	3.36	2.88	86%	0.76	0.38	50%	2.54	1.29	51%
2010	11.10	5.39	48%	2.12	1.45	68%	1.21	0.21	18%	4.37	0.80	18%
2015	10.05	3.55	35%	1.23	0.60	49%	1.10	0.07	7%	4.21	0.58	14%
2016	9.30	2.99	32%	1.02	0.41	41%	1.03	0.05	5%	4.01	0.54	13%
2017	10.05	3.35	33%	0.99	0.36	36%	1.07	0.04	4%	4.21	0.55	13%
2018	9.15	3.02	33%	1.02	0.37	37%	1.03	0.03	3%	4.08	0.48	12%
2019	8.49	2.85	33%	0.83	0.25	31%	0.96	0.02	2%	3.95	0.54	14%
2020	8.14	2.23	27%	0.69	0.08	12%	1.01	0.01	1%	4.00	0.41	10%
2021	7.97	2.17	27%	0.68	0.05	7%	1.05	0.01	1%	4.32	0.55	13%
2022	7.73	2.06	27%	0.70	0.10	15%	1.03	0.01	1%	4.19	0.51	12%

In the approach above different coal types and residual fuel classifications are considered. Table 74 shows some selected aggregated results for 2022. The ratios of measured to calculated emissions show that the application of a simple Tier 2 Approach would introduce a high uncertainty for CO.

Table 74: NFR 1.A.1.a ≥ 50 MW_{th} default emission factors fuel consumption and emissions ratios for the year 2022.

	Fuel consumption [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	NH_3 [kg/TJ]
NFR 1.A.1.a ≥ 50 MWt_h		0.65(1)	0.16(1)		
SNAP 010101		0.54(1)	0.69(1)		
Hard Coal	-	50.0	1.0	0.9	0.07(3)
Oil	1	26.0	3.0	5.0	2.68
Natural gas	64 994	30.0	4.0	0.06	1.0
Sewage sludge	-	100.0	200.0	38.0	0.02
Biomass	1 008	94.0	72.0	5.0	5.0
SNAP 010102		1.70(1)	1.871)		
Natural gas	3 965	30.0	4.0	0.06	1.0
Waste	9 298	100.0	200.0	0.54(2)	0.02
Biomass	619	94.0	72.0	5.0	5.0
SNAP 010201		2.40(1)	3.30(1)		
Oil	2 355	100.0	4.0	5.0	2.68
Natural gas	1 251	25.0	4.0	0.5	1.0
SNAP 010202		0.31(1)	0.03(1)		
Oil	503	85.0	4.0	5.0	2.68
Natural gas	4 385	25.0	4.0	0.5	1.0
Waste	13 265	48.0	200.0	0.54(2)	0.02
Sewage Sludge	332	100.0	200.0	38.0	0.02

(1) Emission ratio of measured emissions divided by calculated emissions.

(2) EMEP/EEA 2016 Guidebook 5.C.1.a – table 3-1 (5.9 g/t).

(3) Calculated from flue gas concentration (0.2 mg/Nm^3).

Boilers and gas turbines < 50 MW_{th}

Table 75 shows main pollutant emission factors used for calculation of emissions from boilers < 50 MW_{th} for the year 2022. Increasing biomass consumption of smaller plants is a main source of NO_x emissions from this category in 2022.

Table 75: NFR 1.A.1.a < 50 MW_{th} main pollutant emission factors and fuel consumption for the year 2022.

Fuel	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
Light Fuel Oil	218	159.4	10/45(1)	0.8	92	2.7
Heavy Fuel Oil	-	26/317.4(1)	3/15(1)	8.0	50/398(1)	2.7
Gasoil	33	65	10	4.8	0.5	2.7
Diesel oil	-	700	15	0.8	18.8	2.7
Liquified Petroleum Gas	-	150	5	0.5	6	1
Natural Gas/power and CHP	4 932	30	4	0.5	0.3	1
Natural Gas/district heating	1 404	41	5	0.5	0.3	1
Solid Biomass	50 436	94	72	5.0	11	5
Biogas, Sewage Sludge Gas, Landfill Gas	4 585	150	4	0.5	NA	1

(1) Different values for: Electricity & CHP/District heating.

Sources of emission factors

Sources of NO_x, SO_2, VOC, CO, and TSP emission factors are periodically published reports (BMWA, 1990), (BMWA, 1996), (BMWA, 2003), (Umweltbundesamt, 2004a). These reports provide information about the methodology of emission factor derivation and are structured by SNAP nomenclature. Emission factors for electricity and heat plants are based on expert judgment by Umweltbundesamt and experts from industry.

The NO_x emission factor for biomass boilers ≤ 50 MW_{th} and municipal solid waste is taken from a national unpublished study (Umweltbundesamt, 2006b). Biomass NO_x EFs are derived by means of measurements of 71 Boilers which have been selected as a representative sample from the approximately 1000 existing biomass boilers in 2005. Municipal waste NO_x EFs are derived from plant specific data taken from (BMLFUW, 2002b).

NH_3 emission factors for coal, oil and gas are taken from (Umweltbundesamt, 1993). For waste the emission factor of coal is selected. NH_3 emission factors for biomass are taken from (EMEP/ CORINAIR 2006, chapter B112) and a value of 5 kg/TJ was selected.

VOC emission factors are divided into NMVOC and CH_4 emission factors as shown in Table 76. The split follows closely (Stanzel et al., 1995).

Table 76: Share of NMVOC emissions in VOC emissions for 1.A.1.a.

	Solid Fossile	Liquid Fossile	Natural Gas	Biomass
Electricity plants	90%	80%	25%	75%
District Heating plants	Hard coal 70% Brown Coal 80%	80%	30%	75%

3.1.3.2 NFR 1.A.1.b Petroleum Refining

In this category, emissions from fuel combustion of a single petroleum refining plant are considered. The plant did not have any secondary DeNOX equipment until 2006, but a certain amount of primary NO_x control has been achieved since 1990 by switching to low NO_x burners (Umweltbundesamt, 2006b). SO_2 reduction is achieved by a regenerative Wellman-Lord process facility (Windsperger & Hintermeier, 2003). Particulates control is achieved by two electrostatic precipitator (ESP) units. CO emissions were significantly reduced between 1990 and 1991 due to reconstruction of a FCC facility (Umweltbundesamt, 2001a). Since 2007 the plant is equipped with a SNO_X facility which reduces SO_2 by about 65% and NO_X emissions by about 55%.

The Austrian association of mineral oil industry (*Fachverband der Mineralölindustrie*) communicates yearly fuel consumption, SO_2, NO_X, CO, VOC and TSP emissions to the Umweltbundesamt (FVMI, 2023). NMVOC emissions from fuel combustion are reported together with fugitive emissions under category 1.B.2.a. NH_3, heavy metals and POPs emissions are calculated by means of emission factors and activity data. The following Table 77 shows the fuel consumption of the refinery.

Table 77: Fuel consumption from NFR 1.A.1.b Petroleum Refining.

NFR	1.A.1.b	1.A.1.b	1.A.1.b	1.A.1.b	1.A.1.b	1.A.1.b
Fuel		**liquid**	**solid**	**gaseous**	**biomass**	**other**
				[PJ]		
1990	35.34	27.46	-	7.88	-	-
1995	34.20	26.59	-	7.61	-	-
2000	33.18	26.65	-	6.53	-	-
2001	40.45	31.13	-	9.32	-	-
2005	39.41	30.41	-	9.00	-	-
2010	39.88	30.89	-	9.00	-	-
2011	39.75	32.00	-	7.75	-	-
2012	39.37	32.58	-	6.79	-	-
2013	37.71	31.75	-	5.96	-	-
2014	38.83	32.68	-	6.15	-	-
2015	38.14	32.24	-	5.90	-	-
2016	38.33	31.21	-	7.12	-	-
2017	39.64	31.05	-	8.59	-	-
2018	39.62	30.56	-	9.06	-	-
2019	38.51	29.57	-	8.94	-	-
2020	39.07	29.49	-	9.58	-	-
2021	32.57	27.16	-	5.40	-	-
2022	-7.8%	-1.1%	-	-31.4%	-	-
Trend 1990–2022	**-16.6%**	**-7.9%**	**-**	**-43.6%**	**-**	**-**
Trend 2021–2022	**35.34**	**27.46**	**-**	**7.88**	**-**	**-**

Sources of emission factors

NH_3 emission factors for petroleum products (2.7 kg/TJ) and natural gas (1 g/TJ) are taken from (Umweltbundesamt, 1993).

Facility specific 1990 to 1998 emissions are presented in (Umweltbundesamt, 2000a) and (Umweltbundesamt, 2001a).

Cd emissions are calculated by means of the methodology from CONCAWE (CONCAWE, 2017). For catalytic crackers, a Cd emission factor of 0.0000625 kg/m^3 fresh feed has been used. The capacity of the cracker is about 1.4 Mt/year.

3.1.3.3 NFR 1.A.1.c Manufacture of Solid fuels and Other Energy Industries

This category includes emissions from natural gas combustion in the oil and gas extraction sector, natural gas refining, natural gas compressors for natural gas storage systems as well as own energy use of gas works which closed in 1995.

Furthermore, PM emissions of charcoal kilns are included in this category.

Emissions from final energy consumption of coal mines are included in category 1.A.2.g. Emissions from coke ovens are included in category 1.A.2.a.

Emissions from this category are presented in the following table.

Fuel consumption is taken from the national energy balance. Emissions are calculated with the simple CORINAIR methodology.

Table 78: Fuel consumption from NFR 1.A.1.c Manufacture of Solid fuels and Other Energy Industries.

NFR	**1.A.1.c**	**1.A.1.c**	**1.A.1.c**	**1.A.1.c**
Fuel	**Total**	**Liquid**	**Gaseous**	**Biomass**
		[PJ]		
1990	9.23	0.06	9.13	0.03
1995	11.06	0.01	11.02	0.03
2000	5.10	-	5.07	0.03
2005	7.14	-	7.10	0.03
2010	4.34	-	4.30	0.04
2011	4.83	-	4.80	0.04
2012	3.76	-	3.72	0.04
2013	4.55	-	4.52	0.04
2014	4.51	-	4.48	0.04
2015	5.01	-	4.97	0.04
2016	4.97	-	4.93	0.04
2017	4.71	-	4.67	0.03
2018	4.36	-	4.32	0.04
2019	5.66	-	5.61	0.04
2020	5.24	-	5.201	0.04
2021	6.78	-	6.741	0.04
2022	6.23	-	6.194	0.03
Trend 1990–2022	**-32.5%**	**-100.0%**	**-32.2%**	**4.3%**
Trend 2021–2022	**-8.2%**	**-**	**-8.1%**	**-22.4%**

Emission factors and activity data 2022

Table 79 summarizes the selected emission factors for main pollutants and activity data for the year 2022. It is assumed that emissions are uncontrolled.

Table 79: NFR 1.A.1.c main pollutant emission factors and fuel consumption for the year 2022.

Fuel	**Source of NO_x, CO, NMVOC, SO_2 emission factors[(1)]**	**Activity [TJ]**	**NO_x [kg/TJ]**	**CO [kg/TJ]**	**NMVOC [kg/TJ]**	**SO_2 [kg/TJ]**	**NH_3 [kg/TJ]**
Natural Gas/Oil gas extraction and Gasworks	(BMWA, 1990)	6 194	150.0	10.0	0.5	0.3	1.0
Residual fuel oil/ Gasworks	(BMWA, 1996)	0[(2)]	235.0	15.0	8.0	398.0	2.7
Liquid petroleum gas/Gasworks	(BMWA, 1990)	0[(2)]	40.0	10.0	0.5	6.0	1.0

[(1)] *Default emission factors for industry are selected*

[(2)] *Gasworks closed in 1995*

NH_3 emission factors are taken from (Umweltbundesamt, 1993).

PM emissions from charcoal production

It has been assumed (Winiwarter et al., 2007) that charcoal is produced in traditionally kilns by approximately 20 producers. Assuming 10 charges per producer and year each of 50 m³ wood input, assuming an output of 200 kg of charcoal from 1 000 kg of wood input and assuming a density of 350 kg/m³ wood leads to an estimated activity of 1 000 t charcoal per year which is 31 TJ (net calorific value 31 MJ/kg charcoal). Applying an emission factor of 2.2 kg TSP/GJ charcoal which is similar to brown coal stoker fired furnaces this leads to an emission of approx. 70 t TSP per year. Furthermore it is assumed that 100% of particles are $PM_{2.5}$. Charcoal production data is taken from the national energy balance which is 1.1 kt in 2022. The following Table 80 shows activity data for charcoal.

Table 80: Charcoal production.

Year	Charcoal production (t)
1990	1 000
1995	1 000
2000	1 000
2005	1 101
2010	1 181
2011	1 130
2012	1 377
2013	1 269
2014	1 263
2015	1 447
2016	1 382
2017	1 222
2018	1 379
2019	1 425
2020	1 442
2021	1 463
2022	1 096

3.1.3.4 Emission factors for heavy metals

Coal

Values were taken from the CORINAIR Guidebook (1999), Page B111-58, Table 31:

For 1985, two thirds of the values for "DBB, Dust Control" were selected (from the ranges given in the guidebook the mean value was used). For 1995, the value for "DBB, Dust Control + FGD" was selected, as in these 10 years the existing dust controls were supplemented with flue gas desulphurisation. For the years in between the values were linearly interpolated.

The net calorific value used to convert values given in [g/Mg fuel] to [g/MJ fuel] was 28 MJ/kg for hard coal and 10.9 MJ/kg for brown coal.

Due to the legal framework, most coal fired power plants were already equipped with dust control and flue gas desulphurisation in 1995, and no substantial further improvements were made since then. Thus, the emission factor for 1995 was used for the years onwards.

The cadmium emission factor of brown coal is derived from a flue gas concentration of 6 µg/m³ (Umweltbundesamt, 2003a).

Fuel oil

The emission factors base on the heavy metal content of oil products of the only Austrian refinery that were analysed in 2001 (see Table 81). It is assumed that imported oil products have a similar metal content.

Table 81: Heavy Metal Contents of Fuel Oils in Austria.

	Cadmium	**Mercury [mg/kg]**	**Lead**
Heating Oil	< 0.01	< 0.003	< 0.01
Light fuel oil	< 0.01	< 0.003	< 0.01
Heavy fuel oil (1%S)	0.04	< 0.003	< 0.01

Only for heavy fuel oil a value for the heavy metal content was quantifiable, for lighter oil products the heavy metal content was below the detection limit. As the heavy metal content depends on the share of residues in the oil product the emission factor of medium fuel oil was assumed to be half the value of heavy fuel oil. For light fuel oil and heating and other gas oil one fifth and one tenth respectively of the detection limit was used.

As legal measures ban the use of heavy fuel oil without dust abatement techniques and the emission limits were lower over the years it was assumed that the emission factor decreased from 1985–1995 by 50%, except for Mercury where dust abatement techniques do not effect emissions as efficiently as Mercury is mainly not dust-bound.

The Pb emission factor for “other oil products” (which is only used in the refinery) is based on the following assumption: the share of Pb in crude oil is about 2%. The share of this HM – in particulate emissions of the refinery – was estimated to be a fifth of the share in crude oil, which results in a share of 0.4% of dust emissions from the refinery. Based on a TSP emission factor of about 5.7 g/GJ, the resulting emission factor for Pb is 10 mg/GJ.

For Mercury, 10 times the EF for heavy fuel oil for category *1.A.1.a* was used. For 1985, twice the value as for 1990 was used.

Other Fuels

For fuel wood the value from (Obernberger, 1995) for plants > 4 MW was used for 1985 and 1990. For 1995 and for wood waste, for the whole time series, the value taken from personal information about emission factors for wood waste from the author was used.

For plants < 50 MW the emission factor for industrial waste is based on measurements of Austrian plants (FTU, 2000).

The emission factors for the years 1985–1995 for municipal waste and sewage sludge base on regular measurements at Austrian facilities (MA22, 1998). For industrial waste and for plants > 50 MW, emission factors were based on (EPA, 1998, CORINAIR, 1997, EPA, 1997, EPA, 1993, Winiwarter, 1993, Orthofer, 1996); improvements in emission control have been considered.

The emission factors for waste (municipal and industrial waste and sewage sludge, for plants > 50 MW and for the year 2004 were taken from (BMLFUW, 2002b).

Natural Gas

Cd and Pb emission factors of natural gas are selected from the EMEP/EEA Guidebook 2019, table 3-17.

Table 82: Cd emission factors for Sector 1.A.1 Energy Industries.

Cadmium EF [mg/GJ]	1985	1990	1995	2010
Coal				
102A Hard coal	0.1548	0.1140	0.073	0.073
105A Brown coal	2.13 (all years)			
Oil				
204A Heating and other gas oil 2050 Diesel	0.02 (all years)			
203B Light fuel oil	0.05 (all years)			
203C Medium fuel oil	0.5 (all years)			
203D Heavy fuel oil	1.0	0.75	0.5	0.5
Refinery liquid fuels	1.2 (all years)			
308A refinery gas	2.1 (all years)			
Biomass and Other Fossil Fuels				
111A Fuel wood 116A Wood waste	6.1	6.1	2.5	2.5
115A Industrial waste (< 50MW)	7 (all years)			
1.A.1.b, 1.A.1.c Natural gas				
301A Natural gas	0.00025 (all years)			

The following table presents Cd emission factors of several waste categories. Emission factors 2006 are derived from measurements (Umweltbundesamt, 2007).

Table 83: Cd emission factors for waste for Sector 1.A.1 Energy Industries.

Cadmium EF [mg/t Waste]	1985	1990	1995	2010
114B Municipal waste	2 580	71	12	11
115A Industrial waste (> 50 MW)	720	510	30	4.5
118A Sewage sludge	–	235	19	5.2

Table 84: Hg emission factors for Sector 1.A.1 Energy Industries.

Mercury EF [mg/GJ]	1985	1990	1995	2010
Coal				
102A Hard coal	2.98	2.38	1.8	1.8
105A Brown coal	7.65	6.12	4.6	4.6

Mercury EF [mg/GJ]	1985	1990	1995	2010
Oil				
204A Heating and other gas oil 2050 Diesel		0.007 (all years)		
203B Light fuel oil		0.015 (all years)		
203C Medium fuel oil		0.04 (all years)		
203D Heavy fuel oil		0.075 (all years)		
110A Petrol coke 224A Other oil products		0.75 (all years)		
Biomass and Other fossil Fuels				
111A Fuel wood		1.9 (all years)		
116A Wood waste (> 50 MW)		1.9 (all years)		
115A Industrial waste (< 50 MW)		2.0 (all years)		
Natural gas				
301A Natural gas		0.07 (all years)		

The following table presents Hg emission factors of several waste categories. Emission factors 2006 are derived from measurements (Umweltbundesamt, 2007).

Table 85: Hg emission factors for waste for Sector 1.A.1 Energy Industries.

Mercury EF [mg/t Waste]	1985	1990	1995	2010
114B Municipal waste	1 800	299	120	25.2
115A Industrial waste (> 50 MW)	100	112	49	15.5
118A Sewage sludge	–	55	9	9

Table 86: Pb emission factors for Sector 1.A.1 Energy Industries.

Lead EF [mg/GJ]	1985	1990	1995	2010
Coal				
102A Hard coal	13.33	11.19	9.1	9.1
105A Brown coal	1.93	1.44	0.96	0.96
Oil				
204A Heating and other gas oil 2050 Diesel			0.02 (all years)	
203B Light fuel oil			0.05 (all years)	
203C Medium fuel oil			0.12 (all years)	
203D Heavy fuel oil	0.25	0.19	0.13	0.13
110A Petrol coke 224A Other oil products			20 (all years)	
Other Fuels				
111A Fuel wood	26.3	26.3	21.15	21.15
116A Wood waste: Public Power [0101]			21 (all years)	
116A Wood waste: District Heating [0102]			50 (all years)	
1.A.1.c Natural gas				
301A Natural gas			0.0015 (all years)	

The following table presents Hg emission factors of several waste categories. Emission factors 2006 are derived from measurements (Umweltbundesamt, 2007).

Table 87: Pb emission factors for waste for Sector 1.A.1 Energy Industries.

Lead EF [mg/t Waste]	1985	1990	1995	2010
114B Municipal waste	30 000	1 170	150	36
115A Industrial waste (> 50 MW)	8 300	2 400	10	10
118A Sewage sludge	–	730	6	6

3.1.3.5 Emission factors for POPs

Fossil fuels

The dioxin (PCDD/F) emission factor for coal and gas were taken from (Wurst & Hübner, 1997), for fuel oil the value given in the same study and new measurements were considered (FTU, 2000).

The HCB emission factor for coal was taken from (Bailey, 2001).

The PAK emission factors are based on results from (UBA BERLIN, 1998), (Baas et al. 1995), (Orthofer & Vesely, 1990) and measurements by FTU.

PCB emission factors have been selected as outlined in chapter 3.1.3.

The 1.A.1.c (SNAP 010503 and 010504) natural gas emission factor for PAK4 is selected from the EMEP/EEA Guidebook 2019, table 3-17.

Other fuels

The dioxin (PCDD/F) emission factor for wood is based on measurements at Austrian plants > 1 MW (FTU, 2000).

The PAK emission factors are based on results from (UBA BERLIN, 1998) and (Baas et al., 1995).

Gasworks

Default national emission factors of industrial boilers were selected. For *224A Other Oil Products* the emission factors of *303A LPG* were selected.

Table 88: POPs emission factors for Sector 1.A.1 Energy Industries.

EF	PCDD/F [µg/GJ]	HCB [µg/GJ]	PAK4 [mg/GJ]	PCB [µg/GJ]
Coal				
Coal (102A, 105A, 106A)	0.0015	0.46	0.0012	0.0033
Fuel Oil and Gasoil				
Fuel Oil (203B, 203C, 204A) excl. Gasworks, 110A Petrol coke	0.0004	0.08	0.16	0.00013
Heavy Fuel Oil (203D)	0.0004	0.08	0.16	85
203D Heavy fuel oil in gasworks	0.009	0.12	0.24	85
224A Other oil products in gasworks	0.0017	0.14	0.011	85
308A Refinery gas	0.0006	0.04	NA	0.000054

EF	PCDD/F [µg/GJ]	HCB [µg/GJ]	PAK4 [mg/GJ]	PCB [µg/GJ]
Gas				
301A Natural gas, 303A LPG exc. SNAP 010202, 010301	0.0002	0.04	NA	NA
301A Natural gas, 303A LPG, SNAP 010202, 010301	0.0004	0.08	NA	0.000036
301A Natural gas 010503, 010504, 010506	0.0002	0.04	0,0116	0.000018
Other Fuels				
114B Municipal Waste 115A Industrial waste/unspecified	0.0051	14.5	0.17	0.0005 0.0008
Biomass				
111A Wood (> 1 MW) 116A Wood waste (> 1 MW)	0.01	2.0	0.2	0.0009
111A Wood (< 1 MW) 116A Wood waste (< 1 MW)	0.14	28.0	2.4	0.0009
116A Wood waste/Straw	0.12	24.0	3.7	0.0009
309A, 309B, 310A Gaseous biofuels	0.0006	0.072	0.032	NA

Waste emissions factors are expressed as per ton of dry substance and derived from plant specific measurements (Hübner, 2001b, Hübner et al., 2002, Umweltbundesamt, 2007). Comma separated values indicate plant specific emissions factors. The PCDD/F emission factor for 2014 onwards has been derived from measurements of 9 waste incineration plants (Umweltbundesamt 2019c).

Table 89: POP emission factors for Sector 1.A.1 Energy Industries waste fuels

EF	PCDD/F [µg/t]	HCB [µg/t]	PAK4 [mg/t]
114B Municipal Waste	0.09/0.044(1)	247.0	0.7; 0.13
115A Industrial waste	0.21/0.044(1)	126.0	0.16
118A Sewage Sludge	0.09/0.044(1)	20.0	0.09

(1) First value for 2000–2013; second value for 2014 onwards.

3.1.3.6 Emission factors for PAH4 substances

PAH emissions factors have been split into benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and ideno[1,2,3-c,d]pyrene by means of the calculated share of the default emission factor values as provided in the EMEP/EEA 2019 GB tables:

- 1.A.1 - Table 3-2 (1.A.1.a hard coal)
- 1.A.1 - Table 3-3 (1.A.1.a brown coal)
- 1.A.1 - Table 3-13 (1.A.1.a wood and wood waste)
- 1.A.1 - Table 3-5 (1.A.1.a heavy fuel oil)
- 1.A.1 - Table 3-4 (1.A.1.a, 1A1c gaseous fuels)
- 1.A.2 - Table 3-2 (1.A.1.b FCC coke)

3.1.3.7 Emission factors for PM

As already described in chapter 1.4 the emission inventories of PM for different years were prepared by contractors and incorporated into the inventory system afterwards.

Large point sources (LPS)

In a first step large point sources (LPS) are considered. For the reporting years up to 2006 the Umweltbundesamt was operating a database to store plant specific data, called *„Dampfkesseldatenbank"* (DKDB) which includes data on fuel consumption, NO_x, SO_x, CO and PM emissions from boilers with a thermal capacity greater than 3 MW_{th} for all years from 1990 onwards. From the reporting year 2007 on this database has been replaced by a web based reporting system (EDM[79]) operated by the ministry of environment. These data are used to generate a split of the categories *Public Power* and *District Heating*, with further distinction between the two categories ≥ *300* MW_{th} and ≥ *50* MW_{th} *to 300* MW_{th} of thermal capacity. Currently about 60 power and district heating plants with 120 boilers and 9 waste incineration plants with 14 boilers/kilns are considered with this approach. From the year 2007 on fuel consumption of large point sources is taken from the emission trading system (ETS) which considers facilities which a total boiler thermal capacity ≥ 20 $MW_{th.}$ The yearly emission declarations from the corresponding boilers are taken from the EDM.

The fuel consumption of all considered point sources is subtracted from the total consumption of this category, which is taken from the energy balance. The other combustion plants are considered as area source.

For point sources ≥ 50 MW plant specific emission and activity data from the DKDB were used. The 'implied emission factors', which are calculated by division of emissions by activity data, are given in Table 90.

Emission factors from 2000 onwards for the fuel type **wood waste** were taken from (Umweltbundesamt, 2006a).

The PM_{10}/TSP and $PM_{2.5}$/TSP ratios were taken from (Winiwarter et al., 2001).

Table 90: PM implied emission factors (IEF) for LPS in NFR 1.A.1 Energy Industries.

	TSP IEF [g/GJ]				**%PM_{10}**	**%$PM_{2.5}$**
	1990	**2000**	**2010**	**2022**	**[%]**	**[%]**
Public Power (SNAP 0101)(1)	5.51	2.74	1.50	0.15	95	80
District Heating (SNAP 0102) (1)	3.23	0.62	0.78	0.22	95	80
Petroleum Refining (SNAP 010301)(2)	4.3	3.3	1.2	0.99	95	80
Wood waste (Fuel 116A)	55	22	22	22	90	75

(1) *Used fuels: Hard coal (102A), Lignite (105A), Log wood (111A), Industrial waste (115A), Sewage sludge (118A), Residual fuel oil (203B, 203C, 203D and Natural gas (301A)*

(2) *Used fuels: Refinery gas (308A), FCC coke (110A), Residual fuel oil (203D), LPG (303A), Other oil products (224A) and Natural gas (301A)*

79 http://edm.gv.at

Area sources

In a second step the emissions of the **area source** are calculated. Emissions of plants < 50 MW are calculated by multiplying emission factors with the corresponding activity.

Coal and gas

The emission factors for **coal** and **gas** were taken from (Winiwarter et al., 2001) and are valid for the whole time series.

Oil

The emission factor for **high-sulphur fuel** (203D) **medium-sulphur fuel** (203C) and **low-sulphur fuel** (203B) base on an analysis of Austrian combustion plants regarding limit values (TSP: 70 mg/Nm³, 60 mg/Nm³ and 50 mg/Nm³) (Umweltbundesamt, 2006a), these values were used for all years.

The emission factor for **heating and other gas oil** (204A) was taken from (Winiwarter et al., 2001) and used for all years. [80]

For diesel the emission factors for heavy duty vehicles and locomotives as described in chapter 3.2.6 were used.

Other Fuels

Emission factors for **wood** and **wood waste** (111A and 116A)**, MSW renewable, MSW non-renewable** and **industrial waste** (114B and 115A) and **low-sulphur fuel** (203B) for the years 1990 and 1995 were taken from (Winiwarter et al., 2001), for the years afterwards an updated value from (Umweltbundesamt, 2006a) has been used.

The emission factor for **biogas, sewage sludge gas** and **landfill gas** (309B and 310A) were taken from (Winiwarter et al., 2001) and used for all years.

The shares of PM_{10} and $PM_{2.5}$ were taken from (Winiwarter et al., 2001).

Table 91: PM emission factors for combustion plants (< 50 MW) in NFR 1.A.1.

	TSP Emission Factors [g/GJ]				PM_{10}	$PM_{2.5}$
	1990	**1995**	**2000**	**2022**	**[%]**	**[%]**
Gas						
301A and 303A	0.50				90	75
Coal						
102A	45.00				90	75
105A and 106.A	50.00				90	75
Oil						
203B	16.00				90	75
203D	22.00				90	80
204A	1.00				90	80
224A	0.50				90	75
2050	50.00				100	100
Other Fuels						
111A and 116A	55.00	55.00	22.00	22.00	90	75

[80] as of central heating boilers in the residential sector (Hauszentralheizung – HZH)

	TSP Emission Factors [g/GJ]				PM_{10}	$PM_{2.5}$
	1990	1995	2000	2022	[%]	[%]
114B and 115 A	9.00	9.00	1.00	1.00	95	80
309B and 310A	0.50				90	75

3.1.3.8 Category-specific Recalculations

Updates of activity data and of NCVs follow the updates of the IEA-compliant energy balance compiled by the federal statistics authority *Statistik Austria* (Chapter 3.1.9).

Error correction of PM emissions for large point sources and years 2007 to 2021.

Error correction of Pb emission factor for sewage sludge and years 2011 to 2021.

3.1.4 NFR 1.A.2 Manufacturing Industry and Combustion

NFR Category *1.A.2 Manufacturing Industries and Construction* comprises emissions from fuel combustion in the sub categories

- Iron and steel (NFR 1.A.2.a),
- Non-ferrous metals (NFR 1.A.2.b),
- Chemicals (NFR 1.A.2.c),
- Pulp, paper and print (NFR 1.A.2.d),
- Food processing, beverages and tobacco (NFR 1.A.2.e),
- Non-metallic Minerals (NFR 1.A.2.f)
- Mobile Combustion in Manufacturing Industries and Construction (NFR 1.A.2.g.7)[81]
- Other Stationary Combustion in Manufacturing Industries and Construction (NFR 1.A.2.g.viii).

3.1.4.1 General Methodology

Table 92 gives an overview of methodologies and data sources of sub category *1.A.2 Manufacturing Industry and Combustion*. Reported/Measured emission data is not always taken one-to-one in cases that reported fuel consumption is not in line with data from energy balance. However, in these cases data is used for emission factor derivation. For the reporting year 2005 on activity data from the emission trading system (ETS) has been considered for validation of the energy statistics and ETS activity data has been used for a breakdown by sectors of category 1.A.2.f.

Fuel consumption of *Industrial Autoproducers* is allocated to the relevant subcategories 1.A.2.a to 1.A.2.g, 1.A.1.b and 1.A.4.a.i.

[81] methodologies for mobile sources are described in Chapter 3.2

Table 92: Overview of 1.A.2 methodologies for main pollutants.

		Activity data	Reported/Measured emissions	Emission factors
1.A.2.a	Iron and Steel – Integrated Plants (2 units)	Reported by plant operator (yearly).	Reported by plant operator: SO_2, NO_x, CO, NMVOC, TSP (yearly).	NH_3: National study
1.A.2.a	Iron and Steel – other	Energy balance 2005–2022: ETS data.		All pollutants: National studies
1.A.2.b	Non-ferrous Metals	Energy balance 2005–2022: ETS data.		All pollutants: National studies
1.A.2.c	Chemicals	Energy balance 2005–2022: ETS data.	Waste incineration: SO_2, NO_X, CO, NMVOC, PM_{10}	All pollutants: National studies
1.A.2.d	Pulp, Paper and Print	Energy balance 2005–2022: ETS data.	Reported by Industry Association: SO_2, NO_x, CO, NMVOC, TSP (yearly).	NO_X, PM_{10}, NH_3: National studies
1.A.2.e	Food Processing, Beverages and Tobacco	Energy balance 2005–2022: ETS data.		All pollutants: National studies
1.A.2.f	Cement Clinker Production	National Studies 2005–2022: ETS data.	Reported by Industry Association: SO_2, NO_x, CO, NMVOC, TSP, Heavy Metals (yearly).	NH_3: National study
1.A.2.f	Glass Production	Association of Glass Industry 2005–2022: ETS data.	Direct information from industry association: NO_x, SO_2.	CO, NMVOC, NH_3: National studies
1.A.2.f	Lime Production	Energy balance 2005–2022: ETS data.		All pollutants: National studies
1.A.2.f	Bricks and Tiles Production	Association of Bricks and Tiles Industry 2005–2022: ETS data.		All pollutants: National studies
1.A.2.g	Other	Energy balance 2005–2022: ETS data.		All pollutants: National studies

The SO_2 emission factor for natural gas is selected from the EMEP 2019 Guidebook.

3.1.4.2 NFR 1.A.2.a Iron and Steel

In this category mainly two integrated iron and steel plants with a total capacity of about 6 Mt pig iron or 7.5 Mt of crude steel per year are considered. Facilities relevant for air emissions are blast furnaces, coke ovens, iron ore sinter plants, on site power plants, LD converters, rolling mills, scrap preheating, collieries and other metal processing. According to the SNAP and NFR nomenclatures these activities have to be reported to several sub categories. In case of the Austrian inventory emissions from above mentioned activities are reported in sub categories *1.A.2.a* and *2.C.* Heavy metals, POPs and PM emissions of the two integrated steel plants are included in category *2.C* (SNAP 0402). Category 1.A.2.a also includes emissions from fuel combustion in other steel manufacturing industries.

Integrated steelworks (two units)

Two companies report their yearly NO_x, SO_2, NMVOC, CO and PM emissions to the Umweltbundesamt. Environmental reports are available on the web at https://www.umweltbundesamt.at/umweltthemen/umweltmanagement/emas under EMAS register-Nr. 221 and 216, which partly include data on air emissions. During the last years parts of the plants where reconstructed and equipped with PM emission controls which has also led to lower heavy metal and POP emissions. Reduction of SO_2 and NO_x emissions of in-plant power stations was achieved by switching from coal and residual fuel oil to natural gas.

Table 93: PM emission controls of integrated iron & steel plants.

	Facility	Controlled emissions
Plant 1 1,5 Mt/a crude steel	Iron ore sinter plant:	PM: electro filter, fabric filter
	Cast house/pig iron recasting	PM
	LD converter	PM: electro filter
	Ladle furnace	PM: electro filter
Plant 2: 6 Mt/a crude steel	Iron ore sinter plant: 2 mio t/a sinter	PM: "AIRFINE" wet scrubber
	Coke oven: 1,9 mio t/a coke	Coke transport and quenching: PM
	Cast house	PM
	LD converter	PM
	Rolling mill	PM

The following table shows emissions of main pollutants from the two integrated iron and steel plants. The comparably low values in 2018 are due to the maintenance of a large blast furnace and correspond to lower steel production (activity data is provided in chapter for category 2.C.1).

Table 94: NFR 1.A.2.a – integrated iron and steel plants – reported main pollutant emissions.

	NO_x (kt)	SO_2 (kt)	NMVOC (kt)	CO (kt)
1990	4.97	6.05	0.07	210.68
1995	4.44	3.69	0.06	182.09
2000	4.18	4.06	0.09	164.47
2005	4.61	4.86	0.29	138.18
2010	4.15	4.72	0.24	107.79
2011	4.05	4.91	0.26	120.81
2012	4.06	5.03	0.26	120.62
2013	3.64	5.21	0.22	125.26
2014	3.45	5.27	0.17	134.60
2015	3.78	5.36	0.18	145.63
2016	3.76	5.12	0.16	144.76
2017	3.42	4.79	0.22	144.94
2018	3.26	4.18	0.15	133.26
2019	3.55	4.57	0.14	152.56
2020	3.32	4.32	0.14	145.59
2021	3.57	4.61	0.14	170.41
2022	3.45	4.63	0.18	168.40

Other fuel combustion

Fuel combustion in other iron and steel manufacturing industry is calculated by the simple CORINAIR methodology. Activity data is taken from energy balance. The following tables summarize the selected emission factors for the main pollutants and activity data for the year 2022. It is assumed that emissions are uncontrolled.

Table 95: NFR 1.A.2.a – area source – main pollutant emission factors and fuel consumption for the year 2022.

Fuel	Source of NO_x, CO, NMVOC, SO_2 emission factors	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
Hard coal	(BMWA, 1990) (1)	-	250.0	150.0	15.0	600.0	0.01
Coke oven coke	(BMWA, 1990) (1)	85	220.0	150.0	8.0	500.0	0.01
Residual fuel oil < 1% S	(BMWA, 1996) (1)	131	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA, 1996) (1)	-	235.0	15.0	8.0	398.0	2.70
Heating oil	(BMWA, 1996) (2)	99	65.0	15.0	4.8	45.0	2.70
Kerosene	(BMWA, 1996) (3)	-	118.0	15.0	4.8	92.0	2.70
Natural gas	(BMWA, 1996) (1)	8 218	41.0	5.0	0.5	0.3(6)	1.00
LPG	(BMWA, 1996) (4)	419	41.0	5.0	0.5	6.0(7)	1.00

(1) *Default emission factors for industry*

(2) *Default emission factors for district heating plants*

(3) *Upper values from residual fuel oil < 1% S and heating oil*

(4) *Values for natural gas are selected*

(5) *Values for bark are selected*

(6) *EMEP 2016 Guidebook 1.A.4.b.i – table 3-13.*

(7) *From (Leutgöb et al., 2003)*

NH_3 emission factors are taken from (Umweltbundesamt, 1993). PM, HM and POP emission factors are described in a separate section below.

3.1.4.3 NFR 1.A.2.b Non-ferrous Metals

This category enfolds emissions from fuel combustion in non-ferrous metals industry including heavy metal and POPs emissions from melting of products. Fuel consumption activity data is taken from the energy balance. Emissions from this category are presented in the following tables.

This category also includes SO_2, heavy metals and POPs emissions from secondary nickel production (SNAP 030324). SO_2 and Hg emissions are plant specific and other pollutants are calculated by means of emission factors (see chapters 3.1.4.10 and 3.1.4.11).

Activity data

Fuel consumption is taken from (IEA JQ, 2023).

Table 96: Fuel consumption from NFR 1.A.2.b Non-ferrous Metals.

NFR	1.A.2.b	1.A.2.b	1.A.2.b	1.A.2.b	1.A.2.b	1.A.2.b
Fuel	**(PJ)**	**liquid**	**solid**	**gaseous**	**biomass**	**other**
1990	2.08	0.51	0.21	1.35	-	-
1995	4.36	0.57	0.09	3.70	-	-
2000	3.12	0.64	0.17	2.31	-	-
2001	3.68	0.45	0.13	3.10	-	-
2005	4.10	0.26	0.07	3.77	-	-
2010	4.31	0.30	0.07	3.94	-	-
2011	4.19	0.28	0.06	3.85	-	-
2012	5.08	0.46	0.13	3.99	-	-
2013	4.93	0.43	0.15	4.31	0.48	0.02
2014	5.09	0.38	0.13	4.54	0.03	0.01
2015	5.30	0.27	0.13	4.85	0.03	0.01
2016	5.18	0.24	0.11	4.80	0.03	0.02
2017	5.80	0.10	0.08	5.57	0.02	0.02
2018	5.27	0.12	0.13	5.01	0.03	0.01
2019	4.73	0.13	0.13	4.42	0.00	0.02
2020	5.27	0.15	0.09	4.98	0.04	0.01
2021	5.34	0.14	0.14	5.01	0.04	0.00
2022	157%	-73%	-35%	270%	0.05	0.01
Trend 1990–2022	**1%**	**-6%**	**46%**	**1%**	**-!**	**-**
Trend 2021–2022	**2.08**	**0.51**	**0.21**	**1.35**	**23%**	**41%**

The following Table 97 shows fuel consumption and main pollutant emission factors of category *1.A.2.b* for the year 2022.

Table 97: NFR 1.A.2.b main pollutant emission factors and fuel consumption for the year 2022.

Fuel	Source of NO_x, CO, NMVOC, SO_2 emission factors	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
Coke oven coke	(BMWA, 1990) [(1)]	137	220.0	150.0	8.0	500.0	0.01
Residual fuel oil < 1% S	(BMWA, 1996) [(1)]	2	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA, 1996) [(1)]	-	235.0	15.0	8.0	398.0	2.70
Heating oil	(BMWA, 1996) [(2)]	2	65.0	15.0	4.8	0.5[(6)]	2.70
Kerosene	(BMWA, 1996) [(3)]	-	118.0	15.0	4.8	92.0	2.70
Other liquid fuels	Similar to 1.A.1.c Other liquid fuels	-	40.0	10.0	0.5	6.0	2.68
Natural Gas	(BMWA, 1996) [(1)]	5 009	41.0	5.0	0.5	0.3[(7)]	1.00
LPG	(BMWA, 1996) [(4)]	133	41.0	5.0	0.5	6.0[(5)]	1.00

[(1)] *Default emission factors for industry*
[(2)] *Default emission factors for district heating plants*
[(3)] *Upper values from residual fuel oil < 1% S and heating oil*
[(4)] *Values for natural gas are selected*
[(5)] *From (Leutgöb et al., 2003)*
[(6)] *10 ppm sulphur content*
[(7)] *EMEP 2019 Guidebook 1.A.4.b.i – table 3-13.*

3.1.4.4 NFR 1.A.2.c Chemicals

Category 1.A.2.c includes emissions from fuel combustion in chemicals manufacturing industry. Because the inventory is linked with the NACE/ISIC consistent energy balance, plants which mainly produce pulp are considered in this category. Main polluters are pulp and basic anorganic chemicals manufacturers. Main pollutant emission factors used for emission calculation are industrial boilers default values or derived from plant specific measurements (fluidized bed boilers).

Waste incineration

NO_X, SO_2, CO, NMVOC and PM_{10} emissions from a large waste incineration plant are plant specific.

Activity data

Fuel consumption is taken from (IEA JQ, 2023).

Table 98: Fuel consumption from NFR 1.A.2.c Chemicals.

NFR	**1.A.2.c**	**1.A.2.c**	**1.A.2.c**	**1.A.2.c**	**1.A.2.c**	**1.A.2.c**
Fuel	**(PJ)**	**liquid**	**solid**	**gaseous**	**biomass**	**other**
1990	16.29	1.27	1.09	9.36	2.90	1.67
1995	17.11	1.34	1.58	10.33	1.72	2.15
2000	25.45	0.85	2.61	15.78	3.95	2.26
2005	24.81	0.98	1.57	18.40	2.43	1.43
2010	28.69	1.89	0.81	18.30	3.51	4.19
2011	27.71	1.68	0.72	18.37	3.25	3.69
2012	28.10	1.31	0.73	18.62	3.67	3.78
2013	26.22	1.10	0.88	18.04	3.35	2.86
2014	26.29	0.71	1.29	18.19	2.86	3.25
2015	25.57	0.75	1.08	18.28	2.40	3.06
2016	28.30	0.79	1.11	20.42	2.62	3.36
2017	29.42	0.73	2.17	20.55	2.93	3.02
2018	27.78	0.52	1.28	19.96	3.24	2.78
2019	28.50	0.57	0.61	21.25	3.59	2.48
2020	28.19	0.99	0.44	20.35	3.17	3.24
2021	29.44	0.47	0.36	22.14	3.46	3.02
2022	27.01	0.64	0.55	17.82	3.91	4.10
Trend 1990–2022	**66%**	**-50%**	**-50%**	**90%**	**35%**	**146%**
Trend 2021–2022	**-8%**	**36%**	**53%**	**-20%**	**13%**	**36%**

Table 99 summarizes activity data and emission factors for 2022. Underlined values category specific emission factors.

Table 99: NFR 1.A.2.c main pollutant emission factors and fuel consumption for the year 2022.

Fuel	Source of NO_x, CO, NMVOC, SO_2 emission factors	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
Hard coal	(BMWA, 1990) (1)	546	80.3(5)	150.0	15.0	60.0(9)	0.01
Coke oven coke	(BMWA, 1990) (1)	-	220.0	150.0	8.0	500.0	0.01
Residual fuel oil < 1% S	(BMWA, 1996) (1)	153	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA, 1996) (1)	99	235.0	15.0	8.0	398.0	2.70
Heating oil	(BMWA, 1996) (2)	276	65.0	15.0	4.8	0.5	2.70
Other liquid fuels	Similar to 1.A.1.c Other liquid fuels	98	40.0	10.0	0.5	6.0	2.68
Natural Gas	(BMWA, 1996) (1)	17 821	41.0	5.0	0.5	0.3(11)	1.00
LPG	(BMWA, 1996) (3)	8	41.0	5.0	0.5	6.0(4)	1.00
Industrial waste	(BMWA, 1990) (1)	4 100	14.6(6)	5.7(6)	0.54	2.1(6)	0.02
Solid biomass	(BMWA, 1996) (1)	3 348	100.0(7)	72.00	5.0	30.0	5.00
Biogas	(BMWA, 1990) (8)	569	150.0	5.0	0.5	NA	1.00

(1) Default emission factors for industry

(2) Default emission factors for district heating plants

(3) Values for natural gas are selected

(4) From (Leutgöb et al., 2003)

(5) 50% of hard coal is assigned to fluidized bed boilers in pulp industry with comparatively low EF.

(6) Implied emission factor

(7) Assumed to be consumed by one plant. The selected NO_x emission factor is derived from plant specific data of the DKDB.

(8) Uncontrolled default emission factors for natural gas fired industrial boilers are selected.

(9) For hard coal an uncontrolled SO_2 emission factor of 600 kg/TJ with a control efficiency of 90% is assumed.

(10) 10 ppm sulphur content

(11) EMEP 2019 Guidebook 1.A.4.b.i – table 3-13.

3.1.4.5 NFR 1.A.2.d Pulp, Paper and Print

Category 1.A.2.d includes emissions from fuel combustion in pulp, paper and print industry. Plants which mainly produce pulp are considered in category *1.A.2.c Chemicals* except black liquor recovery boilers. All black liquor recovery boilers are equipped with flue gas desulphurization and electrostatic precipitators. Additionally all fluidized bed boilers are equipped with electrostatic precipitators and/or fabric filters. A detailed description of boilers, emissions and emission controls is provided in the unpublished study (Umweltbundesamt 2005b).

Fuel consumption is taken from the energy balance. SO_2 emissions are taken from (Austropapier 2002–2023). TSP emissions are taken from (Umweltbundesamt, 2005a). Other main pollutant emission factors used for emission calculation are industrial boilers default values.

Activity data

Fuel consumption is taken from (IEA JQ, 2023).

Table 100: Fuel consumption from NFR 1.A.2.d Pulp, Paper and Print.

NFR	1.A.2.d	1.A.2.d	1.A.2.d	1.A.2.d	1.A.2.d	1.A.2.d
Fuel		**liquid**	**solid**	**gaseous**	**biomass**	**other**
				[PJ]		
1990	55.31	10.94	4.13	17.01	23.03	0.19
1995	67.32	6.72	3.97	24.57	31.58	0.48
2000	67.10	2.20	4.70	31.82	28.38	-
2005	74.09	1.79	5.02	30.85	36.32	0.11
2010	74.80	0.93	3.55	34.41	35.84	0.08
2011	74.07	0.69	3.94	33.39	35.96	0.09
2012	71.34	0.51	3.95	29.40	37.42	0.06
2013	69.12	0.83	4.23	26.05	37.83	0.17
2014	65.64	0.44	4.19	23.88	36.95	0.18
2015	64.66	0.54	4.29	24.87	34.78	0.18
2016	66.14	0.39	4.38	24.52	36.71	0.15
2017	65.78	0.22	4.44	24.35	36.59	0.18
2018	68.43	0.22	4.15	26.60	37.18	0.29
2019	71.89	0.23	4.05	28.42	39.12	0.07
2020	67.42	0.17	3.31	26.61	37.23	0.09
2021	66.97	0.19	2.33	28.66	35.78	0.01
2022	65.94	0.31	1.47	24.67	39.47	0.02
Trend 1990–2022	**19%**	**-97%**	**-64%**	**45%**	**71%**	**-91%**
Trend 2021–2022	**-2%**	**65%**	**-37%**	**-14%**	**10%**	**30%**

Table 101 shows activity data and emission factors for 2022. SO_2 emission factors were derived from national default values for industrial boilers taken from (BMWA, 1990) and not highly representative for single fuels within this category. Black liquor recovery and fluidized bed boilers are fired with combined fuels and therefore NO_x emission factors are not always representative for single fuel types. Underlined values indicate non default emission factors.

Since the year 2017, NO_x and TSP/PM_{10}/$PM_{2.5}$ emission factors are updated by means of a new study (Windsperger, 2019) which is based on boiler specific data. Emission factors 2006–2016 are linearly interpolated.

Table 101: NFR 1.A.2.d main pollutant emission factors and fuel consumption for the year 2022.

Fuel	Source of NO_x, CO, NMVOC, SO_2 emission factors	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
Hard coal	(BMWA, 1990) (1)	1 468	75.0(9)	150.0	15.0	49.3	0.01
Brown coal	(BMWA, 1990) (1)	0	170.0	150.0	23.0	40.8	0.02
Brown coal briquettes	(BMWA, 1990) (1)	0	170.0	150.0	23.0	40.8	0.02
Coke oven coke	(BMWA, 1990) (1)	0	220.0	150.0	8.0	53.9	0.01

Fuel	Source of NO_x, CO, NMVOC, SO_2 emission factors	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
Residual fuel oil < 1% S	(BMWA, 1996) (1)	0	118.0	10.0	0.8	7.1	2.70
Residual fuel oil ≥ 1% S	(BMWA, 1996) (1)	18	235.0	15.0	8.0	30.7	2.70
Heating oil	(BMWA, 1996) (2)	8 431	65.0	15.0	4.8	0.04	2.70
Kerosene	(BMWA, 1996) (6)	728	118.0	15.0	4.8	7.1	2.70
LPG	(BMWA, 1996) (3)	38	41.0	5.0	0.5	IE	1.00
Natural Gas (including lime kilns)	(BMWA, 1996) (1)	81	46.9(9)	5.0	0.5	IE	1.00
Industrial waste	(BMWA, 1990) (1)	179	100.0	200.0	0.54	10.0	0.02
Black liquor	(BMWA, 1990) (1)	1	68.0(9)	20.0	4.0	10.0	0.02
Fuel wood	(BMWA, 1996) (8)	0	110.0	370.0	5.00	4.6	5.00
Solid biomass + Sewage sludge	(BMWA, 1996) (1)	28 934	86.0(9)	72.00	5.0	4.6	5.00
Biogas	(BMWA, 1990) (5)	24 673	150.0	5.0	0.5	IE	1.00

(1) *Default emission factors for industry*

(2) *Default emission factors for district heating plants*

(3) *Values for natural gas are selected*

(4) *From (Leutgöb et al., 2003)*

(5) *Uncontrolled default emission factors for natural gas fired industrial boilers are selected.*

(6) *Upper values from residual fuel oil < 1% S and heating oil*

(7) *NO_x emission factor for black liquor is derived from partly continuous measurements according to (Umweltbundesamt, 2005a).*

(8) *Emission factors of wood chips fired district heating boilers are selected.*

(9) *From (Windsperger, 2019).*

3.1.4.6 NFR 1.A.2.e Food Processing, Beverages and Tobacco

Category 1.A.2.e includes emissions from fuel combustion in food processing, beverages and tobacco industry. Due to the low fuel consumption it is assumed that default emission factors of uncontrolled industrial boilers are appropriate although it is known that sugar factories operate some natural gas and coke oven coke fired lime kilns. It is assumed that any type of secondary emission control does not occur within this sector.

Activity data

Fuel consumption is taken from (IEA JQ, 2023).

Table 102: Fuel consumption from NFR 1.A.2.e Food Processing, Beverages and Tobacco.

NFR	1.A.2.e	1.A.2.e	1.A.2.e	1.A.2.e	1.A.2.e	1.A.2.e
Fuel	**(PJ)**	**liquid**	**solid**	**gaseous**	**biomass**	**other**
1990	13.91	4.45	0.18	9.15	0.13	-
1995	15.10	4.40	0.06	10.53	0.10	-
2000	15.16	2.18	0.21	12.53	0.24	-

NFR	1.A.2.e	1.A.2.e	1.A.2.e	1.A.2.e	1.A.2.e	1.A.2.e
Fuel	**(PJ)**	**liquid**	**solid**	**gaseous**	**biomass**	**other**
2005	16.51	3.19	0.13	12.71	0.48	-
2010	16.97	2.68	0.14	13.52	0.63	0.0040
2011	16.96	2.65	0.15	13.48	0.67	0.0039
2012	16.98	2.09	0.16	13.87	0.86	0.0037
2013	14.98	0.97	0.15	13.31	0.55	0.0016
2014	16.57	1.15	0.17	14.73	0.52	0.0005
2015	17.80	0.90	0.22	16.03	0.64	0.0001
2016	14.87	0.77	0.15	13.39	0.56	0.0003
2017	14.57	0.64	0.17	13.31	0.45	0.0004
2018	14.14	0.49	0.13	12.98	0.53	0.0049
2019	13.86	0.48	0.12	12.80	0.46	-
2020	14.46	0.41	0.11	13.46	0.48	0.0006
2021	14.42	0.48	0.13	13.49	0.33	-
2022	15.90	0.99	0.16	13.96	0.79	0.0005
Trend 1990–2022	**14%**	**-78%**	**-12%**	**53%**	**506%**	**-**
Trend 2021–2022	**10%**	**107%**	**25%**	**4%**	**137%**	**-**

Fuel consumption activity data is taken from the energy balance. Main pollutant emission factors used for emission calculation are industrial boilers default values taken from (BMWA, 1990).

Table 103 summarizes activity data and emission factors for 2022.

Table 103: NFR 1.A.2.e main pollutant emission factors and fuel consumption for the year 2022.

Fuel	Source of NO_x, CO, NMVOC, SO_2 emission factors	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
Hard coal	(BMWA, 1990) (1)	-	250.0	150.0	15.0	600.0	0.01
Brown coal	(BMWA, 1990) (1)	-	170.0	150.0	23.0	630.0	0.02
Brown coal briquettes	(BMWA, 1990) (1)	-	170.0	150.0	23.0	630.0	0.02
Coke oven coke	(BMWA, 1990) (1)	156	220.0	150.0	8.0	500.0	0.01
Residual fuel oil < 1% S	(BMWA, 1996) (1)	198	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA, 1996) (1)	-	235.0	15.0	8.0	398.0	2.70
Heating oil	(BMWA, 1996) (2)	583	65.0	15.0	4.8	0.5	2.70
Kerosene	(BMWA, 1996) (6)	-	118.0	15.0	4.8	92.0	2.7
LPG	(BMWA, 1996) (3, 8)	210	41.0	5.0	0.5	6.0 (4)	1.00
Natural Gas	(BMWA, 1996) (1)	13 959	41.0	5.0	0.5	0.3 (9)	1.00
Industrial waste	(BMWA, 1990) (1)	0	100.0	200.0	0.54	130.0	0.02
Fuel wood	(BMWA, 1996) (7)	-	110.0	370.0	5.00	11.0	5.00
Solid biomass	(BMWA, 1996) (1)	611	143.0	72.00	5.0	60.0	5.00
Biogas	(BMWA, 1990) (5)	57	150.0	5.0	0.5	NA	1.00

(1) *Default emission factors for industry*
(2) *Default emission factors for district heating plants*
(3) *Values for natural gas are selected*
(4) *From (Leutgöb et al., 2003)*
(5) *Uncontrolled default emission factors for natural gas fired industrial boilers are selected.*
(6) *Upper values from residual fuel oil < 1% S and heating oil.*
(7) *Emission factors of wood chips fired district heating boilers are selected.*
(8) *According to a sample survey (Windsperger et al. 2003) natural gas NO_x emissions factors are in the range of 41 (furnaces) to 59 (boilers) kg/TJ.*
(9) *EMEP 2019 Guidebook 1.A.4.b.i – table 3-13.*

3.1.4.7 NFR 1.A.2.f Non-metallic Minerals

Category 1.A.2.f includes emissions from fuel combustion of furnaces and kilns of cement (SNAP 030311), lime (SNAP 030312), bricks/tiles (SNAP 030319) and glass manufacturing industries (SNAP 030317) and magnesite sinter plants (SNAP 030323).

Table 104: Fuel consumption from NFR 1.A.2.f Non-metallic Minerals.

NFR	1.A.2.f.i	1.A.2.f.i	1.A.2.f.i	1.A.2.f.i	1.A.2.f.i	1.A.2.f.i
Fuel	**(PJ)**	**liquid**	**solid**	**gaseous**	**biomass**	**other**
1990	23.34	6.26	5.69	10.09	-	1.31
1995	22.07	4.37	4.63	11.10	-	1.98
2000	22.79	2.32	5.34	11.57	-	3.56
2005	25.77	3.39	3.92	11.90	1.74	4.82
2010	24.26	2.17	3.33	10.86	2.87	5.04
2011	24.60	2.33	2.94	11.14	3.00	5.19
2012	24.27	1.87	3.06	10.55	3.25	5.53
2013	25.03	1.83	2.71	11.35	3.28	5.87
2014	25.83	1.69	2.88	11.48	3.28	6.51
2015	26.43	1.72	2.77	11.28	3.43	7.23
2016	26.69	1.81	2.29	11.64	3.45	7.50
2017	26.85	1.48	2.19	12.04	3.39	7.74
2018	27.82	1.41	2.41	12.10	3.70	8.20
2019	27.69	1.15	2.46	12.61	3.59	7.89
2020	27.24	0.88	3.27	12.57	3.35	7.17
2021	28.22	1.61	2.64	11.96	4.02	7.99
2022	26.73	1.75	2.18	10.66	4.41	7.73
Trend 1990–2022	**14%**	**-72%**	**-62%**	**6%**	**-**	**489%**
Trend 2021–2022	**-5%**	**9%**	**-17%**	**-11%**	**10%**	**-3%**

Table 105 shows total fuel consumption and emissions of main pollutants for sub categories of *1.A.2.f Non-metallic Minerals* for the year 2022.

Table 105: NFR 1.A.2.f Non-metallic Minerals - Fuel consumption and emissions of main pollutants by sub category for the year 2022.

Category	Fuel Consumption [TJ]	NO_x [kt]	CO [kt]	NMVOC [kt]	SO_2 [kt]	NH_3 [kt]	$PM_{2.5}$ [kt]
SNAP 030311 Cement Clinker Production	13 764	2.27	3.48	0.15	0.12	0.132	IE in 2A1
SNAP 030312 Lime Production	3 015	0.83	0.13	0.01	0.17	0.003	IE in 2A2
SNAP 030317 Glass Production	2 848	0.48	0.01	0.00	0.13	0.003	0.001
SNAP 030319 Bricks and Tiles Production	2 927	0.75	0.08	0.01	0.13	0.005	0.031
SNAP 030323 Magnesia Production	4 173	1.11	0.20	0.01	0.11	0.004	0.047
Total	**26 726**	**5.45**	**3.90**	**0.19**	**0.65**	**0.147**	**0.080**

Cement clinker manufacturing industry (SNAP 030311)

Currently nine cement clinker manufacturing plants are operated in Austria. Some rotary kilns are operated with a high share of industrial waste. In 2006, all exhaust streams from kilns and product heat recovery units were controlled by electrostatic precipitators. All plants are using SNCR/SCR to reduce NO_X emissions and one plant is equipped with a SO_2 scrubber (Mauschitz 2018). All plants are equipped with continuous emission measurement devices for PM, NO_x and $SO_{x,}$ four plants with CO, two plants with TOC and one plant with a continuous Hg measurement device (Mauschitz 2004). Annual activity data for 1990 to 2013 and emissions of 25 pollutants of all plants are estimated in periodic surveys (Hackl & Mauschitz, 1995, 1997, 2001, 2003, 2007), (Mauschitz, 2004, 2008, 2010–2023). Table 106 shows detailed fuel consumption data for 2020.

Table 106: Cement clinker manufacturing industry. Fuel consumption for the year 2022.

Fuel	Activity [TJ]
Hard coal	747
Brown coal	1 110
Petrol coke	406
Residual fuel oil < 1% S	3
Residual fuel oil 0.5% S	-
Residual fuel oil ≥ 1% S	19
Heating oil	28
Natural Gas	230
Industrial waste	7 643
Pure biogenic residues	3 578
Total	13 764

HCB accidental release

Within the period, 2012 to 2014 high amounts of HCB were released from a cement plant unintentionally[82]. The reason for release was the co-incineration of HCB contaminated material (lime) at temperatures that were too low to destroy the HCB. Around 97 kt of lime was incinerated which contained about 586 kg of HCB of which 40% were released. It has to be noted that these assumptions are very uncertain due to the absence of measurements during this period. The underlying data for the assumptions was collected after authorities stopped plant operation and is mainly based on expert judgement.

The releases are estimated to be the following:

Table 107: HCB accidental releases for the years 2012, 2013 and 2014.

Year	HCB (kg)
2012	24
2013	102
2014	108

Lime manufacturing industry (SNAP 030312)

This category includes emissions from natural gas fired lime kilns. From 1990 to 2004 it includes magnesit sinter plants because sector specific data is available from the year 2005 on only (ETS data). Natural gas consumption is calculated by subtracting natural gas consumption of glass manufacturing industry (SNAP 030317), bricks and tiles industry (SNAP 030319), magnesite sinter industry (SNAP 030323) and cement industry (SNAP 030311) from final consumption of energy balance category *Non-metallic Mineral Products*. Thus it is assumed that uncertainty of this "residual" activity data could be rather high especially for the last inventory year because the energy balance is based on preliminary data. Lime production data are presented in Table 108. Heavy metals emission factors are presented in the following subchapter. Fuel consumption and main pollutant emission factors are presented in Table 110.

Table 108: Lime production.

Year	Lime [kt]
1990	513
1995	523
2000	654
2005	788
2010	765
2011	810
2012	761
2013	779
2014	787
2015	772
2016	773
2017	775

[82] http://www.ktn.gv.at/302524_DE-HCB-Messberichte

Year	Lime [kt]
2018	735
2019	783
2020	747
2021	845
2022	795

Glass manufacturing industry (SNAP 030317)

This category includes emissions from glass melting furnaces. Fuel consumption 1990 to 1994 is taken from (WIFO, 1996). For the years 1997 and 2002 fuel consumption, SO_2 and NO_x emissions and for 2017 NO_x emissions are reported from the Austrian association of glass manufacturing industry to the Umweltbundesamt GmbH by personal communication. Activity data for the years in between are interpolated. Natural gas consumption 2003 to 2004 is estimated by means of glass production data and an energy intensity rate of 7.1 GJ/t glass. Fuel consumption from 2005 onwards is taken from ETS. NO_X and SO_2 emissions for missing years of the time series are calculated by implied emission factors derived from years were complete data is available. SO_2 emissions include process emissions. For 2003 to 2016 NO_X implied emission factors have been interpolated.

Fuel consumption and main pollutant emission factors are presented in Table 110. Table 109 shows the sum of flat and packaging glass production data. The share of flat glass in total glass production is about 5%.

Table 109: Glass production.

Year	Glass [kt]
1990	399
1995	435
2000	375
2005	418
2010	498
2011	474
2012	472
2013	487
2014	497
2015	497
2016	481
2017	502
2018	487
2019	526
2020	503
2021	510
2022	546

Bricks and tiles manufacturing industry (SNAP 030319)

This category includes emissions from fuel combustion in bricks and tiles manufacturing industry. Bricks are baked with continuously operated natural gas or fuel oil fired tunnel kilns at temperatures around 1000°C. The chlorine content of porousing material is limited by a national regulation

(Hübner, 2001b). Activity data 1990 to 1995 is communicated by the Austrian association of non-metallic mineral industry. Activity data 1996 to 2004 are linearly extrapolated 1995 activity data. Activity data 2005 to 2022 is taken from ETS. For main pollutants default emissions factors of industry are selected except for natural gas combustion for which the NO_x emission factor (294 kg/TJ) is taken from (Windsperger et al., 2003). Table 110 presents fuel consumption and main pollutant emission factors.

1.A.2.f Fuel consumption and main pollutant emission factors

Table 110 shows activity data and main pollutant emission factors of 1.A.2.f sub categories except for SNAP 030311 cement industry were emission factors are not available by type of fuel. Underlined cells indicate emission factors other than default values for industrial boilers.

Table 110: NFR 1.A.2.f main pollutant emission factors and fuel consumption for the year 2022 by sub category.

Fuel	Source of NO_x, CO, NMVOC, SO_2 emission factors	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
SNAP 030312 Lime manufacturing							
Brown coal	(BMWA, 1990) [1]	224	170.0	150.0	23.0	630.0	0.02
Petrol coke	(BMWA, 1990) [1]	32	220.0	150.0	8.0	323.0[8]	0.01
Residual fuel oil < 1% S	(BMWA, 1996) [1]	12	235.0	15.0	8.0	398.0	2.70
Heating oil	(BMWA, 1996) [2]	0	65.0	15.0	4.8	0.5	2.70
Natural Gas	(BMWA, 1996) [1]	2 575	294.0[5]	30.0[6]	0.5	0.3[10]	1.00
Industrial waste	(BMWA, 1990) [1]	-	100.0	200.0	38.0	130.0	0.02
SNAP 030317 Glass manufacturing							
Residual fuel oil	(BMWA, 1996) [1]	24	299.1[11]	15.0	8.0	442.9[7]	2.70
LPG	(BMWA, 1996) [3]	-	167.2[12]	5.0	0.5	44.9[7]	1.00
Natural Gas	(BMWA, 1996) [1]	2 824		5.0	0.5	44.9[7]	1.00
SNAP 030319 Bricks and tiles manufacturing							
Brown coal	(BMWA, 1990) [1]	100	170.0	150.0	23.0	630.0	0.02
Coke oven coke	(BMWA, 1990) [1]	1	220.0	150.0	8.0	500.0	0.01
Petrol coke	(BMWA, 1990) [1]	-	220.0	150.0	8.0	323.0[8]	0.01
Residual fuel oil < 1% S	(BMWA, 1996) [1]	2	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA, 1996) [1]	69	235.0	15.0	8.0	398.0	2.70
Heating oil, Diesel oil	(BMWA, 1996) [2]	5	65.0	15.0	4.8	0.5	2.70
LPG	(BMWA, 1996) [3]	-	41.0	5.0	0.5	6.0[4]	1.00
Natural Gas	(BMWA, 1996) [1]	2 183	294.0[5]	5.0	0.5	0.3[10]	1.00
Industrial waste	(BMWA, 1990) [1]	67	100.0	200.0	38.0	130.0	0.02
Solid biomass	(BMWA, 1996) [1]	499	143.0	72.0	5.0	60.0	5.00
SNAP 030323 Magnesia Production							
Petrol coke	(BMWA, 1990) [1]	1 143	220.0	150.0	8.0	81.0[9]	0.01
Natural Gas	(BMWA, 1996) [1]	2 848	294.0[5]	5.0	0.5	0.3[10]	1.00
Industrial waste	(BMWA, 1990) [1]	16	100.0	200.0	38.0	130.0	0.02
Solid biomass	(BMWA, 1996) [1]	165	143.0	72.0	5.0	60.0	5.00

(1) Default emission factors for industry.

(2) Default emission factors for district heating plants.

(3) Values for natural gas are selected.

(4) From (Leutgöb et al., 2003)

(5) NO_x emission factor of natural gas fired lime kilns and bricks and tiles production is taken from (Windsperger et al., 2003).

(6) CO emission factor of natural gas fired lime kilns is assumed to be 5 times higher than for industrial boilers.

(7) SO_2 emission factors of fuels used for glass manufacturing include emissions from product processing.

(8) For petrol coke a sulphur content of 0.5% is assumed. The emission factor is calculated by means of the heating value (emission factor SO_2(g/GJ) = $2*0.5\%*10^6/31$GJ/t)

(9) Same assumptions as for SNAPs 030312/030319 but 75% of sulphur remains in the product. (carbide).

(10) EMEP 2019 Guidebook 1.A.4.b.i – table 3-13.

(11) Implied emission factor 2002.

(12) Implied emission factor 2022.

3.1.4.8 NFR 1.A.2.g.viii Other Stationary Combustion in Manufacturing Industries and Construction

Category 1.A.2.g.viii includes emissions of industrial boilers not considered in categories 1.A.2.a to 1.A.2.f. Table 111 presents the industrial branches, which are considered in category 1.A.2.g.viii.

Table 111: ISIC divisions considered in category 1.A.2.g.viii

ISIC Division(s)	Name
13 and 14	Mining and Quarrying (Non fuel)
17, 18 and 19	Textile and Leather
20	Wood and Wood Products
25	Rubber and Plastic Products
28, 29, 30, 32 and 33	Machinery and Instruments
34 and 35	Transport Equipment
36	Furniture
37	Recycling
45	Construction

The following Table 112 presents the fuel consumption of category 1.A.2.g.viii by type of fuel.

Table 112: Fuel consumption from NFR 1.A.2.g.viii Other Stationary Combustion in Manufacturing Industries and Construction.

NFR	1.A.2.g.viii	1.A.2.g.viii	1.A.2.g.viii	1.A.2.g.viii	1.A.2.g.viii	1.A.2.g.viii
Fuel	(PJ)	liquid	solid	gaseous	biomass	other
1990	30.82	8.20	0.88	18.30	3.39	0.05
1995	39.32	10.55	0.17	25.68	2.24	0.67
2000	36.45	8.15	0.29	19.31	8.26	0.44
2005	51.77	9.47	0.33	23.29	17.16	1.52
2010	59.51	6.86	-	27.93	22.87	1.85
2011	58.13	7.06	-	24.40	23.75	2.92
2012	61.46	7.81	-	25.14	26.54	1.97
2013	59.52	4.14	0.01	28.57	24.52	2.30
2014	53.12	3.67	0.00	23.92	24.51	1.02
2015	51.86	3.48	0.00	21.70	26.23	0.43
2016	50.68	3.40	0.00	24.66	21.77	0.85
2017	50.39	3.05	0.03	25.15	21.34	0.82
2018	46.79	2.30	0.00	24.72	18.96	0.80
2019	42.25	2.87	-	21.54	17.31	0.52

NFR	1.A.2.g.viii	1.A.2.g.viii	1.A.2.g.viii	1.A.2.g.viii	1.A.2.g.viii	1.A.2.g.viii
Fuel	**(PJ)**	**liquid**	**solid**	**gaseous**	**biomass**	**other**
2020	43.30	2.09	0.00	22.21	17.92	1.08
2021	45.38	1.87	0.03	23.78	19.36	0.33
2022	47.01	1.56	0.02	22.88	21.38	1.18
Trend 1990–2022	**30.82**	**8.20**	**-98%**	**25%**	**530%**	**2455%**
Trend 2021–2022	**39.32**	**10.55**	**-28%**	**-4%**	**10%**	**253%**

Other manufacturing industry – boilers (SNAP 0301)

This sub category includes emissions of industrial boilers not considered in categories 1.A.2.a to 1.A.2.f. No specific distinction of technologies is made but national default emission factors of industrial boilers (BMWA, 1990) are taken for emission calculation except for PM and NO_X emissions from biomass use in wood processing and chipboard manufacturing industries. It is assumed that facilities are not equipped with secondary emission controls. Activity data is taken from the energy balance.

Activity data and main pollutant emission factors are shown in Table 110.

Table 113 shows activity data and main pollutant emission factors of category 1.A.2.g.viii.

Table 113: NFR 1.A.2.g.viii main pollutant default emission factors and fuel consumption for the year 2022.

Fuel	Source of NO_x, CO, NMVOC, SO_2 emission factors	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
SNAP 0301 Other boilers							
Coke oven coke	(BMWA, 1990)(1)	0	220.0	150.0	8.0	500.0	0.01
Brown coal	(BMWA, 1990)(1)	21	170.0	150.0	23.0	630.0	0.02
Residual fuel oil < 1% S	(BMWA, 1996)(1)	526	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA, 1996)(1)	-	235.0	15.0	8.0	398.0	2.70
Heating oil, Diesel oil	(BMWA, 1996)(2)	7	65.0	15.0	4.8	0.5	2.70
LPG	(BMWA, 1996)(3)	1 025	41.0	5.0	0.5	6.0(4)	1.00
Natural gas	(BMWA, 1996)(1)	22 880	41.0	5.0	0.5	0.3(7)	1.00
Industrial waste	(BMWA, 1990)(1)	1 175	100.0	200.0	0.54	11.0	0.02
Fuel wood	(BMWA, 1996)(6)	-	110.0	370.0	5.00	11.0	5.00
Solid biomass	(BMWA, 1996)(1)	21 280	143.0	72.00	5.0	60.0	5.00
Sewage sludge	(BMWA, 1996)(1)	-	100.0	200.0	38.00	NA	0.02
Biogas	(BMWA, 1990)(5)	98	150.0	4.0	0.5	NA	1.00

(1) *Default emission factors for industry.*

(2) *Default emission factors for district heating plants.*

(3) *Values for natural gas are selected.*

(4) *From (Leutgöb et al., 2003)*

(5) *Uncontrolled default emission factors for natural gas fired industrial boilers are selected.*

(6) *Emission factors of wood chips fired district heating boilers are selected.*

(7) *EMEP 2019 Guidebook 1.A.4.b.i – table 3-13.*

3.1.4.9 Wood processing and chipboard manufacturing industries

For "wood and wood products" industry a branch specific set of emission factors has been applied. A national study (Windsperger, 2018) carried out in 2018 provides new NO_X and PM emission factors for biomass combustion of large chipboard production facilities and saw mills. The study is based on a survey conducted by the Austrian association of wood processing industries (Fachverband der Holzverarbeitenden Industrie) for the year 2016. Emission factors have been derived from measurements and applied to total biomass consumption as provided in the Austrian energy balance.

Table 114: Wood processing and chipboard manufacturing emission factors and fuel consumption for the year 2022.

Fuel	Activity [TJ]	NO_x [kg/TJ]	TSP [kg/TJ]	PM_{10} [kg/TJ]	$PM_{2.5}$ [kg/TJ]
Solid biomass	20 346	169.0[(1)] 133.0[(2)]	55.0[(3)] 7.6[(4)]	50.0 6.8	41.0 5.7

[(1)] NO_x emission factor 1990 to 2000

[(2)] NO_xemission factor 2016

[(3)] TSP emission factor 1990 to 1999

[(4)]TSP emission factor 2016

3.1.4.10 Emission factors for heavy metals

For cement industries (SNAP 030311) emission values were taken from (Hackl & Mauschitz, 2001 to Hackl & Mauschitz, 2023); in the Tables presented below implied emission factors (IEF) are given.

For the other sub categories emission factors are applied, references are provided below.

Coal

Heavy metal emission factors for 1995 were taken from (CORINAIR, 1997), Chapter B112, Table 12. For 1990 the emission factors were assumed to be 50% and for 1985 100% higher, respectively.

Fuel Oil

For fuel oil the same heavy metal emission factors as for 1.A.1 were used.

Other Fuels

For fuel wood and wood wastes the value from (Obernberger, 1995) for plants > 4 MW was used for 1990. For fuel wood from 1995 onwards the value taken from personal information about emission factors for wood waste from the author was used.

For wood wastes from 1995 onwards the value for fuel wood of category 1.A.4.a (7 mg/GJ for Cd, 2 mg/GJ for Hg and 50 mg/GJ for Pb, valid for small plants) and a value of 0.8 mg/GJ for Cd, 13 mg/GJ for Hg and 1.0 mg/GJ for Pb, respectively, which are valid for plants with higher capacity (measurements at Austrian fluid bed combustion plants by FTU in 1999/2000) was weighted according to the share of overall installed capacity of the Austrian industry (25% high capacity and 75% low [< 5 MW] capacity).

Table 115: Cd emission factors for NFR 1.A.2 Manufacturing Industries and Construction.

Cadmium EF [mg/GJ]	**1990**	**1995**	**2022**
Coal			
102A Hard coal 107A Coke oven coke	0.15	0.10	0.10
105A Brown coal 106A brown coal briquettes	0.60	0.40	0.40
Oil			
204A Heating and other gas oil 2050 Diesel		0.02 (all years)	
203B light fuel oil		0.05 (all years)	
203D heavy fuel oil	0.75	0.50	0.50
110A petrol coke		0.1 (all years)	
Other Fuels			
111A Fuel wood	6.10	2.50	2.50
116A Wood waste 115A Industrial waste	6.10	2.35	2.35
1.A.2.d Pulp and paper - solid biomass			
118A Sewage sludge	67.14	24.13	7.38
215A Black liquor	6.10	2.19	0.83

Table 116: Hg emission factors for NFR 1.A.2 Manufacturing Industries and Construction.

Mercury EF [mg/GJ]	**1990**	**1995**	**2022**
Coal			
102A Hard coal 107A Coke oven coke	2.55	1.70	1.70
105A Brown coal 106A brown coal briquettes	6.60	4.40	4.40
Oil			
204A Heating and other gas oil 2050 Diesel		0.007 (all years)	
203B light fuel oil		0.015 (all years)	
203D heavy fuel oil		0.75 (all years)	
110A petrol coke		1.70 (all years)	
Other Fuels			
111A Fuel wood 116A Wood waste	1.90	1.25	1.25
115A Industrial waste 215A Black liquor		1.9 (all years)	
Natural Gas			
301A Natural gas		0.07 (all years)	

Table 117: Pb emission factors for NFR 1.A.2 Manufacturing Industries and Construction.

LEAD EF [mg/GJ]	**1990**	**1995**	**2022**
Coal			
102A Hard coal 107A Coke oven coke	9.00	6.00	6.00

LEAD EF [mg/GJ]	1990	1995	2022
105A Brown coal 106A brown coal briquettes	5.85	3.90	3.90
Oil			
204A Heating and other gas oil 2050 Diesel		0.02 (all years)	
203B light fuel oil		0.05 (all years)	
203D heavy fuel oil	0.19	0.13	0.13
110A petrol coke		6.00 (all years)	
Other Fuels			
111A Fuel wood 116A Wood waste	26.3	21.15	21.15
115A Industrial waste		72.00 (all years)	
1.A.2.d Pulp and paper - solid biomass			
118A Sewage sludge	208.6	75.0	22.9
215A Black liquor	26.3	9.5	3.6

Emission factors not related to fuel input

The following Tables show production data of iron and steel, non-ferrous metals and other activity data for selected years used as activity data for calculating heavy metals and POPs emissions from products processing.

Table 118: Non-ferrous metals production [t].

Year	Nickel Production (SNAP 030324)
	[t]
1990	638
1995	822
2000	2 000
2010	2 000
2022	2 000

Nickel Production is taken from (Östat Industrie- und Gewerbestatistik), (European Commission IPPC Bureau 2000) and the nickel-institute (http://www.nickelinstitute.org).

Table 119: Activity data for calculation of HM and POP emissions with EF not related to fuel input.

Year	Cast Iron Production [kt]	Cement clinker [kt]
1990	110	3 694
1995	69	2 930
2000	75	3 053
2005	76	3 221
2010	65	3 097
2011	67	3 176
2012	63	3 206
2013	67	3 156
2014	65	3 143
2015	61	3 257

Year	Cast Iron Production [kt]	Cement clinker [kt]
2016	56	3 300
2017	61	3 313
2018	64	3 552
2019	62	3 423
2020	53	3 522
2021	59	3 663
2022	58	3 560

Table 120: Asphalt concrete production.

Year	Asphalt concrete [kt]
1990	403
2022	522

Emission factors for Iron and Steel: reheating furnaces were taken from (Winiwarter & Schneider, 1995).

For lime production the emission factors for cement production (Hackl & Mauschitz, 2001) were used, as the two processes are technologically comparable.

Pb and Cd emission factors for glass production base on measurements at two Austrian facilities for the year 2000. As emission limits are legally restricted, and for 1995 the emission allowances were higher, for 1995 twice the value of 2000 was used. For 1990 and 1985 the Cd and Pb emission factors as well as the Hg emission factor are from (Winiwarter & Schneider, 1995).

Heavy metals emissions from burning of fine ceramic materials arise if metal oxides are used as pigments for glaze. The emission factors for fine ceramic materials base on results from (Boos, 2001), assuming that HM concentrations in waste gas is 5% of raw gas concentrations.

Emission factors for nickel production base on measurements at the only relevant Austrian facility.

Table 121: HM emission factors not related to fuel input for NFR 1.A.2 Manufacturing Industries and Construction.

NFR	SNAP	Category Description	EF [mg/t Product]		
			Cd	Hg	Pb
1.A.2.a	030302	Iron and Steel: reheating furnaces	50	–	2 400
1.A.2.f	030311	Cement production (year 2017 value)	1.91	39.7	9.82
1.A.2.f	030312	Lime production	8.7	21	29
1.A.2.f	030317	Other glass	150–8[83]	50–30[84]	12 000–200[84]
1.A.2.f	030320	Fine ceramic materials	150	–	5 000
1.A.2.b	030324	Nickel production	5	570	230

[83] upper value for 1985, lower value for 2000; years in between were linearly interpolated

3.1.4.11 Emission factors for POPs

For cement industries the dioxin (PCDD/F) emission factor of 0.01 µg/GJ is derived from measured 0.02 ng TE/Nm³ at 10% O_2 (Wurst & Hübner, 1997) assuming a flue gas volume of 1 600–1 700 Nm³/t cement clinker (Hübner, 2001b) and an average energy demand of 3.55 GJ/t cement clinker. HCB emission factors are taken from (Hübner, 2001b). The PAK4 emission factor of 0.28 mg/GJ fuel input is derived on actual measurements communicated to the Umweltbundesamt.

The dioxin (PCDD/F) emission factor for bricks and tiles and lime production is based on findings of the study (Wurst & Hübner, 1997). HCB emissions were calculated on the basis of dioxin emissions and assuming a factor of 200.

For pulp and paper industries the dioxin emission factor of 0.009 µgTE/GJ for all fuels bases on measurements of fluidized bed combustors in pulp and paper industries (Wurst, F. & C. Hübner, 1997) and data from literature with typical fuel mixes (LAI-REPORT, 1995), (Nussbaumer, 1994). HCB emissions were calculated on the basis of dioxin emissions and assuming a factor of 200.

For the other sub categories emission factors for plants with different capacities were applied, together with assumptions on plant structure of the Austrian industry mean values for each fuel were calculated. The IEFs (average EF per fuel category) were used for all years; they are presented in Table 123.

Emission factors for dioxin were taken from (Wurst & Hübner, 1997) and measurements at Austrian plants (FTU, 2000).

References for PAH emission factors are provided in the following table.

Table 122: Source of PAH emission factor of different fuels.

PAH4 EF [mg/GJ]	Small plants ≤ 0.35 MW	Medium plants 0.35–1 MW	Large plants 1–50 MW	Source of selected emission factors
Natural gas	0.04	NA	NA	For households, central heating (Hübner, 2001b); for larger plants not relevant
Heating oil	0.24	0.16	0.16	For small plants: households central heating (Hübner, 2001b); for larger plants: (UBA BERLIN, 1998) (four times the value of BaP).
Fuel oil	0.24	0.24	0.24	(UBA BERLIN, 1998) (four times the value of BaP)
Wood	85	2.7	0.055	For small plants: households central heating (Hübner, 2001b); for larger plants: measurements at Austrian plants by (FTU, 2000).
Coal	85	2	0.04	For small plants: households central heating (Hübner, 2001b); for large plants: (UBA BERLIN, 1998) (four times the value of BaP). For medium plants: expert judgement[84].

For other oil products the same emission factors as for category 1.A.1 were used.

For gaseous biofuels the same emission factors as for natural gas were used.

PCB emission factors have been selected as outlined in chapter 3.1.3.

[84] As the size structure for coal fired plants was not known, the EF for medium plants – which is the main size – was used for all activity data in this category.

Table 123: POP emission factors (average EF per fuel category) for 1.A.2 Manufacturing Industries and Construction.

	PCDD/F [µg/GJ]	HCB [µg/GJ]	PAK4 [mg/GJ]	PCB [µg/GJ]
All fuels in pulp and paper industries except biogases	0.009	1.8	0.055	-
Solid biomass in pulp and paper ind.				0.0008
Coal				
Hard coal	0.042	4.5	2.0	170
Brown coal	0.033	3.6	2.0	170
Brown coal briquettes	0.064	6.6	2.0	170
Coke oven coke	0.052	5.5	2.0	170
Fuel Oil				
Fuel Oil	0.0009	0.12	0.24	85
Heating and other gas oil	0.0006	0.095	0.18	NA
Other Oil Products	0.0017	0.14	0.011	NA
Gas				
Natural gas	0.0006	0.072	0.0032 (for iron and steel) NA (for other categories)	NA
LPG	0.0006	0.079	0.004	NA
Other Fuels				
Fuel Wood	0.083	13.0	2.7	0.0075
Industrial waste Wood Waste	0.083	13.0	3.3	0.0075
Gaseous biofuels	0.0006	0.072	0.0032	NA

Emission factors not related to fuel input

Dioxin emission factors for reheating furnaces in iron and steel industries (foundries) were taken from (UBA BERLIN, 1998) (average of hot air and cold air furnaces).

For calculation of PAK emissions from reheating furnaces in iron and steel industries the same emission factor as for coke in blast furnaces was used, as the coke fired reheating furnaces are technologically comparable to these.

HCB emissions for foundries were calculated on the basis of dioxin emissions and assuming a factor of 200.

POPs emissions are released in asphalt concrete plants when the bitumen/flint mixture is heated.

As dioxin EF the mean value of the emission factors given in (US-EPA, 1998) was applied.

The PAH emission factor for asphalt concrete plants was taken from (Scheidl, 1996).

Nickel is mainly produced by one company which uses catalysts and other potential recyclable as raw material. The raw material is processed in a rotary kiln and an electric arc furnace. Dioxin emissions 1993 are taken from an emissions declaration. Dioxin emissions of the remaining time series are calculated by multiplying production data with the implied emission factor of 1993.

The dioxin emission factor for nickel production bases on measurements in the only relevant Austrian facility.

Table 124: POP emission factors not related to fuel input for Sector 1.A.2 Manufacturing Industries and Construction.

	Dioxin [µg/t]	HCB [µg/t]	PAK4 [mg/t]
030302 Iron and Steel: reheating furnaces	0.25	50	1.1
030311 Cement production (2020 value)	0.039	5.88	1.1
030313 Asphalt concrete plants	0.014	2.8	0.15
030324 Nickel production	13	2 600–2.25[85]	–

3.1.4.12 Emission factors for PAH4 substances

PAH emissions factors have been split into benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and ideno[1,2,3-c,d]pyrene by means of the calculated share of the default emission factor values as provided in the EMEP/EEA 2019 GB tables:

- 1A2 - Table 3-2 (solid fuels)
- 1A2 - Table 3-5 (biomass)
- 1A2 - Table 3-4 (liquid fuels)
- 1A1 - Table 3-5 (heavy fuel oil)
- 1A2 - Table 3-3 (gaseous fuels)

3.1.4.13 Emission factors for PM

As already described in Chapter 1.4 the emission inventories of PM for different years were prepared by contractors and incorporated into the inventory system afterwards.

The emission factors were taken from (Winiwarter et al., 2001) and were used for the whole time series except for

- cement production (NFR 1.A.2.f): emissions taken from (Hackl & Mauschitz, 1995/1997/2001/2003/2007–2023) are included in category 2.A.1.
- NFR 1.A.2.d pulp, paper and print: emission values until 2017 were taken from (Austropapier, 2002–2023) and default national PM emission factors for industrial boilers have been adapted to fit the emissions. From the year 2018 onwards, PM emission factors from (IIÖ, 2019) have been applied for the most relevant fuels (coal, black liqueur, solid biomass and natural gas).

For these sources IEFs are presented in the following Table. The shares of PM_{10} and $PM_{2.5}$ were taken from (Winiwarter et al., 2001).

[85] Higher value for 1995/1990, lower value for 2000

Table 125: PM emission factors for NFR 1.A.2 for the years where values have been updated and 2022.

	TSP Emission Factors [g/GJ]				PM_{10}	$PM_{2.5}$
	1990	**1995**	**2000**	**2022**	**[%]**	**[%]**
Gas						
Natural gas & LPG	0.5				90	75
Natural gas – Pulp & Paper (IEF)	0.20	0.10	0.06	0.78	90	75
Coal						
Hard coal & Coke oven coke	45				90	75
Brown coal & Brown coal briquettes	50				90	75
Coal – Pulp & Paper industries (IEF)	7.94	3.92	4.46	8.20	95	80
Oil						
Light fuel oil & Gasoil	3.0				90	75
Medium fuel oil	35				90	75
Heavy fuel oil	65				90	75
Other kerosene	3.0				95	80
Oil – Pulp & Paper industries (IEF)	19.85	9.81	11.16	5.15	90	75
Other Fuels						
Fuel wood, Wood waste & Industrial waste	55				90	75
Fuel wood, Wood waste & Industrial waste – Pulp & Paper (IEF)	13.65	4.91	5.58	1.50	90	75
Black liquor – Pulp & Paper industries (IEF)	40.94	14.72	11.16	5.60	90	75
Gaseous biofuels	0.5				90	75

3.1.4.14 Category-specific Recalculations

Updates of activity data and of NCVs follow the updates of the IEA-compliant energy balance compiled by the federal statistics authority Statistik Austria (Chapter 3.1.9).

For category *1.A.2.f*, TSP, PM_{10}, $PM_{2.5}$ and all years, emissions from glass furnaces were mistakenly removed for the 2023 submission and have now been allocated again to category *1.A.2.f*.

3.1.5 NFR 1.A.3.e.i Pipeline compressors

Category 1.A.3.e considers emissions from natural gas powered turbines used for natural gas pipelines transport. The simple CORINAIR methodology is used for emissions calculation except for NO_x emissions, which are based on reported data.

Activity data is taken from the energy balance. The following Table 126 shows activity data and main pollutant emission factors. The NO_x emission factor of 150 kg/TJ is an expert guess by Umweltbundesamt. Since 2007 the NO_x emissions as reported in emissions declarations (http://www.edm.gv.at) have been used for the inventory.

Heavy metal and PAK4 emission factors are from the EMEP Guidebook 2019 table 3-17. The PCB emission factor is derived from the PCCD/F factor (see Table 88)

Table 126: NFR 1.A.3.e.i main pollutant emission factors and fuel consumption for the year 2022.

Fuel	Source of NO_x, CO, NMVOC, SO_2 emission factors	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
Natural Gas	(BMWA, 1996) [(1)]	6 730	150.0[(2)] 28.16[(3)]	5.0	0.5	0.3	1.00
			Cd [mg/GJ]	**Hg [mg/GJ]**	**Pb [mg/GJ]**	**PAK4 [mg/GJ]**	**PCB [µg/GJ]**
			0.0003	0.1	0.0015	0.0116	0.000018

[(1)] *Default emission factors for industry.*

[(2)] *Emission factor 1990 to 2006.*

[(3)] *Implied emission factor 2022.*

3.1.6 Quality Assurance and Quality Control (QA/QC)

Comparison with EPER and E-PRTR data

Comparison of emissions with reported 2004/2005 EPER and E-PRTR data does not explicitly identify inconsistencies for main pollutants.

1.A.1.a

Activity data and GHG emissions are in general of high quality due to the needs of GHG calculation and CO_2-trading. The quality system which is well defined for GHG is basically also applied to non-GHG but is not always fully documented in the inventory system. The following QA/QC procedures are performed depending on resource availability.

Since inventory year 2007 large combustion plant data is reported via the online EDM (electronic data management, module "eVerbrennung") system.

1.A.1.a LPS data gap filling (DKDB)

It has to be noted that emissions from *DKDB* ("Dampfkessel-Datenbank") had been reported for heating periods from October $year_{(n)}$ to September $year_{(n+1)}$ for the years 1990 to 2006. Due to this circumstance and in case of other missing values emissions and fuel consumption for an inventory year data was completed by taking the monthly values from the previous inventory year if available. In some cases either activity data or emission data was not complete and gap filling has been performed by using other monthly emission ratios of that plant. For boilers with mixed fuel consumption a linear regression model was sometimes used.

1.A.1.a LPS data validation (DKDB)

An outcome of the methodology as presented in Table 74 is the ratios of measured and calculated emissions by fuel type. Possible reasons for unexplainable ratios:

- Default emission factors are not appropriate because the group includes inhomogeneous boiler technologies.
- Changed technologies are not reflected.

- Boilers used for default emission factor derivation are not the consistent with boilers considered in the inventory approach.
- Emission declarations are not appropriate (fuel consumption is not consistent with emissions).

Activity data of large boilers and other large plants is checked with the national energy balance. For some fuels (coal, residual fuel oil, waste) and categories total national consumption is limited to a few boilers. In this case LPS consumption may be checked with data from *Statistik Austria* or with the spatial „Bundesländer" energy balance. In some cases published environmental reports which are underlying a QA/QC system like EMAS have been used for validation purpose.

1.A.1.b Petroleum refining

Reported fuel consumption is checked with energy balance. Monthly data from *DKDB* provides emissions by boiler which have been cross-checked with reported flue gas concentrations or mandatory limits.

3.1.7 Planned improvements

No improvements are planned.

3.1.8 Recalculations

This chapter presents the recalculations based on revised fuel combustion activity data expressed as the difference to the previous submission.

Revision of the energy balance

The federal statistics office "Statistik Austria" revised the national energy balance (mainly for the year 2021) with the following **main implications** for energy consumption as used in the inventory:

- Natural gas 2021: Gross inland consumption has not been revised. Transformation input has been revised by +0.6 PJ (*1.A.1.a*). Own use of energy sector has been revised by +0.4 PJ (*1.A.1.c*). -1.8 PJ of final energy consumption has been subtracted from *1.A.4* and +0.8 PJ has been shifted to *1.A.2*.
- Gasoil 2021: Gross inland consumption has been revised by -2.2 PJ, of which -1.1 PJ is referred to final energy consumption for *1.A.2* and -1.1 PJ for *1.A.4*.
- LPG 2021: Minor shifts (0.1 PJ) from *1.A.4* and Transport to 'non energy use'.
- Residual fuel oil: 0.7 PJ (59 kt CO_2) has been shifted from *1.A.4* to *1.A.2*.
- Coal 2021: Final energy consumption has been revised by -0.1 PJ (mainly *1.A.4*).
- Solid biomass 2021: Final energy consumption has been revised by +6.9 PJ, which has been mostly allocated to the residential sector (*1.A.4.b*).

Methodological Changes

1.A.1 Energy Industries and 1.A.2 Manufacturing Industries

For the categories *1.A.1* and *1.A.2*, the revisions follow those of the energy balance. The methods applied (emissions factors and data sources) remain unchanged except:

- For the categories *1.A.1* and *1.A.2*, the revisions follow those of the energy balance. The methods applied (emission factors and data sources) remain unchanged.
- Minor revisions to PM emissions from *1.A.1.a* are due to error correction of plant-specific data allocation. Minor revisions to PM emissions from *1.A.2.f* are due to the correction of an erroneous change to the previous year's submission.
- For the submission 2023, TSP, PM_{10} and $PM_{2.5}$ emissions from glass furnaces were mistakenly removed from *1.A.2.f*, which has now been reversed.

3.1.9 NFR 1.A.4 Other Sectors – Stationary

Category *1.A.4 Other Sectors* enfolds emissions from stationary fuel combustion in the small combustion sector. It also includes emissions from mobile sources in households and gardening including snow cats and skidoos as well as from agriculture and forestry (see Table 127).

Table 127: NFR 1.A.4 category definitions (partly taken from the IPCC 2006 Guidelines).

NFR	Category	Definitions
1.A.4	Other Sectors	Combustion activities as described below, including combustion for the generation of electricity and heat for own use in these sectors.
1.A.4.a	Commercial/Institutional	Fuel combustion in commercial and institutional buildings; all activities included in ISIC Rev 3.1 Divisions 41, 50, 51, 52, 55, 63–67, 70–75, 80, 85, 90–93 and 99. *Bonfire and open fire pits.*
1.A.4.b	Residential	Fuel combustion in households.
1.A.4.b.i	Residential: Stationary	Fuel combustion in buildings. *Barbecue.*
1.A.4.c.i	Agriculture/Forestry/Fishing: Stationary	Fuels combusted in pumps, grain drying, horticultural greenhouses and other agriculture, forestry or stationary combustion in the fishing industry.
1.A.4.c.ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	Fuels combusted in traction vehicles and other mobile machinery on farmland and in forests.
1.A.4.c.iii	Agriculture/Forestry/Fishing: National Fishing	Fuels combusted for inland, coastal and deep-sea fishing. Fishing should cover vessels of all flags that have refuelled in the country (include international fishing).

This section describes stationary fuel combustion emissions from category *1.A.4* only. For further information on mobile sources, see chapter 3.2.7 below.

Source Description

Category *1.A.4 Other Sectors – Stationary* includes emissions from stationary fuel combustion in the small combustion sector. Emissions of public district heating plants are included in category *1.A.1.a Public Electricity and Heat Production.* Emissions of district heat generation delivered to third parties by industry are included in category *1.A.2 Manufacturing Industries and Construction*.

In addition, non-combustion PM emission sources are accounted to category *1.A.4.a.i* and *1.A.4.b.i* (see Table 128).

Table 128: PM emissions from non-combustion sources in 2022.

Pollutant		TSP		PM_{10}		$PM_{2.5}$	
NFR		**1.A.4.a.i**	**1.A.4.b.i**	**1.A.4.a.i**	**1.A.4.b.i**	**1.A.4.a.i**	**1.A.4.b.i**
Source	**Subcategory**	**[t]**		**[t]**		**[t]**	
Non-combustion sources	Bonfire	150	NO	150	NO	150	NO
	Open fire pits	16	NO	16	NO	16	NO
	Barbecue	NO	763	NO	763	NO	763
Total		**166**	**763**	**166**	**763**	**166**	**763**

3.1.9.1 Methodology

For calculation of emissions from category *1.A.4 Other Sectors – Stationary*, a country specific tier 2 methodology is applied.

Total fuel consumption for each of the sub categories of *1.A.4 Other Sectors – Stationary* is taken from (IEA JQ, 2023) and the national energy balance (Statistik Austria, 2023a). This approach provides the most detailed data over time series, while both data sources are different in structure but consistent. From the view of energy statistics compilers this sector is sometimes the residual of gross inland fuel consumption because fuel consumption data of energy industries and manufacturing industry is collected each year in more detail and therefore of higher quality. However, in case of the Austrian energy balance fuel consumption of the small combustion sector is modelled over time series in consideration of heating degree days, micro census data and service industries survey panel.

Information about type of heating is derived from an energy demand model for space heating based on heating market surveys and on federal provinces data validated by micro census surveys and calibrated according to the energy statistics supplier. A clear distinction between “real” public district heating or micro heating networks, which serve several buildings under the same ownership, cannot always be made by the interviewed person or interviewers.

The energy demand model for space heating, consists of five consecutive modules:

- **Building and dwelling stock:** by building type, year of construction, type of residence (number of buildings and dwellings, net floor area, useful area, number of residents) (BML, 2023c, STATcube, 2014a, 2014b, 2014c, 2023a, 2023b, Statistik Austria, 1973, 1982, 1992a, 2004, 2013, 2023b, 2023c, 2023d)
- **Heating type by energy carrier:** by categories of module ‘building and dwelling stock’ and energy carrier including heat pumps, district heating, solar thermal and electric heating (number of buildings and dwellings, net floor area, useful area, number of residents) (Statistik Austria, 2019, 2021, 2023a, 2023e)
- **Heating type by technology:** by categories of module ‘building and dwelling stock’, type of application (as main or auxiliary heating) and twenty-two technology and fuel dependent subcategories (number of buildings and dwellings, net floor area, useful area, residents) (Amt der Steiermärkischen Landesregierung, 2021, Amt der Vorarlberger Landesregierung, 2021, BEKat, 2021, e7 Energie Markt Analyse GmbH, 2009, 2017, Land Salzburg, 2021, Stadt Wien, 2017)
- **Building energy performance:** by categories of module ‘building and dwelling stock’ based on type of energy-efficient building renovation, year of construction and residents (space heating demand, hot water demand) (AEA, 2015, BMWFW, 2014b)

- **Final energy demand by technology:** by categories of module 'heating type by technology' based on results of module 'building energy performance' considering heating degree days (GeoSphere Austria & Statistik Austria, 2023) and calibrated according to the energy statistics supplier to maintain consistency with fuel demand reported in (IEA JQ, 2023) and (Statistik Austria, 2023a)

There are twenty-two technology and fuel dependent main subcategories (heating types) for category *1.A.4 Other Sectors – Stationary* as presented in the following table.

Table 129: Heating types of category 1.A.4. Other sectors – Stationary.

No.	Heating type	Fuel
#1	Fuel oil boilers	Light fuel oil, medium fuel oil, heavy fuel oil, diesel, petroleum, other petroleum products
#2	Gas oil stoves	Gas oil
#3	Vapourizing burners	Gas oil
#4	Yellow burners	Gas oil
#5	Blue burners with conventional technology	Gas oil
#6	Blue burners with low temperature or condensing technology	Gas oil
#7	Natural gas convectors	Natural gas
#8	Atmospheric burners	Natural gas, biogas, sewage sludge gas and landfill gas
#9	Forced-draft natural gas burners	Natural gas, biogas, sewage sludge gas and landfill gas
#10	LPG stoves	Liquefied petroleum gases
#11	LPG boilers	Liquefied petroleum gases
#12	Wood stoves and cooking stoves	Fuel wood
#13	Tiled wood stoves and masonry heaters	Fuel wood
#14	Mixed-fuel wood boilers	Fuel wood
#15	Natural-draft wood boilers	Fuel wood
#16	Forced-draft wood boilers	Fuel wood
#17	Wood chips boilers with conventional technology	Wood waste
#18	Wood chips boilers with oxygen sensor emission control	Wood waste
#19	Pellet stoves	Wood waste
#20	Pellet boilers	Wood waste
#21	Coal stoves	Hard coal and Hard coal briquettes, lignite and brown coal, brown coal briquettes, coke, peat
#22	Coal boilers	Hard coal and Hard coal briquettes, lignite and brown coal, brown coal briquettes, coke, peat, industrial waste

In addition, the whole fuel consumption of charcoal is assumed to be combusted in devices similar to *#12 Wood stoves and cooking stoves* and calculated separately. For each technology, a fuel dependent emission factor is applied.

3.1.9.2 Activity Data

Total fuel consumption for each of the sub categories of *1.A.4* is taken from (IEA JQ, 2023) and (Statistik Austria, 2023a) (for further details see section *Methodology* above).

Fuel Consumption by Fuel Group

Total fuel consumption of *1.A.4.a.i*, *1.A.4.b.i* and *1.A.4.c.i* is divided into 6 fuel groups (liquid, solid, gaseous, biomass, peat and other) (see Table 130, Table 131 and

Table 132).

Table 130: Fuel consumption from 1.A.4.a.i Commercial/Institutional: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	**1.A.4.a.i**						
Fuel group	**Total**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Peat**	**Other**
Year	**[PJ]**						
1990	35.39	18.66	0.96	12.60	2.06	NO	1.11
1995	50.64	17.64	0.64	29.29	2.55	NO	0.52
2000	47.43	17.84	1.10	23.67	4.26	NO	0.56
2005	54.73	26.86	0.71	23.16	2.92	NO	1.07
2010	31.09	9.49	0.22	17.19	4.13	NO	0.06
2011	27.33	8.83	0.15	14.99	3.32	NO	0.05
2012	25.61	6.05	0.00	16.90	2.66	NO	NO
2013	25.78	5.87	0.01	17.01	2.82	NO	0.07
2014	22.72	6.01	0.00	14.27	2.36	NO	0.08
2015	24.24	5.95	0.00	15.25	2.96	NO	0.08
2016	22.56	5.60	NO	14.37	2.49	NO	0.09
2017	26.63	7.73	NO	15.10	3.73	NO	0.08
2018	25.97	6.71	NO	15.43	3.74	NO	0.09
2019	26.52	6.25	NO	16.11	4.07	NO	0.10
2020	25.13	6.00	NO	15.15	3.97	NO	0.01
2021	29.23	7.85	NO	16.88	4.50	NO	0.01
2022	23.18	6.65	NO	12.91	3.62	NO	0.01
Trend 1990–2022	**-34%**	**-64%**	**-100%**	**+2.5%**	**+75%**	**NO**	**-100%**
Trend 2021–2022	**-21%**	**-15%**	**NO**	**-24%**	**-20%**	**NO**	**-9.2%**

Table 131: Fuel consumption from 1.A.4.b.i Residential: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	**1.A.4.b.i**						
Fuel group	**Total**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Peat**	**Other**
Year	**[PJ]**						
1990	191.02	72.50	26.62	33.50	58.40	0.0044	NO
1995	200.23	75.59	17.56	44.28	62.80	0.0044	NO
2000	190.62	72.60	9.05	48.90	60.07	0.0044	NO

NFR				1.A.4.b.i			
Fuel group	**Total**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Peat**	**Other**
Year				**[PJ]**			
2005	192.43	63.88	3.97	65.71	58.86	0.0044	NO
2010	199.34	55.88	2.61	65.47	75.38	0.0044	NO
2011	179.92	48.34	1.69	58.18	71.71	0.0044	NO
2012	180.81	44.01	1.77	59.22	75.81	0.0044	NO
2013	186.20	47.32	1.35	59.83	77.69	0.0044	NO
2014	163.15	41.46	1.11	52.40	68.18	0.0044	NO
2015	173.49	43.18	0.91	56.84	72.55	0.0044	NO
2016	181.09	42.84	0.87	62.82	74.56	NO	NO
2017	180.66	43.35	0.96	61.50	74.85	NO	NO
2018	164.63	38.58	0.82	56.28	68.95	NO	NO
2019	169.63	38.84	0.83	59.49	70.46	NO	NO
2020	171.20	39.80	0.58	60.05	70.78	NO	NO
2021	194.90	41.91	0.48	66.14	86.38	NO	NO
2022	159.93	36.01	0.36	54.52	69.04	NO	NO
Trend 1990–2022	**-16%**	**-50%**	**-99%**	**+63%**	**+18%**	**-100%**	**NO**
Trend 2021–2022	**-18%**	**-14%**	**-25%**	**-18%**	**-20%**	**NO**	**NO**

Table 132: Fuel consumption from 1.A.4.c.i Agriculture/Forestry/Fishing: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR				1.A.4.c.i			
Fuel group	**Total**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Peat**	**Other**
Year				**[PJ]**			
1990	10.26	5.34	0.55	0.37	4.01	NO	NO
1995	7.68	2.30	0.39	0.49	4.49	NO	NO
2000	8.46	2.79	0.18	0.54	4.95	NO	NO
2005	8.11	1.47	0.12	0.77	5.75	NO	NO
2010	7.80	0.53	0.06	0.84	6.37	NO	NO
2011	7.30	0.42	0.04	0.72	6.13	NO	NO
2012	7.56	0.42	0.04	0.46	6.64	NO	NO
2013	8.34	0.53	0.03	0.51	7.28	NO	NO
2014	7.84	0.56	0.02	0.56	6.70	NO	NO
2015	8.02	0.50	0.02	0.62	6.88	NO	NO
2016	8.41	0.60	0.02	0.74	7.05	NO	NO
2017	8.68	0.28	0.03	1.01	7.37	NO	NO
2018	7.86	0.25	0.02	0.90	6.68	NO	NO
2019	7.47	0.16	0.02	1.09	6.20	NO	NO
2020	7.35	0.17	0.02	0.91	6.26	NO	NO
2021	8.63	0.18	0.01	0.97	7.47	NO	NO

NFR	1.A.4.c.i						
Fuel group	**Total**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Peat**	**Other**
Year	**[PJ]**						
2022	7.06	0.15	0.01	0.83	6.08	NO	NO
Trend 1990–2022	**-31%**	**-97%**	**-98%**	**+126%**	**+52%**	**NO**	**NO**
Trend 2021–2022	**-18%**	**-16%**	**-30%**	**-15%**	**-19%**	**NO**	**NO**

Fuel Consumption by Fuel

Fuel consumption of liquid fuels, solid fuels and biomass fuels is further subdivided (from *1.A.4.a.i* see Table 133, Table 134 and Table 135, from *1.A.4.b.i* see Table 136, Table 137 and Table 138, from *1.A.4.c.i* see Table 139, Table 140 and Table 141). All fuel consumption of biogas, sewage sludge gas and landfill gas is assigned to *1.A.4.a.i*. Gaseous fuel consumption applies to natural gas only. All fuel consumption of peat (fuel group) is occuring in *1.A.4.b.i* and is peat (fuel) only. Other fuel consumption is industrial waste only.

3.1.9.2.1 1.A.4.a.i Commercial/Institutional: Stationary

Table 133: Share of liquid fuel consumption from 1.A.4.a.i Commercial/Institutional: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	1.A.4.a.i							
Fuel group	**Liquid**							
Fuel	**Total**	**Light fuel oil**	**Medium fuel oil**	**Heavy fuel oil**	**Diesel**	**Petroleum and other petroleum products**	**Gas oil**	**Liquefied petroleum gases**
Year	**[% TJ]**							
1990	100.0	48.3	24.0	8.7	NO	5.1	5.9	8.0
1995	100.0	44.2	13.1	2.6	0.1	1.5	22.3	16.1
2000	100.0	19.8	8.2	0.8	0.0	1.5	63.4	6.3
2005	100.0	12.5	NO	NO	0.0	NO	75.6	11.8
2010	100.0	2.3	NO	NO	0.0	NO	68.5	29.2
2011	100.0	8.4	NO	NO	0.0	NO	65.8	25.9
2012	100.0	7.2	NO	NO	0.0	NO	89.9	2.9
2013	100.0	8.3	NO	NO	0.0	NO	88.8	2.8
2014	100.0	10.4	NO	NO	0.0	NO	87.4	2.2
2015	100.0	9.3	NO	NO	0.0	NO	88.3	2.4
2016	100.0	20.1	NO	NO	0.0	NO	77.7	2.2
2017	100.0	7.8	NO	NO	0.0	NO	88.1	4.1
2018	100.0	5.0	NO	NO	0.0	NO	90.7	4.3
2019	100.0	0.4	NO	NO	0.0	NO	94.5	5.1
2020	100.0	0.2	NO	NO	0.0	NO	94.7	5.2
2021	100.0	0.7	NO	NO	NO	NO	94.7	4.5

NFR	1.A.4.a.i							
Fuel group	Liquid							
Fuel	Total	Light fuel oil	Medium fuel oil	Heavy fuel oil	Diesel	Petro-leum and other pe-troleum products	Gas oil	Liquefied petro-leum gases
Year	[% TJ]							
2022	100.0	0.1	NO	NO	NO	NO	95.8	4.2

Table 134: Share of solid fuel consumption from 1.A.4.a.i Commercial/Institutional: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	1.A.4.a.i				
Fuel group	Solid				
Fuel	Total	Hard coal and hard coal bri-quettes	Lignite and brown coal	Brown coal bri-quettes	Coke
Year	[% TJ]				
1990	100.0	33.5	10.4	16.5	39.6
1995	100.0	34.4	8.1	19.2	38.3
2000	100.0	23.3	3.4	59.1	14.2
2005	100.0	38.5	1.4	45.1	14.9
2010	100.0	6.2	2.8	70.9	20.2
2011	100.0	7.8	1.5	65.1	25.5
2012	100.0	NO	NO	NO	100.0
2013	100.0	94.8	NO	NO	5.2
2014	100.0	NO	NO	NO	100.0
2015	100.0	NO	NO	NO	100.0
2016	NO	NO	NO	NO	NO
2017	NO	NO	NO	NO	NO
2018	NO	NO	NO	NO	NO
2019	NO	NO	NO	NO	NO
2020	NO	NO	NO	NO	NO
2021	NO	NO	NO	NO	NO
2022	NO	NO	NO	NO	NO

Table 135: Share of biomass fuel consumption from 1.A.4.a.i Commercial/Institutional: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	1.A.4.a.i				
Fuel group	**Biomass**				
Fuel	**Total**	**Fuel wood**	**Wood waste**	**Biogas, sewage sludge gas and landfill gas**	**Charcoal**
Year	**[% TJ]**				
1990	100.0	64.6	30.9	NO	4.5
1995	100.0	45.8	23.6	25.8	4.9
2000	100.0	8.1	77.1	11.9	2.9
2005	100.0	20.2	61.4	13.5	4.9
2010	100.0	14.7	71.0	10.7	3.6
2011	100.0	15.4	67.7	12.7	4.2
2012	100.0	6.8	71.9	15.3	6.0
2013	100.0	6.7	75.2	12.7	5.4
2014	100.0	5.5	69.2	19.2	6.1
2015	100.0	3.2	74.9	15.8	6.0
2016	100.0	3.8	65.8	22.9	7.5
2017	100.0	5.7	74.6	15.5	4.3
2018	100.0	5.1	77.2	12.8	4.8
2019	100.0	5.2	78.9	11.5	4.4
2020	100.0	5.2	78.2	12.0	4.6
2021	100.0	5.3	79.8	10.8	4.1
2022	100.0	5.1	76.7	14.2	3.9

3.1.9.2.2 1.A.4.b.i Residential: Stationary

Table 136: Share of liquid fuel consumption from 1.A.4.b.i Residential: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	1.A.4.b.i						
Fuel group	**Liquid**						
Fuel	**Total**	**Light fuel oil**	**Medium fuel oil**	**Heavy fuel oil**	**Diesel**	**Petro-leum and other pe-troleum products**	**Gas oil**	**Liquefied petro-leum gases**
Year	**[% TJ]**							
1990	100.0	26.6	NO	NO	NO	0.9	71.4	1.0
1995	100.0	10.4	NO	NO	NO	0.0	88.0	1.6
2000	100.0	13.3	NO	NO	NO	NO	83.5	3.2
2005	100.0	7.3	NO	NO	NO	NO	89.6	3.1
2010	100.0	2.2	NO	NO	NO	NO	95.0	2.7

NFR	1.A.4.b.i							
Fuel group	Liquid							
Fuel	Total	Light fuel oil	Medium fuel oil	Heavy fuel oil	Diesel	Petroleum and other petroleum products	Gas oil	Liquefied petroleum gases
Year	[% TJ]							
2011	100.0	1.1	NO	NO	NO	NO	96.7	2.3
2012	100.0	0.6	NO	NO	NO	NO	96.8	2.6
2013	100.0	0.4	NO	NO	NO	NO	96.9	2.7
2014	100.0	NO	NO	NO	NO	NO	97.4	2.6
2015	100.0	NO	NO	NO	NO	NO	97.5	2.5
2016	100.0	NO	NO	NO	NO	NO	97.4	2.6
2017	100.0	NO	NO	NO	NO	NO	97.0	3.0
2018	100.0	NO	NO	NO	NO	NO	96.8	3.2
2019	100.0	NO	NO	NO	NO	NO	96.8	3.2
2020	100.0	NO	NO	NO	NO	NO	96.8	3.2
2021	100.0	NO	NO	NO	NO	NO	96.8	3.2
2022	100.0	NO	NO	NO	NO	NO	97.0	3.0

Table 137: Share of solid fuel consumption from 1.A.4.b.i Residential: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	1.A.4.b.i				
Fuel group	Solid				
Fuel	Total	Hard coal and hard coal briquettes	Lignite and brown coal	Brown coal briquettes	Coke
Year	[% TJ]				
1990	100.0	18.5	8.5	15.5	57.5
1995	100.0	21.8	6.2	16.0	56.0
2000	100.0	22.4	6.6	14.9	56.1
2005	100.0	28.2	3.8	15.7	52.3
2010	100.0	25.3	3.7	16.0	55.0
2011	100.0	25.8	2.5	16.0	55.7
2012	100.0	26.5	2.2	17.3	54.0
2013	100.0	28.2	3.5	21.6	46.7
2014	100.0	28.6	2.8	21.6	47.0
2015	100.0	29.4	4.1	21.5	45.0
2016	100.0	28.8	3.1	20.5	47.7
2017	100.0	37.2	3.9	26.1	32.8
2018	100.0	39.8	3.7	29.3	27.2
2019	100.0	37.7	3.9	23.1	35.3

NFR	1.A.4.b.i				
Fuel group	**Solid**				
Fuel	**Total**	**Hard coal and hard coal briquettes**	**Lignite and brown coal**	**Brown coal briquettes**	**Coke**
Year	**[% TJ]**				
2020	100.0	19.5	5.2	32.9	42.5
2021	100.0	16.2	2.6	48.9	32.3
2022	100.0	19.5	3.2	43.9	33.4

Table 138: Share of biomass fuel consumption from 1.A.4.b.i Residential: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	1.A.4.b.i				
Fuel group	**Biomass**				
Fuel	**Total**	**Fuel wood**	**Wood waste**	**Biogas, sewage sludge gas and landfill gas**	**Charcoal**
Year	**[% TJ]**				
1990	100.0	98.5	1.3	NO	0.2
1995	100.0	97.5	2.2	IE(1), NO(2)	0.2
2000	100.0	92.2	7.5	IE(1), NO(2)	0.3
2005	100.0	90.1	9.5	IE(1), NO(2)	0.4
2010	100.0	85.5	14.2	IE(1), NO(2)	0.3
2011	100.0	83.5	16.3	IE(1), NO(2)	0.3
2012	100.0	82.6	17.1	IE(1), NO(2)	0.3
2013	100.0	81.8	18.0	IE(1), NO(2)	0.3
2014	100.0	80.7	19.0	IE(1), NO(2)	0.3
2015	100.0	78.4	21.2	IE(1), NO(2)	0.4
2016	100.0	78.2	21.5	IE(1), NO(2)	0.4
2017	100.0	77.9	21.8	IE(1), NO(2)	0.3
2018	100.0	77.1	22.5	IE(1), NO(2)	0.4
2019	100.0	76.4	23.2	IE(1), NO(2)	0.4
2020	100.0	76.2	23.4	IE(1), NO(2)	0.4
2021	100.0	73.7	26.0	IE(1), NO(2)	0.3
2022	100.0	73.6	26.1	IE(1), NO(2)	0.3

(1) Biogas included elsewhere in category 1.A.4.a.i

(2) Sewage sludge gas and landfill gas not occurring in category 1.A.4.b.i

3.1.9.2.3 1.A.4.c.i Agriculture/Forestry/Fishing: Stationary

Table 139: Share of liquid fuel consumption from 1.A.4.c.i Agriculture/Forestry/Fishing: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	**1.A.4.c.i**							
Fuel group	**Liquid**							
Fuel	**Total**	**Light fuel oil**	**Medium fuel oil**	**Heavy fuel oil**	**Diesel**	**Petroleum and other petroleum products**	**Gas oil**	**Liquefied petroleum gases**
Year	**[% TJ]**							
1990	100.0	97.8	NO	NO	NO	NO	0.8	1.4
1995	100.0	92.3	NO	NO	NO	NO	2.3	5.4
2000	100.0	89.9	NO	NO	NO	NO	1.6	8.6
2005	100.0	82.2	NO	NO	NO	NO	4.0	13.8
2010	100.0	61.1	NO	NO	NO	NO	9.7	29.2
2011	100.0	62.9	NO	NO	NO	NO	10.6	26.5
2012	100.0	61.9	NO	NO	NO	NO	10.7	27.4
2013	100.0	66.8	NO	NO	NO	NO	8.3	24.9
2014	100.0	72.9	NO	NO	NO	NO	6.9	20.2
2015	100.0	69.6	NO	NO	NO	NO	8.0	22.4
2016	100.0	74.7	NO	NO	NO	NO	6.6	18.8
2017	100.0	35.8	NO	NO	NO	NO	15.1	49.1
2018	100.0	NO	NO	NO	NO	NO	48.6	51.4
2019	100.0	NO	NO	NO	NO	NO	20.6	79.4
2020	100.0	NO	NO	NO	NO	NO	21.0	79.0
2021	100.0	NO	NO	NO	NO	NO	21.7	78.3
2022	100.0	NO	NO	NO	NO	NO	24.9	75.1

Table 140: Share of solid fuel consumption from 1.A.4.c.i Agriculture/Forestry/Fishing: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	**1.A.4.c.i**				
Fuel group	**Solid**				
Fuel	**Total**	**Hard coal and hard coal briquettes**	**Lignite and brown coal**	**Brown coal briquettes**	**Coke**
Year	**[% TJ]**				
1990	100.0	5.1	NO	30.0	64.8
1995	100.0	14.2	NO	28.3	57.5
2000	100.0	NO	NO	33.7	66.3
2005	100.0	6.7	NO	54.9	38.4
2010	100.0	8.2	NO	32.8	59.0

NFR	1.A.4.c.i				
Fuel group	Solid				
Fuel	Total	Hard coal and hard coal briquettes	Lignite and brown coal	Brown coal briquettes	Coke
Year	[% TJ]				
2011	100.0	8.8	NO	32.3	58.9
2012	100.0	8.6	NO	34.7	56.8
2013	100.0	8.7	NO	42.8	48.5
2014	100.0	8.1	NO	42.9	49.0
2015	100.0	9.8	NO	43.1	47.2
2016	100.0	8.9	NO	41.0	50.0
2017	100.0	9.3	NO	64.4	26.3
2018	100.0	9.8	NO	69.3	21.0
2019	100.0	13.1	NO	48.2	38.7
2020	100.0	4.9	NO	58.9	36.2
2021	100.0	2.0	NO	72.8	25.2
2022	100.0	2.3	NO	69.9	27.8

Table 141: Share of biomass fuel consumption from 1.A.4.c.i Agriculture/Forestry/Fishing: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	1.A.4.c.i				
Fuel group	Biomass				
Fuel	Total	Fuel wood	Wood waste	Biogas, sewage sludge gas and landfill gas	Charcoal
Year	[% TJ]				
1990	100.0	90.5	9.5	NO	NO
1995	100.0	86.0	14.0	IE(1), NO(2)	NO
2000	100.0	70.5	29.5	IE(1), NO(2)	NO
2005	100.0	70.6	29.4	IE(1), NO(2)	NO
2010	100.0	63.8	36.2	IE(1), NO(2)	NO
2011	100.0	61.5	38.5	IE(1), NO(2)	NO
2012	100.0	59.4	40.6	IE(1), NO(2)	NO
2013	100.0	55.0	45.0	IE(1), NO(2)	NO
2014	100.0	51.7	48.3	IE(1), NO(2)	NO
2015	100.0	52.2	47.8	IE(1), NO(2)	NO
2016	100.0	52.1	47.9	IE(1), NO(2)	NO
2017	100.0	49.9	50.1	IE(1), NO(2)	NO
2018	100.0	50.1	49.9	IE(1), NO(2)	NO
2019	100.0	54.8	45.2	IE(1), NO(2)	NO
2020	100.0	54.3	45.7	IE(1), NO(2)	NO

NFR	1.A.4.c.i				
Fuel group	**Biomass**				
Fuel	**Total**	**Fuel wood**	**Wood waste**	**Biogas, sewage sludge gas and landfill gas**	**Charcoal**
Year	**[% TJ]**				
2021	100.0	53.8	46.2	IE(1), NO(2)	NO
2022	100.0	52.7	47.3	IE(1), NO(2)	NO

(1) Biogas included elsewhere in category 1.A.4.a.i

(2) Sewage sludge gas and landfill gas not occurring in category 1.A.4.c.i

Fuel Consumption by Heating Type

The fuel consumption reported in (IEA JQ, 2023) and (Statistik Austria, 2023a) is assigned to twenty-two heating types (see section *Methodology* above).

If occuring, all fuel consumption of light fuel oil, medium fuel oil, heavy fuel oil, diesel, and petroleum and other petroleum products is assigned to heating type *#1 Fuel oil boilers*. Fuel consumption of gas oil is assigned to five different heating types *(#2 Gas oil stoves*, *#3 Vapourizing burners*, *#4 Yellow burners*, *#5 Blue burners with conventional technology*, *#6 Blue burners with low temperature or condensing technology*). Fuel consumption of liquefied petroleum gas is assigned to two different heating types *(#10 LPG stoves*, *#11 LPG boilers*) (from *1.A.4.a.i* see Table 142, from *1.A.4.b.i* see Table 145).

If occuring, all fuel consumption of hard coal and hard coal briquettes, lignite and brown coal, brown coal briquettes and coke is assigned to two different types of heating *(#21 Coal stoves*, *#22 Coal boilers)* with the same share (from *1.A.4.a.i* see Table 143, from *1.A.4.b.i* see Table 146).

Fuel consumption of natural gas is assigned to three different heating types *(#7 Natural gas convectors*, *#8 Atmospheric burners*, *#9 Forced-draft natural gas burners*) (from *1.A.4.a.i* see Table 143, from *1.A.4.b.i* see Table 146).

If occuring, fuel consumption of biogas, sewage sludge gas and landfill gas is assigned to two different heatiny types (#8 Atmospheric burners, #9 Forced-draft natural gas burners) (from *1.A.4.a.i* see Table 143, from *1.A.4.b.i* see Table 146).

Fuel consumption of fuel wood (log wood) is assigned to five different heating types *(#12 Wood stoves and cooking stoves*, *#13 Tiled wood stoves and masonry heaters*, *#14 Mixed-fuel wood boilers*, *#15 Natural-draft wood boilers*, *#16 Forced-draft wood boilers*). Fuel consumption of wood waste (wood chips, pellets and other biomass) is assigned to four different heating types (*#17 Wood chips boilers with conventional technology*, *#18 Wood chips boilers with oxygen sensor emission control*, *#19 Pellet stoves*, *#20 Pellet boilers*) (from *1.A.4.a.i* see Table 144, from *1.A.4.b.i* see Table 147). In addition, the whole fuel consumption of charcoal is assumed to be combusted in devices similar to *#12 Wood stoves and cooking stoves* and calculated separately.

If occuring, all fuel consumption of industrial waste is assigned to heating type *#22 Coal boilers*.

1.A.4.a.i Commercial/Institutional: Stationary

The fuel consumption from category *1.A.4.a.i* reported in (IEA JQ, 2023) and (Statistik Austria, 2023a) is assigned to twenty-two heating types derived from an energy demand model for space heating based on heating market surveys and by federal provinces data and calibrated according to the energy statistics supplier (see section *Methodology* above).

Table 142: Percentual liquid fuel consumption by type of heating from 1.A.4.a.i Commercial/Institutional: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	1.A.4.a.i							
Fuel group	**Liquid**							
Fuel	**Other liquid fuels**	**Gas oil**					**Liquefied petroleum gases**	
Heating type No.	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	**#10**	**#11**
Year	**[% TJ]**	**[%TJ]**					**[%TJ]**	
1990	100.0	10.1	2.3	78.6	1.7	7.4	86.7	13.3
1995	100.0	9.6	1.7	68.8	4.8	15.1	84.6	15.4
2000	100.0	8.8	1.2	57.0	9.1	23.9	81.8	18.2
2005	100.0	8.2	1.0	52.6	9.6	28.5	76.1	23.9
2010	100.0	7.8	0.7	49.4	6.8	35.3	73.1	26.9
2011	100.0	7.7	0.6	48.2	6.0	37.4	72.2	27.8
2012	100.0	7.6	0.5	47.0	5.1	39.7	71.7	28.3
2013	100.0	7.5	0.4	45.7	4.1	42.3	71.1	28.9
2014	100.0	7.4	0.3	44.1	2.9	45.4	70.0	30.0
2015	100.0	7.3	0.1	42.3	1.4	49.0	69.6	30.4
2016	100.0	6.6	0.1	41.7	1.3	50.3	68.1	31.9
2017	100.0	5.9	0.1	41.0	1.1	51.9	66.4	33.6
2018	100.0	5.2	0.1	40.3	1.0	53.5	64.3	35.7
2019	100.0	4.3	0.1	39.5	0.8	55.3	62.1	37.9
2020	100.0	3.4	0.1	38.9	0.6	57.0	59.6	40.4
2021	100.0	2.3	0.1	38.2	0.4	59.0	57.0	43.0
2022	100.0	1.8	0.1	37.2	0.4	60.5	54.1	45.9

Table 143: Percentual solid, gaseous and biomass fuel consumption by type of heating from 1.A.4.a.i Commercial/Institutional: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	1.A.4.a.i						
Fuel group	**Solid**		**Gaseous**			**Biomass**	
Fuel	**All solid fuels**		**Natural gas**			**Biogas, sewage sludge gas and landfill gas**	
Heating type No.	**#21**	**#22**	**#7**	**#8**	**#9**	**#8**	**#9**
Year	**[% TJ]**		**[%TJ]**			**[%TJ]**	
1990	81.3	18.7	27.0	59.4	13.6	NO	NO
1995	81.4	18.6	19.8	58.1	22.1	72.5	27.5
2000	86.2	13.8	14.6	53.9	31.5	63.1	36.9
2005	89.8	10.2	14.8	49.5	35.7	58.1	41.9
2010	77.3	22.7	15.3	47.7	36.9	56.4	43.6

NFR	1.A.4.a.i						
Fuel group	Solid		Gaseous			Biomass	
Fuel	All solid fuels		Natural gas			Biogas, sewage sludge gas and landfill gas	
Heating type No.	#21	#22	#7	#8	#9	#8	#9
Year	[% TJ]		[%TJ]			[%TJ]	
2011	76.7	23.3	15.8	47.4	36.8	56.3	43.7
2012	69.2	30.8	15.8	47.4	36.8	56.3	43.7
2013	95.3	4.7	15.8	47.5	36.7	56.4	43.6
2014	99.4	0.6	16.6	47.2	36.3	56.5	43.5
2015	99.5	0.5	16.4	47.5	36.1	56.9	43.1
2016	NO	NO	15.7	47.6	36.6	56.5	43.5
2017	NO	NO	15.1	47.6	37.4	56.0	44.0
2018	NO	NO	14.6	47.2	38.2	55.3	44.7
2019	NO	NO	13.8	47.0	39.2	54.5	45.5
2020	NO	NO	13.1	46.7	40.2	53.8	46.2
2021	NO	NO	12.0	46.6	41.4	53.0	47.0
2022	NO	NO	12.2	45.7	42.2	52.0	48.0

Table 144: Percentual biomass fuel consumption by type of heating from 1.A.4.a.i Commercial/Institutional: Stationary 1990, 1995, 2000, 2005 and 2010–2022 (continued).

NFR	1.A.4.a.i								
Fuel group	Biomass								
Fuel	Fuel wood					Wood waste			
Heating type No.	#12	#13	#14	#15	#16	#17	#18	#19	#20
Year	[%TJ]					[%TJ]			
1990	1.6	64.8	32.7	NO	0.9	89.8	10.0	NO	0.2
1995	1.6	60.4	34.8	NO	3.2	40.1	13.7	0.9	45.4
2000	2.0	55.2	36.3	NO	6.6	19.2	12.1	2.9	65.9
2005	2.0	70.0	21.6	0.2	6.2	10.9	14.4	5.0	69.7
2010	2.4	83.5	10.9	0.1	3.1	13.4	43.3	3.1	40.3
2011	2.8	85.9	8.7	0.1	2.5	10.6	40.3	3.4	45.6
2012	2.8	88.7	6.5	0.1	1.9	11.3	50.0	2.7	35.9
2013	2.9	91.4	4.4	0.0	1.3	9.1	45.8	3.2	42.0
2014	3.7	93.5	2.2	0.0	0.6	6.5	36.8	3.9	52.8
2015	3.5	96.5	NO	NO	NO	8.5	53.6	2.6	35.2
2016	3.4	96.6	NO	NO	NO	5.5	37.4	4.0	53.2
2017	3.4	96.6	NO	NO	NO	4.5	33.6	4.3	57.6
2018	3.7	96.3	NO	NO	NO	5.3	42.2	3.6	49.0
2019	3.7	96.3	NO	NO	NO	4.9	42.5	3.5	49.1
2020	3.6	96.4	NO	NO	NO	4.5	43.0	3.4	49.0
2021	3.2	96.8	NO	NO	NO	4.1	43.4	3.3	49.2

NFR	1.A.4.a.i								
Fuel group	Biomass								
Fuel	Fuel wood					Wood waste			
Heating type No.	#12	#13	#14	#15	#16	#17	#18	#19	#20
Year	[%TJ]					[%TJ]			
2022	3.6	96.4	NO	NO	NO	3.9	43.9	3.0	49.3

1.A.4.b.i Residential: Stationary

Energy consumption from category *1.A.4.b.i* by type of fuel and by type of heating is derived from an energy demand model for space heating based on heating market surveys and federal provinces data. The model is validated with a statistical evaluation of micro census data 1990, 1992, 1999/2000, 2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022 (Statistik Austria, 1990, 1992b, 2002, 2019, 2021, 2023e). Micro census data of fuel wood use includes collected wood, i.e. wood directly harvested from the forest outside formal market activity. The calculated shares are used to subdivide total final energy consumption to the several technologies. For the years in between the shares are interpolated. Because the newest census data is always reconsidered to improve previous years' census data evaluation this implies a periodic recalculation in time series. The energy demand model is calibrated according to the energy statistics supplier (see section *Methodology* above).

Table 145: Percentual liquid fuel consumption by type of heating from 1.A.4.b.i Residential: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	1.A.4.b.i							
Fuel group	Liquid							
Fuel	Other liquid fuels	Gas oil					Liquefied petroleum gases	
Heating type No.	#1	#2	#3	#4	#5	#6	#10	#11
Year	[%TJ]	[%TJ]					[%TJ]	
1990	100.0	15.0	12.3	64.2	1.4	7.1	24.5	75.5
1995	100.0	12.7	10.6	57.2	3.7	15.9	16.0	84.0
2000	100.0	10.4	8.1	51.3	7.4	22.8	11.6	88.4
2005	100.0	4.4	7.3	51.9	8.4	28.1	9.8	90.2
2010	100.0	2.8	5.8	48.8	6.1	36.4	14.0	86.0
2011	100.0	2.7	5.4	47.5	5.5	38.9	16.6	83.4
2012	100.0	2.8	4.9	46.3	4.7	41.3	15.7	84.3
2013	100.0	2.8	4.3	44.7	3.9	44.2	15.3	84.7
2014	NO	2.9	3.7	43.0	2.9	47.6	19.0	81.0
2015	NO	2.8	2.9	40.9	1.7	51.7	19.0	81.0
2016	NO	2.6	2.6	40.6	1.5	52.7	16.9	83.1
2017	NO	2.4	2.2	40.2	1.3	53.8	15.9	84.1
2018	NO	2.4	1.8	39.8	1.1	54.8	19.2	80.8
2019	NO	2.3	1.4	39.4	0.9	55.9	20.8	79.2

NFR	1.A.4.b.i							
Fuel group	**Liquid**							
Fuel	**Other liquid fuels**	**Gas oil**					**Liquefied petroleum gases**	
Heating type No.	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	**#10**	**#11**
Year	**[%TJ]**	**[%TJ]**					**[%TJ]**	
2020	NO	2.3	1.0	39.1	0.7	56.8	20.5	79.5
2021	NO	2.0	0.6	38.9	0.5	58.0	19.1	80.9
2022	NO	2.1	0.6	37.8	0.5	59.0	21.3	78.7

Table 146: Percentual solid, gaseous and biomass fuel consumption by type of heating from 1.A.4.b.i Residential: Stationary 1990, 1995, 2000, 2005 and 2010–2022.

NFR	1.A.4.b.i						
Fuel group	**Solid**		**Gaseous**			**Biomass**	
Fuel	**All solid fuels**		**Natural gas**			**Biogas, sewage sludge gas and landfill gas**	
Heating type No.	**#21**	**#22**	**#7**	**#8**	**#9**	**#8**	**#9**
Year	**[%TJ]**		**[%TJ]**			**[%TJ]**	
1990	30.0	70.0	39.1	53.7	7.2	NO	NO
1995	26.6	73.4	31.9	55.4	12.8	IE(1), NO(2)	IE(1), NO(2)
2000	23.2	76.8	24.7	55.3	20.0	IE(1), NO(2)	IE(1), NO(2)
2005	18.2	81.8	16.6	56.1	27.3	IE(1), NO(2)	IE(1), NO(2)
2010	17.7	82.3	14.9	51.7	33.4	IE(1), NO(2)	IE(1), NO(2)
2011	24.1	75.9	15.5	50.1	34.4	IE(1), NO(2)	IE(1), NO(2)
2012	24.1	75.9	13.5	50.0	36.5	IE(1), NO(2)	IE(1), NO(2)
2013	24.2	75.8	11.7	49.6	38.7	IE(1), NO(2)	IE(1), NO(2)
2014	22.2	77.8	12.5	47.7	39.7	IE(1), NO(2)	IE(1), NO(2)
2015	19.8	80.2	12.0	47.3	40.7	IE(1), NO(2)	IE(1), NO(2)
2016	22.0	78.0	11.4	46.6	42.0	IE(1), NO(2)	IE(1), NO(2)
2017	24.0	76.0	11.1	45.6	43.3	IE(1), NO(2)	IE(1), NO(2)
2018	25.9	74.1	12.0	43.7	44.3	IE(1), NO(2)	IE(1), NO(2)
2019	27.9	72.1	12.4	42.1	45.5	IE(1), NO(2)	IE(1), NO(2)
2020	33.0	67.0	11.1	41.4	47.5	IE(1), NO(2)	IE(1), NO(2)
2021	38.6	61.4	9.2	40.9	49.9	IE(1), NO(2)	IE(1), NO(2)
2022	41.4	58.6	9.4	39.8	50.8	IE(1), NO(2)	IE(1), NO(2)

(1) Biogas included elsewhere in category 1.A.4.a.i

(2) Sewage sludge gas and landfill gas not occurring in category 1.A.4.b.i

Table 147: Percentual biomass fuel consumption by type of heating from 1.A.4.b.i Residential: Stationary 1990, 1995, 2000, 2005 and 2010–2022 (continued).

NFR	**1.A.4.b.i**								
Fuel group	**Biomass**								
Fuel	**Fuel wood**					**Wood waste**			
Heating type No.	**#12**	**#13**	**#14**	**#15**	**#16**	**#17**	**#18**	**#19**	**#20**
Year	**[%TJ]**					**[%TJ]**			
1990	22.6	8.7	66.6	NO	2.1	89.9	10.1	NO	NO
1995	19.5	8.2	64.9	NO	7.5	39.2	13.6	NO	47.2
2000	16.3	8.1	61.4	NO	14.3	23.7	18.0	NO	58.3
2005	9.5	7.1	60.3	0.9	22.2	23.3	38.2	1.7	36.8
2010	9.1	8.5	53.0	3.6	25.8	8.3	29.1	3.0	59.5
2011	8.8	8.4	52.1	4.0	26.8	6.5	25.8	3.6	64.2
2012	9.3	8.9	50.3	4.3	27.2	4.9	22.3	3.6	69.2
2013	9.7	9.4	48.8	4.5	27.5	6.6	33.4	2.8	57.2
2014	10.1	9.6	47.6	4.8	27.9	5.9	33.0	2.8	58.2
2015	10.5	9.9	46.3	5.0	28.3	3.7	22.7	3.5	70.1
2016	10.6	9.9	45.2	5.3	29.0	3.5	22.9	3.7	69.9
2017	10.7	9.8	44.0	5.7	29.8	4.1	29.2	3.6	63.1
2018	11.4	10.1	42.3	6.0	30.3	2.4	18.3	4.5	74.8
2019	12.0	10.4	40.4	6.3	30.8	1.6	12.6	5.3	80.6
2020	11.2	9.2	39.9	7.0	32.7	1.3	11.1	5.4	82.2
2021	10.2	7.9	39.0	7.8	35.1	1.9	18.0	4.8	75.3
2022	9.3	6.8	39.2	8.5	36.2	1.8	18.5	4.3	75.4

1.A.4.c.i Agriculture/Forestry/Fishing: Stationary

The fuel consumption reported in (IEA JQ, 2023) and (Statistik Austria, 2023a) for category *1.A.4.c.i* is predominantly assigned to implied emission factors derived from category *1.A.4.a.i* assuming similar structure of heating types in both categories (see section *Fuel Consumption by Heating Type* above).

Fuel Consumption by Subcategory of Heating Type

The following table shows gas oil share of blue burners with low temperature or condensing technology stock from 2001, which are considered with lower NO_x emissions than equipment installed before 2001. New installations reflect the market entrance of condensing boiler technology. The selected factors are derived from the energy demand model for space heating (see section *Methodology* above).

Table 148: Share of new blue burners with low temperature or condensing technology stock 2005 and 2010–2022.

Heating type No.	#6			
Subcategory	**Blue burners with low temperature or condensing technology (new)**		**Blue burners with low temperature or condensing technology (conventional)**	
NFR	**1.A.4.a.i**	**1.A.4.b.i**	**1.A.4.a.i**	**1.A.4.b.i**
Year	**[% TJ]**		**[%TJ]**	
2005	22.5	16.3	77.5	83.7
2010	31.7	27.8	68.3	72.2
2011	33.5	30.4	66.5	69.6
2012	34.8	32.3	65.2	67.7
2013	36.2	34.4	63.8	65.6
2014	37.8	35.9	62.2	64.1
2015	39.4	37.3	60.6	62.7
2016	39.0	36.5	61.0	63.5
2017	39.0	35.8	61.0	64.2
2018	39.0	34.8	61.0	65.2
2019	39.3	34.3	60.7	65.7
2020	39.3	33.6	60.7	66.4
2021	39.6	33.3	60.4	66.7
2022	40.7	34.3	59.3	65.7

The following table shows natural gas share of forced-draft natural gas burners stock from 2001, which are considered with lower NO_x emissions than equipment installed before 2001. New installations reflect the market entrance of condensing boiler technology. The selected factors are derived from the energy demand model for space heating (see section *Methodology* above).

Table 149: Share of new forced-draft natural gas burners stock 2005 and 2010–2022.

Heating type No.	#9			
Subcategory	**Forced-draft natural gas burners (new)**		**Forced-draft natural gas burners (conventional)**	
NFR	**1.A.4.a.i**	**1.A.4.b.i**	**1.A.4.a.i**	**1.A.4.b.i**
Year	**[% TJ]**		**[%TJ]**	
2005	29.7	28.9	70.3	71.1
2010	38.6	44.6	61.4	55.4
2011	39.3	46.6	60.7	53.4
2012	40.0	48.5	60.0	51.5
2013	40.5	50.2	59.5	49.8
2014	41.1	52.2	58.9	47.8
2015	42.1	54.0	57.9	46.0
2016	42.8	54.7	57.2	45.3
2017	43.5	55.5	56.5	44.5

Heading type No.	#9			
Subcategory	Forced-draft natural gas burners (new)		Forced-draft natural gas burners (conventional)	
NFR	1.A.4.a.i	1.A.4.b.i	1.A.4.a.i	1.A.4.b.i
Year	[% TJ]		[%TJ]	
2018	44.2	56.8	55.8	43.2
2019	45.2	58.0	54.8	42.0
2020	46.0	58.4	54.0	41.6
2021	47.0	58.9	53.0	41.1
2022	48.8	59.8	51.2	40.2

The following table shows biomass share of wood stoves and cooking stoves stock from 2001, which are considered with lower CO, NMVOC and CH_4 emissions than equipment installed before 2001. The selected factors are derived from the energy demand model for space heating (see section *Methodology* above).

Table 150: Share of new and conventional wood stoves and cooking stoves stock 2001–2022.

Heating type No.	#12			
Subcategory	Wood stoves and cooking stoves (new)		Wood stoves and cooking stoves (conventional)	
NFR	1.A.4.a.i	1.A.4.b.i	1.A.4.a.i	1.A.4.b.i
Year	[% TJ]		[%TJ]	
2005	11.2	7.9	88.8	92.1
2010	20.5	12.7	79.5	87.3
2011	22.4	14.3	77.6	85.7
2012	24.1	16.6	75.9	83.4
2013	25.9	19.0	74.1	81.0
2014	28.0	21.6	72.0	78.4
2015	30.0	24.7	70.0	75.3
2016	31.1	26.4	68.9	73.6
2017	32.6	28.4	67.4	71.6
2018	34.0	28.9	66.0	71.1
2019	35.6	29.5	64.4	70.5
2020	37.3	30.3	62.7	69.7
2021	39.1	31.5	60.9	68.5
2022	40.5	31.8	59.5	68.2

The following table shows biomass share of mixed-fuel wood boilers stock with (comparatively) advanced technology which are considered with (slightly) lower NO_x, CO, NMVOC, CH_4, HCB (additional advanced mixed-fuel boilers share relative to base year 2000 only) and PM emissions than conventional equipment. The selected factors are derived from the energy demand model for space heating (see section *Methodology* above).

Table 151: Share of advanced and conventional mixed-fuel wood boilers stock 1990, 1995, 2000, 2005 and 2010–2022.

Heating type No.	**#14**			
Subcategory	**Mixed-fuel wood boilers (advanced)**		**Mixed-fuel wood boilers (conventional)**	
NFR	**1.A.4.a.i**	**1.A.4.b.i**	**1.A.4.a.i**	**1.A.4.b.i**
Year	**[% TJ]**		**[% TJ]**	
1990	2.1	2.9	97.9	97.1
1995	8.8	13.6	91.2	86.4
2000	11.9	18.7	88.1	81.3
2005	14.4	19.9	85.6	80.1
2010	13.8	19.9	86.2	80.1
2011	13.7	19.8	86.3	80.2
2012	13.6	19.8	86.4	80.2
2013	13.6	19.8	86.4	80.2
2014	13.5	19.7	86.5	80.3
2015	13.4	19.7	86.6	80.3
2016	13.4	19.3	86.6	80.7
2017	13.3	18.8	86.7	81.2
2018	13.2	18.3	86.8	81.7
2019	13.1	17.8	86.9	82.2
2020	13.1	17.1	86.9	82.9
2021	13.0	16.4	87.0	83.6
2022	12.9	15.9	87.1	84.1

3.1.9.3 Emission Factors

Due to the wide variation of technologies, fuel quality and device maintenance the uncertainty of emission factors is rather high for almost all pollutants and technologies.

3.1.9.3.1 Emission Factors for Main Pollutants (NO_X. NMVOC, CO, SO_2, NH_3)

1.A.4.a.i Commercial/Institutional: Stationary and 1.A.4.b.i Residential: Stationary

Country specific main pollutant emission factors from national studies (BMWA, 1990, 1996, 1999) and (Umweltbundesamt, 2001a) are applied. In these studies emission factors are provided for the years 1987, 1995 and 1996. Emission factors prior to 1996 are taken from (Stanzel et al., 1995) and mainly based on literature research.

Gaseous and liquid fuels emission factors 1996 are determined by means of test bench measurements of boilers and stoves sold in Austria. Solid fuels emission factors 1996 are determined by means of field measurements of Austrian small combustion devices.

For the years 1990 to 1994 emission factors were interpolated. From 1997 onwards the emission factors from 1996 are applied.

In some cases only VOC emission factors are provided in the studies, NMVOC emission factors are determined assuming that a certain percentage of VOC emissions is released as methane as listed in Table 152. The split follows closely (Stanzel et al., 1995).

Table 152: Share of CH_4 and NMVOC in VOC for small combustion devices.

Pollutant		**CH_4**	**NMVOC**	**VOC**
Fuel group	**Fuel**		**[% VOC]**	
Liquid	Light fuel oil, Medium fuel oil, Heavy fuel oil	25.0	75.0	100.0
	Petroleum, Gas oil	20.0	80.0	100.0
	Liquefied petroleum gases	80.0	20.0	100.0
Solid	All solid fuels	25.0	75.0	100.0
Gaseous	Natural gas	80.0	20.0	100.0
Biomass	All biomass fuels	25.0	75.0	100.0

Additional literature research based on (Umweltbundesamt, 2017b) was done to reflect the twenty-two technology and fuel dependent main subcategories (heating types). This work concluded in following additions:

- Supplemental CO emission factors are taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a), the Fact Sheet of the Swiss Federal Office for the Environment (FOEN, 2015) and (Lang et al., 2003).
- Supplemental NMVOC emission factors are taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a), (Lang et al., 2003) and (German Environment Agency, 2008).
- Supplemental NO_x emission factors are taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a), the Fact Sheet of the Swiss Federal Office for the Environment (FOEN, 2015), (Leutgöb et al., 2003) and (German Environment Agency, 2008).
- Supplemental SO_2 emission factors are taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a) and (Leutgöb et al., 2003).
- Supplemental NH_3 emission factors are taken from the EMEP/CORINAIR Emission Inventory Guidebook – 2006 (EEA, 2007) and (Umweltbundesamt, 1993).

1.A.4.c.i Agriculture/Forestry/Fishing: stationary

In general, the same sources for emission factors as for categories *1.A.4.a.i* and *1.A.4.b.i* were used (see section above). Other emission factors are derived from category *1.A.4.a.i* assuming similar structure of heating types in both categories (implied emission factors). Those values given in the following tables are averaged values per fuel category. Supplemental implied emission factors derived from category *1.A.4.b.i* were assigned, if no activity data for the specific fuel in category *1.A.4.a.i* occurred.

3.1.9.3.1.1 NO_x Emission Factors

Table 153: NFR 1.A.4. NO_x emission factors for the year 2022.

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**NO_x**	
Fuel	**No.**	**Heating type**		**[kg/TJ]**	
Light fuel oil	#1	Fuel oil boilers	115.0	115.0	115.0
Medium fuel oil	#1	Fuel oil boilers	118.0	118.0	118.0
Heavy fuel oil	#1	Fuel oil boilers	235.0	235.0	235.0
Diesel	#1	Fuel oil boilers	700.0	700.0	700.0
Petroleum	#1	Fuel oil boilers	42.0	42.0	42.0
Other petroleum products	#1	Fuel oil boilers	40.0	40.0	40.0
Gas oil	#2	Gas oil stoves	48.0	48.0	33.1(1)
	#3	Vapourizing burners	61.6	61.6	33.1(1)
	#4	Yellow burners	37.5	37.5	33.1(1)
	#5	Blue burners with conventional technology	36.6	36.6	33.1(1)
	#6	Blue burners with low temperature or condensing technology	29.8(2)	30.9(2)	33.1(1)
Natural gas	#7	Natural gas convectors	51.0	51.0	37.7(1)
	#8	Atmospheric burners	42.0	42.0	37.7(1)
	#9	Forced-draft natural gas burners	29.3(3)	26.5(3)	37.7(1)
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	150.0	150.0	150.0
	#9	Forced-draft natural gas burners	150.0	150.0	150.0
Liquefied petroleum gases	#10	LPG stoves	51.0	51.0	47.8(1)
	#11	LPG boilers	44.0	44.0	47.8(1)
Fuel wood	#12	Wood stoves and cooking stoves	106.0	106.0	80.9(1)
	#13	Tiled wood stoves and masonry heaters	80.0	80.0	80.9(1)
	#14	Mixed-fuel wood boilers	121.3(4)	121.8(4)	80.9(1)
	#15	Natural-draft wood boilers	107.0	107.0	80.9(1)
	#16	Forced-draft wood boilers	80.0	80.0	80.9(1)
Wood waste	#17	Wood chips boilers with conventional technology	107.0	107.0	70.6(1)
	#18	Wood chips boilers with oxygen sensor emission control	80.0	80.0	70.6(1)
	#19	Pellet stoves	60.0	60.0	70.6(1)
	#20	Pellet boilers	60.0	60.0	70.6(1)
Hard coal and hard coal briquettes	#21	Coal stoves	132.0	132.0	100.3(1)
	#22	Coal boilers	78.0	78.0	100.3(1)
Lignite and brown coal	#21	Coal stoves	132.0	132.0	100.3(1)
	#22	Coal boilers	78.0	78.0	100.3(1)
Brown coal briquettes	#21	Coal stoves	132.0	132.0	100.3(1)
	#22	Coal boilers	78.0	78.0	100.3(1)
Coke	#21	Coal stoves	132.0	132.0	100.3(1)

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				NO_x	
Fuel	**No.**	**Heating type**		[kg/TJ]	
	#22	Coal boilers	78.0	78.0	100.3[(1)]
Peat	#21	Coal stoves	70.0	70.0	70.0
	#22	Coal boilers	78.0	78.0	78.0
Industrial waste	#22	Coal boilers	100.0	100.0	100.0
Charcoal	–		40.0	40.0	40.0

(1) Implied emission factor based on fuel-dependent implied NO_X emission factor of NFR 1.A.4.a.i (alternatively from NFR 1.A.4.b.i, if there is no fuel consumption from NFR 1.A.4.a.i in particular inventory year)

(2) Implied emission factor based on NO_x emission factors of new and conventional blue burners with low temperature or condensing technology stock (see Table 154) weighted with fuel consumption by subcategory of heating type (see Table 148)

(3) Implied emission factor based on NO_x emission factors of new and conventional forced-draft natural gas burners stock (see Table 155) weighted with fuel consumption by subcategory of heating type (see Table 149)

(4) Implied emission factor based on NO_x emission factors of advanced and conventional mixed-fuel boilers stock (see Table 156) weighted with fuel consumption by subcategory of heating type (see Table 151)

Desulphurisation of gas oil down to 10 ppm sulphur content reduced the organic nitrogen content from 2009 onwards. This is reflected by lowering NO_x emission factors for all conventional boilers burning gas oil by about 10.7% in the year 2009. The following table shows this effect on NO_x emission factors for fuel consumption of gas oil and NO_x emission factors for new and conventional blue burners with low temperature or condensing technology taken from (Leutgöb et al., 2003).

Table 154: NO_X emission factors of category 1.A.4 considering desulphurisation of gas oil (starting from 2009) and for new and conventional blue burners with low temperature or condensing technology.

Pollutant			NO_x	
NFR			**1.A.4.a.i**	**1.A.4.b.i**
Inventory year			**1990–2008**	**2009–2022**
Fuel	**No.**	**Heating type (subcategory)**	[kg/TJ]	
Gas oil	#3	Vapourizing burners	69.0	61.6
	#4	Yellow burners	42.0	37.5
	#5	Blue burners with conventional technology	41.0	36.6
	#6	Blue burners with low temperature or condensing technology (new)	20.0	20.0
		Blue burners with low temperature or condensing technology (conventional)	41.0	36.6

The following table shows NO_x emission factors for new and conventional forced-draft natural gas burners taken from (Leutgöb et al., 2003).

Table 155: NO_x emission factors of category 1.A.4 for new and conventional forced-draft natural gas burners.

Pollutant			**NO_x**	
NFR			**1.A.4.a.i**	**1.A.4.b.i**
Fuel	**No.**	**Heating type (subcategory)**	**[kg/TJ]**	
Natural gas	#9	Forced-draft natural gas burners (new)	16.0	16.0
		Forced-draft natural gas burners (conventional)	42.0	42.0

The following table shows NO_x emission factors for advanced and conventional mixed-fuel boilers taken from (Lang et al. 2003).

Table 156: NO_x emission factors of category 1.A.4 for advanced and conventional mixed-fuel boilers.

Pollutant			**NO_x**	
NFR			**1.A.4.a.i**	**1.A.4.b.i**
Fuel	**No.**	**Heating type (subcategory)**	**[kg/TJ]**	
Fuel wood	#14	Mixed-fuel wood boilers (advanced)	107.0	107.0
		Mixed-fuel wood boilers (conventional)	124.0	124.0

3.1.9.3.1.2 NMVOC Emission Factors

Table 157: NFR 1.A.4. NMVOC emission factors for the year 2022.

NFR			**1.A.4.a.i**	**1.A.4.b.i**	**1.A.4.c.i**
Pollutant				**NMVOC**	
Fuel	**No.**	**Heating type**		**[kg/TJ]**	
Light fuel oil	#1	Fuel oil boilers	0.75	0.75	0.75
Medium fuel oil	#1	Fuel oil boilers	8.00	8.00	8.00
Heavy fuel oil	#1	Fuel oil boilers	8.00	8.00	8.00
Diesel	#1	Fuel oil boilers	0.80	0.80	0.80
Petroleum	#1	Fuel oil boilers	0.80	0.80	0.80
Other petroleum products	#1	Fuel oil boilers	0.50	0.50	0.50
Gas oil	#2	Gas oil stoves	1.50	1.50	0.80
	#3	Vapourizing burners	0.80	0.80	0.80
	#4	Yellow burners	0.80	0.80	0.80
	#5	Blue burners with conventional technology	0.51	0.51	0.80
	#6	Blue burners with low temperature or condensing technology	0.17	0.17	0.80
Natural gas	#7	Natural gas convectors	2.00	2.00	0.56(1)
	#8	Atmospheric burners	0.51	0.51	0.56(1)
	#9	Forced-draft natural gas burners	0.20	0.20	0.56(1)
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	0.51	0.51	0.51
	#9	Forced-draft natural gas burners	0.20	0.20	0.20
Liquefied petroleum gases	#10	LPG stoves	2.00	2.00	1.31(1)
	#11	LPG boilers	0.50	0.50	1.31(1)
Fuel wood	#12	Wood stoves and cooking stoves	519.51(2)	546.24(2)	344.47(1)
	#13	Tiled wood stoves and masonry heaters	338.00	338.00	344.47(1)
	#14	Mixed-fuel wood boilers	419.32(3)	421.73(3)	344.47(1)

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				NMVOC	
Fuel	No.	Heating type		[kg/TJ]	
	#15	Natural-draft wood boilers	350.00	350.00	344.47(1)
	#16	Forced-draft wood boilers	325.00	325.00	344.47(1)
Wood waste	#17	Wood chips boilers with conventional technology	432.40	432.40	68.10(1)
	#18	Wood chips boilers with oxygen sensor emission control	78.00	78.00	68.10(1)
	#19	Pellet stoves	39.00	39.00	68.10(1)
	#20	Pellet boilers	32.50	32.50	68.10(1)
Hard coal and hard coal briquettes	#21	Coal stoves	333.30	333.30	304.63(1)
	#22	Coal boilers	284.40	284.40	304.63(1)
Lignite and brown coal	#21	Coal stoves	333.30	333.30	304.63(1)
	#22	Coal boilers	284.40	284.40	304.63(1)
Brown coal briquettes	#21	Coal stoves	333.30	333.30	304.63(1)
	#22	Coal boilers	284.40	284.40	304.63(1)
Coke	#21	Coal stoves	333.30	333.30	304.63(1)
	#22	Coal boilers	284.40	284.40	304.63(1)
Peat	#21	Coal stoves	900.00	900.00	900.00
	#22	Coal boilers	900.00	900.00	900.00
Industrial waste	#22	Coal boilers	0.54	0.54	0.54
Charcoal	–		2 000.00	2 000.00	2 000.00

(1) *Implied emission factor based on fuel-dependent implied NMVOC emission factor of NFR 1.A.4.a.i (alternatively from NFR 1.A.4.b.i, if there is no fuel consumption from NFR 1.A.4.a.i in particular inventory year)*

(2) *Implied emission factor based on NMVOC emission factors of new and conventional wood stoves and cooking stoves stock (see Table 158) weighted with fuel consumption by subcategory of heating type (see Table 150)*

(3) *Implied emission factor based on NMVOC emission factors of advanced and conventional mixed-fuel boilers stock (see Table 159) weighted with fuel consumption by subcategory of heating type (see Table 151)*

The following table shows NMVOC emission factors for advanced and conventional wood stoves and cooking stoves taken from (Lang et al., 2003).

Table 158: NMVOC emission factors of category 1.A.4 for new and conventional wood stoves and cooking stoves.

Pollutant			NMVOC	
NFR			1.A.4.a.i	1.A.4.b.i
Fuel	No.	Heating type (subcategory)	[kg/TJ]	
Fuel wood	#12	Wood stoves and cooking stoves (new)	338.00	338.00
		Wood stoves and cooking stoves (conventional)	643.20	643.20

The following table shows NO_x emission factors for advanced and conventional mixed-fuel boilers taken from (Lang et al. 2003).

Table 159: NMVOC emission factors of category 1.A.4 for advanced and conventional mixed-fuel boilers.

Pollutant			**NMVOC**	
NFR			**1.A.4.a.i**	**1.A.4.b.i**
Fuel	**No.**	**Heating type (subcategory)**	**[kg/TJ]**	
Fuel wood	#14	Mixed-fuel wood boilers (advanced)	350.00	350.00
		Mixed-fuel wood boilers (conventional)	432.40	432.40

3.1.9.3.1.3 CO Emission Factors

Table 160: NFR 1.A.4. CO emission factors for the year 2022.

NFR			**1.A.4.a.i**	**1.A.4.b.i**	**1.A.4.c.i**
Pollutant				**CO**	
Fuel	**No.**	**Heating type**		**[kg/TJ]**	
Light fuel oil	#1	Fuel oil boilers	45.0	45.0	45.0
Medium fuel oil	#1	Fuel oil boilers	15.0	15.0	15.0
Heavy fuel oil	#1	Fuel oil boilers	15.0	15.0	15.0
Diesel	#1	Fuel oil boilers	15.0	15.0	15.0
Petroleum	#1	Fuel oil boilers	15.0	15.0	15.0
Other petroleum products	#1	Fuel oil boilers	10.0	10.0	10.0
Gas oil	#2	Gas oil stoves	150.0	150.0	67.0
	#3	Vapourizing burners	67.0	67.0	67.0
	#4	Yellow burners	13.0	13.0	67.0
	#5	Blue burners with conventional technology	5.0	5.0	67.0
	#6	Blue burners with low temperature or condensing technology	3.0	3.0	67.0
Natural gas	#7	Natural gas convectors	80.0	80.0	37.0
	#8	Atmospheric burners	48.0	48.0	37.0
	#9	Forced-draft natural gas burners	37.0	37.0	37.0
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	48.0	48.0	48.0
	#9	Forced-draft natural gas burners	37.0	37.0	37.0
Liquefied petroleum gases	#10	LPG stoves	80.0	80.0	37.0
	#11	LPG boilers	50.0	50.0	37.0
Fuel wood	#12	Wood stoves and cooking stoves	3 509.6(1)	3 681.1(1)	2 386.8(2)
	#13	Tiled wood stoves and masonry heaters	2 345.3	2 345.3	2 386.8(2)
	#14	Mixed-fuel wood boilers	4 172.8(3)	4 196.8(3)	2 386.8(2)
	#15	Natural-draft wood boilers	3 483.0	3 483.0	2 386.8(2)
	#16	Forced-draft wood boilers	3 234.2	3 234.2	2 386.8(2)
Wood waste	#17	Wood chips boilers with conventional technology	2 400.0	2 400.0	534.3(2)
	#18	Wood chips boilers with oxygen sensor emission control	776.2	776.2	534.3(2)
	#19	Pellet stoves	402.5	402.5	534.3(2)

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				CO	
Fuel	No.	Heating type		[kg/TJ]	
	#20	Pellet boilers	180.4	180.4	534.3(2)
Hard coal and hard coal briquettes	#21	Coal stoves	3 705.0	3 705.0	4 206.0
	#22	Coal boilers	4 206.0	4 206.0	4 206.0
Lignite and brown coal	#21	Coal stoves	3 705.0	3 705.0	4 206.0
	#22	Coal boilers	4 206.0	4 206.0	4 206.0
Brown coal briquettes	#21	Coal stoves	3 705.0	3 705.0	4 206.0
	#22	Coal boilers	4 206.0	4 206.0	4 206.0
Coke	#21	Coal stoves	3 705.0	3 705.0	4 206.0
	#22	Coal boilers	4 206.0	4 206.0	4 206.0
Peat	#21	Coal stoves	11 000.0	11 000.0	11 000.0
	#22	Coal boilers	4 206.0	4 206.0	4 206.0
Industrial waste	#22	Coal boilers	200.0	200.0	200.0
Charcoal	–		8 100.0	8 100.0	8 100.0

(1) *Implied emission factor based on CO emission factors of new and conventional wood stoves and cooking stoves stock (see Table 161) weighted with fuel consumption by subcategory of heating type (see Table 150)*

(2) *Implied emission factor based on fuel-dependent implied CO emission factor of NFR 1.A.4.a.i (alternatively from NFR 1.A.4.b.i, if there is no fuel consumption from NFR 1.A.4.a.i in particular inventory year)*

(3) *Implied emission factor based on CO emission factors of advanced and conventional mixed-fuel boilers stock (see Table 162) weighted with fuel consumption by subcategory of heating type (see Table 151)*

The following table shows CO emission factors for advanced and conventional wood stoves and cooking stoves taken from (Lang et al. 2003).

Table 161: CO emission factors of category 1.A.4 for new and conventional wood stoves and cooking stoves.

Pollutant			CO	
NFR			1.A.4.a.i	1.A.4.b.i
Fuel	No.	Heating type (subcategory)	[kg/TJ]	
Fuel wood	#12	Wood stoves and cooking stoves (new)	2 345.3	2 345.3
		Wood stoves and cooking stoves (conventional)	4 463.0	4 463.0

The following table shows NO_x emission factors for advanced and conventional mixed-fuel boilers taken from (Lang et al. 2003).

Table 162: CO emission factors of category 1.A.4 for advanced and conventional mixed-fuel boilers.

Pollutant			CO	
NFR			1.A.4.a.i	1.A.4.b.i
Fuel	No.	Heating type (subcategory)	[kg/TJ]	
Fuel wood	#14	Mixed-fuel wood boilers (advanced)	3 483.0	3 483.0
		Mixed-fuel wood boilers (conventional)	4 303.0	4 303.0

3.1.9.3.1.4 SO_2 Emission Factors

Table 163: NFR 1.A.4. SO_2 emission factors for the year 2022.

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**SO_2**	
Fuel	**No.**	**Heating type**		**[kg/TJ]**	
Light fuel oil	#1	Fuel oil boilers	90.00	90.00	90.00
Medium fuel oil	#1	Fuel oil boilers	196.00	196.00	196.00
Heavy fuel oil	#1	Fuel oil boilers	398.00	398.00	398.00
Diesel	#1	Fuel oil boilers	18.76	18.76	18.76
Petroleum	#1	Fuel oil boilers	90.00	90.00	90.00
Other petroleum products	#1	Fuel oil boilers	6.00	6.00	6.00
Gas oil	#2	Gas oil stoves	0.47	0.47	0.47
	#3	Vapourizing burners	0.47	0.47	0.47
	#4	Yellow burners	0.47	0.47	0.47
	#5	Blue burners with conventional technology	0.47	0.47	0.47
	#6	Blue burners with low temperature or condensing technology	0.47	0.47	0.47
Natural gas	#7	Natural gas convectors	0.30	0.30	0.30
	#8	Atmospheric burners	0.30	0.30	0.30
	#9	Forced-draft natural gas burners	0.30	0.30	0.30
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	NE(1)	NE(1)	NE(1)
	#9	Forced-draft natural gas burners	NE(1)	NE(1)	NE(1)
Liquefied petroleum gases	#10	LPG stoves	6.00	6.00	6.00
	#11	LPG boilers	6.00	6.00	6.00
Fuel wood	#12	Wood stoves and cooking stoves	11.00	11.00	11.00
	#13	Tiled wood stoves and masonry heaters	11.00	11.00	11.00
	#14	Mixed-fuel wood boilers	11.00	11.00	11.00
	#15	Natural-draft wood boilers	11.00	11.00	11.00
	#16	Forced-draft wood boilers	11.00	11.00	11.00
Wood waste	#17	Wood chips boilers with conventional technology	11.00	11.00	11.00
	#18	Wood chips boilers with oxygen sensor emission control	11.00	11.00	11.00
	#19	Pellet stoves	11.00	11.00	11.00
	#20	Pellet boilers	11.00	11.00	11.00
Hard coal and hard coal briquettes	#21	Coal stoves	543.00	543.00	543.00
	#22	Coal boilers	543.00	543.00	543.00
Lignite and brown coal	#21	Coal stoves	543.00	543.00	543.00
	#22	Coal boilers	543.00	543.00	543.00
Brown coal briquettes	#21	Coal stoves	543.00	543.00	543.00
	#22	Coal boilers	543.00	543.00	543.00
Coke	#21	Coal stoves	543.00	543.00	543.00

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				SO_2	
Fuel	No.	Heating type		[kg/TJ]	
	#22	Coal boilers	543.00	543.00	543.00
Peat	#21	Coal stoves	530.00	530.00	530.00
	#22	Coal boilers	530.00	530.00	530.00
Industrial waste	#22	Coal boilers	130.00	130.00	130.00
Charcoal	–		11.00	11.00	11.00

(1) Sulphur content of filtered biogenic gas injected into gas distribution net currently unknown

Desulphurisation of gas oil reduced the sulphur content down to 10 ppm from 2009 onwards. This is reflected by lowering SO_2 emission factors for all heating types burning gas oil from 45.0 [kg/TJ] down to 0.47 [kg/TJ] in the year 2009.

3.1.9.3.1.5 NH_3 Emission Factors

Table 164: NFR 1.A.4. NH_3 emission factors for the year 2022.

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				NH_3	
Fuel	No.	Heating type		[kg/TJ]	
Light fuel oil	#1	Fuel oil boilers	2.68	2.68	2.68
Medium fuel oil	#1	Fuel oil boilers	2.68	2.68	2.68
Heavy fuel oil	#1	Fuel oil boilers	2.68	2.68	2.68
Diesel	#1	Fuel oil boilers	2.68	2.68	2.68
Petroleum	#1	Fuel oil boilers	2.68	2.68	2.68
Other petroleum products	#1	Fuel oil boilers	2.68	2.68	2.68
Gas oil	#2	Gas oil stoves	2.68	2.68	2.68
	#3	Vapourizing burners	2.68	2.68	2.68
	#4	Yellow burners	2.68	2.68	2.68
	#5	Blue burners with conventional technology	2.68	2.68	2.68
	#6	Blue burners with low temperature or condensing technology	2.68	2.68	2.68
Natural gas	#7	Natural gas convectors	1.00	1.00	1.00
	#8	Atmospheric burners	1.00	1.00	1.00
	#9	Forced-draft natural gas burners	1.00	1.00	1.00
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	1.00	1.00	1.00
	#9	Forced-draft natural gas burners	1.00	1.00	1.00
Liquefied petroleum gases	#10	LPG stoves	1.00	1.00	1.00
	#11	LPG boilers	1.00	1.00	1.00
Fuel wood	#12	Wood stoves and cooking stoves	5.00	5.00	5.00
	#13	Tiled wood stoves and masonry heaters	5.00	5.00	5.00
	#14	Mixed-fuel wood boilers	5.00	5.00	5.00

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				NH_3	
Fuel	**No.**	**Heating type**		**[kg/TJ]**	
	#15	Natural-draft wood boilers	5.00	5.00	5.00
	#16	Forced-draft wood boilers	5.00	5.00	5.00
Wood waste	#17	Wood chips boilers with conventional technology	5.00	5.00	5.00
	#18	Wood chips boilers with oxygen sensor emission control	5.00	5.00	5.00
	#19	Pellet stoves	5.00	5.00	5.00
	#20	Pellet boilers	5.00	5.00	5.00
Hard coal and hard coal briquettes	#21	Coal stoves	0.0089	0.0089	0.0089
	#22	Coal boilers	0.0089	0.0089	0.0089
Lignite and brown coal	#21	Coal stoves	0.0229	0.0229	0.0229
	#22	Coal boilers	0.0229	0.0229	0.0229
Brown coal briquettes	#21	Coal stoves	0.0229	0.0229	0.0229
	#22	Coal boilers	0.0229	0.0229	0.0229
Coke	#21	Coal stoves	0.0088	0.0088	0.0088
	#22	Coal boilers	0.0088	0.0088	0.0088
Peat	#21	Coal stoves	0.0229	0.0229	0.0229
	#22	Coal boilers	0.0229	0.0229	0.0229
Industrial waste	#22	Coal boilers	0.0230	0.0230	0.0230
Charcoal	–		5.00	5.00	5.00

3.1.9.3.2 Emission Factors for Heavy Metals (Cd, Hg, Pb)

1.A.4.a.i Commercial/Institutional: Stationary and 1.A.4.b.i Residential: Stationary

Heavy metals emission factors for liquid fuel consumption from category *1.A.4. Stationary* are the same as for category *1.A.1 Energy Industries*.

Heavy metals emission factors for solid fuel, peat and other fuel consumption from category *1.A.4.a.i* and *1.A.4.b.i* are based on findings from (Hartmann, Böhm & Maier, 2000), (Launhardt et al., 2000), (Pfeiffer et al., 2000), (Stanzel et al., 1995). All heavy metals emission factors applied to solid fuel consumption from category *1.A.4.c.i* are derived from (CORINAIR, 1996), Table 12, B112.

Heavy metals emission factors for heating types burning natural gas are taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a) based on conclusions from (Umweltbundesamt, 2017b).

Heavy metals emission factors for fuel wood, wood waste and charcoal fuel consumption from category *1.A.4.a.i* and *1.A.4.b.i* are based on findings from (Hartmann, Böhm & Maier, 2000), (Launhardt et al., 2000), (Pfeiffer et al., 2000), (Stanzel et al., 1995). Emission factors for heating types, which are burning biogas, sewage sludge gas and landfill gas, are taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a) based on conclusions from (Umweltbundesamt, 2017b).

Results of measurements (Spitzer et al., 1998) show that the TSP emission factor for solid fuel and biomass stoves in households are about 50% higher than the emission factor for central heating boilers. Thus, the Cd and Pb emission factors for fuel consumption of solid fuels, peat, fuel wood and wood waste in heating types *#12 Wood stoves and cooking stoves*, *#13 Tiled wood stoves and masonry heaters*, *#19 Pellet stoves* and *#21 Coal stoves* are assumed to be about 50% higher for category *1.A.4.b.i*. These higher estimates are also used in category *1.A.4.a.i*.

Heavy metals emission factors applied to fuel wood and wood waste fuel consumption from category *1.A.4.c.i* consider results from (Obernberger, 1995), (Launhardt et al., 2000) and (FTU, 2000).

<u>1.A.4.c.i Agriculture/Forestry/Fishing: stationary</u>

The same sources for emission factors as for categories *1.A.4.a.i* and *1.A.4.b.i* were used (see section above).

3.1.9.3.2.1 Cd Emission Factors

Table 165: NFR 1.A.4. Cd emission factors for the year 2022.

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**Cd**	
Fuel	**No.**	**Heating type**		**[g/TJ]**	
Light fuel oil	#1	Fuel oil boilers	0.05	0.05	0.05
Medium fuel oil	#1	Fuel oil boilers	0.5	0.5	0.5
Heavy fuel oil	#1	Fuel oil boilers	0.5	0.5	0.5
Diesel	#1	Fuel oil boilers	0.02	0.02	0.02
Petroleum	#1	Fuel oil boilers	0.02	0.02	0.02
Other petroleum products	#1	Fuel oil boilers	NE(1)	NE(1)	NE(1)
Gas oil	#2	Gas oil stoves	0.02	0.02	0.02
	#3	Vapourizing burners	0.02	0.02	0.02
	#4	Yellow burners	0.02	0.02	0.02
	#5	Blue burners with conventional technology	0.02	0.02	0.02
	#6	Blue burners with low temperature or condensing technology	0.02	0.02	0.02
Natural gas	#7	Natural gas convectors	0.00025	0.00025	0.00025
	#8	Atmospheric burners	0.00025	0.00025	0.00025
	#9	Forced-draft natural gas burners	0.00025	0.00025	0.00025
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	0.00025	0.00025	0.00025
	#9	Forced-draft natural gas burners	0.00025	0.00025	0.00025
Liquefied petroleum gases	#10	LPG stoves	0.02	0.02	0.02
	#11	LPG boilers	0.02	0.02	0.02
Fuel wood	#12	Wood stoves and cooking stoves	4.5	4.5	7.0
	#13	Tiled wood stoves and masonry heaters	4.5	4.5	7.0
	#14	Mixed-fuel wood boilers	7.0	3.0	7.0
	#15	Natural-draft wood boilers	7.0	3.0	7.0
	#16	Forced-draft wood boilers	7.0	3.0	7.0

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**Cd**	
Fuel	**No.**	**Heating type**		**[g/TJ]**	
Wood waste	#17	Wood chips boilers with conventional technology	7.0	3.0	7.0
	#18	Wood chips boilers with oxygen sensor emission control	7.0	3.0	7.0
	#19	Pellet stoves	4.5	4.5	7.0
	#20	Pellet boilers	7.0	3.0	7.0
Hard coal and hard coal briquettes	#21	Coal stoves	6.0	6.0	5.4
	#22	Coal boilers	5.4	4.0	5.4
Lignite and brown coal	#21	Coal stoves	3.0	3.0	3.7
	#22	Coal boilers	3.7	2.0	3.7
Brown coal briquettes	#21	Coal stoves	3.0	3.0	3.7
	#22	Coal boilers	3.7	2.0	3.7
Coke	#21	Coal stoves	6.0	6.0	5.4
	#22	Coal boilers	5.4	4.0	5.4
Peat	#21	Coal stoves	4.5	4.5	4.5
	#22	Coal boilers	7.0	3.0	7.0
Industrial waste	#22	Coal boilers	7.0	7.0	7.0
Charcoal	–		4.5	4.5	4.5

(1) Cd emissions from gas works gas (liquefied petroleum gases) injected into gas distribution net currently not estimated

3.1.9.3.2.2 Hg Emission Factors

Table 166: NFR 1.A.4. Hg emission factors for the year 2022.

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**Hg**	
Fuel	**No.**	**Heating type**		**[g/TJ]**	
Light fuel oil	#1	Fuel oil boilers	0.015	0.015	0.015
Medium fuel oil	#1	Fuel oil boilers	0.04	0.04	0.04
Heavy fuel oil	#1	Fuel oil boilers	0.075	0.075	0.075
Diesel	#1	Fuel oil boilers	0.007	0.007	0.007
Petroleum	#1	Fuel oil boilers	0.007	0.007	0.007
Other petroleum products	#1	Fuel oil boilers	NE(1)	NE(1)	NE(1)
Gas oil	#2	Gas oil stoves	0.007	0.007	0.007
	#3	Vapourizing burners	0.007	0.007	0.007
	#4	Yellow burners	0.007	0.007	0.007
	#5	Blue burners with conventional technology	0.007	0.007	0.007
	#6	Blue burners with low temperature or condensing technology	0.007	0.007	0.007
Natural gas	#7	Natural gas convectors	0.1	0.1	0.07
	#8	Atmospheric burners	0.1	0.1	0.07

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**Hg**	
Fuel	**No.**	**Heating type**		**[g/TJ]**	
	#9	Forced-draft natural gas burners	0.1	0.1	0.07
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	0.1	0.1	0.1
	#9	Forced-draft natural gas burners	0.1	0.1	0.1
Liquefied petroleum gases	#10	LPG stoves	0.007	0.007	0.007
	#11	LPG boilers	0.007	0.007	0.007
Fuel wood	#12	Wood stoves and cooking stoves	1.9	1.9	1.9
	#13	Tiled wood stoves and masonry heaters	1.9	1.9	1.9
	#14	Mixed-fuel wood boilers	2.0	1.9	1.9
	#15	Natural-draft wood boilers	2.0	1.9	1.9
	#16	Forced-draft wood boilers	2.0	1.9	1.9
Wood waste	#17	Wood chips boilers with conventional technology	2.0	1.9	1.9
	#18	Wood chips boilers with oxygen sensor emission control	2.0	1.9	1.9
	#19	Pellet stoves	1.9	1.9	1.9
	#20	Pellet boilers	2.0	1.9	1.9
Hard coal and hard coal briquettes	#21	Coal stoves	10.7	10.7	10.7
	#22	Coal boilers	10.7	10.7	10.7
Lignite and brown coal	#21	Coal stoves	9.2	9.2	9.2
	#22	Coal boilers	9.2	9.2	9.2
Brown coal briquettes	#21	Coal stoves	9.2	9.2	9.2
	#22	Coal boilers	9.2	9.2	9.2
Coke	#21	Coal stoves	10.7	10.7	10.7
	#22	Coal boilers	10.7	10.7	10.7
Peat	#21	Coal stoves	1.9	1.9	1.9
	#22	Coal boilers	2.0	1.9	2.0
Industrial waste	#22	Coal boilers	2.0	2.0	2.0
Charcoal	–		1.9	1.9	1.9

(1) Hg emissions from gas works gas (liquefied petroleum gases) injected into gas distribution net currently not estimated

3.1.9.3.2.3 Pb Emission Factors

Table 167: NFR 1.A.4. Pb emission factors for the year 2022.

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**Pb**	
Fuel	**No.**	**Heating type**		**[g/TJ]**	
Light fuel oil	#1	Fuel oil boilers	0.05	0.05	0.05
Medium fuel oil	#1	Fuel oil boilers	0.12	0.12	0.12
Heavy fuel oil	#1	Fuel oil boilers	0.125	0.125	0.125
Diesel	#1	Fuel oil boilers	0.02	0.02	0.02
Petroleum	#1	Fuel oil boilers	0.02	0.02	0.02

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**Pb**	
Fuel	**No.**	**Heating type**		**[g/TJ]**	
Other petroleum products	#1	Fuel oil boilers	NE[1]	NE[1]	NE[1]
Gas oil	#2	Gas oil stoves	0.02	0.02	0.02
	#3	Vapourizing burners	0.02	0.02	0.02
	#4	Yellow burners	0.02	0.02	0.02
	#5	Blue burners with conventional technology	0.02	0.02	0.02
	#6	Blue burners with low temperature or condensing technology	0.02	0.02	0.02
Natural gas	#7	Natural gas convectors	0.0015	0.0015	0.0015
	#8	Atmospheric burners	0.0015	0.0015	0.0015
	#9	Forced-draft natural gas burners	0.0015	0.0015	0.0015
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	0.0015	0.0015	0.0015
	#9	Forced-draft natural gas burners	0.0015	0.0015	0.0015
Liquefied petroleum gases	#10	LPG stoves	0.02	0.02	0.02
	#11	LPG boilers	0.02	0.02	0.02
Fuel wood	#12	Wood stoves and cooking stoves	35.0	35.0	23.0
	#13	Tiled wood stoves and masonry heaters	35.0	35.0	23.0
	#14	Mixed-fuel wood boilers	50.0	23.0	23.0
	#15	Natural-draft wood boilers	50.0	23.0	23.0
	#16	Forced-draft wood boilers	50.0	23.0	23.0
Wood waste	#17	Wood chips boilers with conventional technology	50.0	23.0	23.0
	#18	Wood chips boilers with oxygen sensor emission control	50.0	23.0	23.0
	#19	Pellet stoves	35.0	35.0	23.0
	#20	Pellet boilers	50.0	23.0	23.0
Hard coal and hard coal briquettes	#21	Coal stoves	135.0	135.0	90.0
	#22	Coal boilers	89.0	90.0	90.0
Lignite and brown coal	#21	Coal stoves	33.0	33.0	22.0
	#22	Coal boilers	22.0	22.0	22.0
Brown coal briquettes	#21	Coal stoves	33.0	33.0	22.0
	#22	Coal boilers	22.0	22.0	22.0
Coke	#21	Coal stoves	135.0	135.0	90.0
	#22	Coal boilers	89.0	90.0	90.0
Peat	#21	Coal stoves	66.1	66.1	66.1
	#22	Coal boilers	66.1	66.1	66.1
Industrial waste	#22	Coal boilers	50.0	50.0	50.0
Charcoal	–		35.0	35.0	35.0

[1] Pb emissions from gas works gas (liquefied petroleum gases) injected into gas distribution net currently not estimated

3.1.9.3.3 Emission Factors for POPs (PCDD/F, HCB, PAH4, PCB)

1.A.4.a.i Commercial/Institutional: Stationary and 1.A.4.b.i Residential: Stationary

For categories *1.A.4.a.i* and *1.A.4.b.i* the PCDD/F emission factors for solid fuels and fuel wood were taken from (Hübner & Boos, 2000). For *#3 Vapourizing burners*, *#13 Tiled wood stoves and masonry heaters*, *#15 Natural-draft wood boilers* and *#19 Pellet stoves* the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a) was considered. For heating oil a mean value from (Pfeiffer et al., 2000), (Boos & Hübner, 1999) measurements by (FTU, 2000) and the EMEP/EEA Guidebook 2023 (EEA, 2023a) was used. Combustion of waste in residential plants was not considered, as no activity data was available.

HCB emission factors are taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a) and the national study (Hübner et al., 2002) which is based on field measurements from 15 solid fuel residential boilers and stoves with a capacity less than 50 kW using the standard methodology according to (ÖNORM EN-1948-1, 1997). The results show a high variation in flue gas concentrations without any correlation between type of heating (stove, boiler) or fuel (log wood, pellets, wood chips, coal). Inter alia for commercial and institutional plants the same emission factors as used for small (and medium) plants of category *1.A.2* were chosen (the share of the different size classes is based on expert judgement).

EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a) refers to (Syc et al., 2011) showing a range from 0.1 to 30 mg/TJ thus recommending 5 mg/TJ as a Tier 2 HCB emission factor for biomass. However, the HCB emission factors from (Hübner et al., 2002) for biomass range from 100 mg/TJ for new biomass boilers up to 600 mg/TJ for old wood boilers (year of installation before 1980).

- Manually stoked stoves and boilers fed with so-called realistic fuel mix suggest the use of treated old wood products (potentially with HCB as wood preservative) or waste. It is assumed, that such practises are less common in recent years and in more advanced wood combustion technologies.
- Fuel wood harvested from local forests spoiled with accumulated HCB from soils (seed dressing with HCB before its legal ban in Austria in the year 1992) may have been more common in former years. It is assumed that the HCB content of fuel wood constantly declines in recent years.

In general, the 1990 HCB biomass emission factors from (Hübner et al., 2002) are gradually switched to lower emission factors for new boilers from (Hübner et al., 2002) starting from the year 2000 (interpolation between 1990 and 2000). This method is applied to *#12 Wood stoves and cooking stoves*, *#14 Mixed-fuel wood boilers*, *#15 Natural-draft wood boilers*, *#17 Wood chips boilers with conventional technology* and *#18 Wood chips boilers with oxygen sensor emission control*. Inter alia, this reflects effects of waste collection systems, less available old wood products (treated with HCB), the turnover of heating types (phase-out of old stoves and boilers) and the legal ban of HCB application. The emission factor HCB from (Hübner et al., 2002) for *#13 Tiled wood stoves and masonry heaters* is set constant. The HCB emission factors for *#16 Forced-draft wood boilers*, *#19 Pellet stoves* and *#20 Pellet boilers* are set constant over time solely taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a).

The PAH emission factors are trimmed mean values from values given in (Umweltbundesamt Berlin, 1998), (Scheidl, 1996), (Orthofer & Vesely, 1990), (Sorger, 1993), (Launhardt et al., 2000), (Pfeiffer et al., 2000) (Launhardt et al., 1998), (Stanzel et al., 1995), (Baas et al., 1995). However, it was not possible to determine different emission factors for stoves and central heating boilers from the values given in the cited literature. Thus for solid fuels the same proportions given from the dioxin emission factors, and for oil the proportions of carbon black given in (Hübner et al., 1996), was used. For natural gas it was assumed that the values given in literature are valid for stoves and that the values for central heating boilers are assumed to be five times lower. Supplemental PAH emission factors for *#3 Vaporizing burners*, *#12 Wood stoves and cooking stoves*, *#15 Natural-draft wood boilers* and *#19 Pellet stoves* are taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a). Inter alia for commercial and institutional plants the same emission factors as used for small (and medium) plants of category *1.A.2* were chosen (the share of the different size classes is based on expert judgement).

- The resulting PAH emissions for category *1.A.4.a.i*, *1.A.4.b.i* and *1.A.4.c.i* were subdivided into the contributing PAH4 substances Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene considering the ratio of emission factors from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a).

PCB emission factors for *#13 Tiled wood stoves and masonry heaters*, *#15 Natural-draft wood boilers*, *#19 Pellet stoves*, *#21 Coal stoves* and *#22 Coal boilers* are selected from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a). The PCB emission factor of 3 600 µg/t for heavy fuel oil has been selected from (Kakareka et al., 2004) and was converted to 85 µg/GJ.

The PCB emission factors for other heating types burning fuel wood, wood waste, charcoal, peat and industrial waste have been derived from the ratio of Dioxin and PCB emission factors according to the measurements undertaken by (Hedman et al., 2006). A ratio of 0.09 g PCB per g Dioxin has been selected. Any other liquid fuel, gaseous fuel, biogas, sewage sludge gas and landfill gas PCB emission factors were set as *not applicable*, as only insignificant PCB emissions are expected.

1.A.4.c.i Agriculture/Forestry/Fishing: stationary

For liquid and gaseous fuels the same PCDD/F, HCB and PCB emission factors as used for small (and medium) plants of category *1.A.2* were used (the share of the different size classes is based on expert judgement). Other emission factors are derived from category *1.A.4.a.i* assuming similar structure of heating types in both categories (implied emission factors). Those values given in the following tables are averaged values per fuel category. Supplemental implied emission factors derived from category *1.A.4.b.i* were assigned, if no activity data for the specific fuel in category *1.A.4.a.i* occurred.

3.1.9.3.3.1 PCDD/F Emission Factors

Table 168: NFR 1.A.4. PCDD/F emission factors for the year 2022.

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**PCDD/F**	
Fuel	**No.**	**Heating type**		**[mg/TJ]**	
Light fuel oil	#1	Fuel oil boilers	0.002	0.0015	0.0015
Medium fuel oil	#1	Fuel oil boilers	0.002	0.002	0.002
Heavy fuel oil	#1	Fuel oil boilers	0.0009	0.0009	0.0009
Diesel	#1	Fuel oil boilers	0.0004	0.0004	0.0004
Petroleum	#1	Fuel oil boilers	0.0012	0.0012	0.0012

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**PCDD/F**	
Fuel	**No.**	**Heating type**		**[mg/TJ]**	
Other petroleum products	#1	Fuel oil boilers	0.0017	0.0017	0.0017
Gas oil	#2	Gas oil stoves	0.003	0.003	0.0015
	#3	Vapourizing burners	0.0018	0.0018	0.0015
	#4	Yellow burners	0.0015	0.0015	0.0015
	#5	Blue burners with conventional technology	0.0012	0.0012	0.0015
	#6	Blue burners with low temperature or condensing technology	0.0012	0.0012	0.0015
Natural gas	#7	Natural gas convectors	0.006	0.006	0.0025
	#8	Atmospheric burners	0.0025	0.0025	0.0025
	#9	Forced-draft natural gas burners	0.0016	0.0016	0.0025
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	0.0006	0.0006	0.0006
	#9	Forced-draft natural gas burners	0.0006	0.0006	0.0006
Liquefied petroleum gases	#10	LPG stoves	0.003	0.003	0.0025
	#11	LPG boilers	0.0017	0.0025	0.0025
Fuel wood	#12	Wood stoves and cooking stoves	0.75	0.75	0.27[(1)]
	#13	Tiled wood stoves and masonry heaters	0.25	0.25	0.27[(1)]
	#14	Mixed-fuel wood boilers	0.24	0.38	0.27[(1)]
	#15	Natural-draft wood boilers	0.1	0.1	0.27[(1)]
	#16	Forced-draft wood boilers	0.01	0.01	0.27[(1)]
Wood waste	#17	Wood chips boilers with conventional technology	0.43	0.43	0.13[(1)]
	#18	Wood chips boilers with oxygen sensor emission control	0.24	0.24	0.13[(1)]
	#19	Pellet stoves	0.10	0.10	0.13[(1)]
	#20	Pellet boilers	0.01	0.01	0.13[(1)]
Hard coal and hard coal briquettes	#21	Coal stoves	0.75	0.75	0.53[(1)]
	#22	Coal boilers	0.38	0.38	0.53[(1)]
Lignite and brown coal	#21	Coal stoves	0.75	0.75	0.53[(1)]
	#22	Coal boilers	0.38	0.38	0.53[(1)]
Brown coal briquettes	#21	Coal stoves	0.75	0.75	0.53[(1)]
	#22	Coal boilers	0.38	0.38	0.53[(1)]
Coke	#21	Coal stoves	0.75	0.75	0.53[(1)]
	#22	Coal boilers	0.38	0.38	0.53[(1)]
Peat	#21	Coal stoves	0.75	0.75	0.75
	#22	Coal boilers	0.38	0.38	0.38
Industrial waste	#22	Coal boilers	0.30	0.30	0.30
Charcoal	–		0.75	0.75	0.75

[(1)] *Implied emission factor based on fuel-dependent implied PCDD/F emission factor of NFR 1.A.4.a.i (alternatively from NFR 1.A.4.b.i, if there is no fuel consumption from NFR 1.A.4.a.i in particular inventory year)*

3.1.9.3.3.2 HCB Emission Factors

Table 169: NFR 1.A.4. HCB emission factors for the year 2022.

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**HCB**	
Fuel	**No.**	**Heating type**		**[mg/TJ]**	
Light fuel oil	#1	Fuel oil boilers	0.19	0.15	0.15
Medium fuel oil	#1	Fuel oil boilers	0.19	0.19	0.19
Heavy fuel oil	#1	Fuel oil boilers	0.12	0.12	0.12
Diesel	#1	Fuel oil boilers	0.08	0.08	0.08
Petroleum	#1	Fuel oil boilers	0.12	0.12	0.12
Other petroleum products	#1	Fuel oil boilers	0.14	0.14	0.14
Gas oil	#2	Gas oil stoves	0.3	0.3	0.15
	#3	Vapourizing burners	0.12	0.15	0.15
	#4	Yellow burners	0.12	0.15	0.15
	#5	Blue burners with conventional technology	0.12	0.15	0.15
	#6	Blue burners with low temperature or condensing technology	0.12	0.15	0.15
Natural gas	#7	Natural gas convectors	0.60	0.60	0.25
	#8	Atmospheric burners	0.14	0.25	0.25
	#9	Forced-draft natural gas burners	0.14	0.25	0.25
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	0.072	0.072	0.072
	#9	Forced-draft natural gas burners	0.072	0.072	0.072
Liquefied petroleum gases	#10	LPG stoves	0.3	0.3	0.25
	#11	LPG boilers	0.14	0.195	0.25
Fuel wood	#12	Wood stoves and cooking stoves	135.7(1)	140.9(1)	101.3(2)
	#13	Tiled wood stoves and masonry heaters	100.0	100.0	101.3(2)
	#14	Mixed-fuel wood boilers	159.4(3)	161.7(3)	101.3(2)
	#15	Natural-draft wood boilers	100.0	100.0	101.3(2)
	#16	Forced-draft wood boilers	30.0	30.0	101.3(2)
Wood waste	#17	Wood chips boilers with conventional technology	160.0	160.0	53.4(2)
	#18	Wood chips boilers with oxygen sensor emission control	100.0	100.0	53.4(2)
	#19	Pellet stoves	30.0	30.0	53.4(2)
	#20	Pellet boilers	5.0	5.0	53.4(2)
Hard coal and hard coal briquettes	#21	Coal stoves	600.0	600.0	600.0(2)
	#22	Coal boilers	180.0	600.0	600.0(2)
Lignite and brown coal	#21	Coal stoves	600.0	600.0	600.0(2)
	#22	Coal boilers	160.0	600.0	600.0(2)
Brown coal briquettes	#21	Coal stoves	600.0	600.0	600.0(2)
	#22	Coal boilers	190.0	600.0	600.0(2)
Coke	#21	Coal stoves	600.0	600.0	600.0(2)
	#22	Coal boilers	180.0	600.0	600.0(2)
Peat	#21	Coal stoves	600.0	600.0	600.0

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				HCB	
Fuel	No.	Heating type		[mg/TJ]	
	#22	Coal boilers	190.0	600.0	190.0
Industrial waste	#22	Coal boilers	250.0	250.0	250.0
Charcoal	–		600.0	600.0	600.0

(1) Implied emission factor based on HCB emission factors of new and conventional wood stoves and cooking stoves stock (see Table 170) weighted with fuel consumption by subcategory of heating type (see Table 150)

(2) Implied emission factor based on fuel-dependent implied HCB emission factor of NFR 1.A.4.a.i (alternatively from NFR 1.A.4.b.i, if there is no fuel consumption from NFR 1.A.4.a.i in particular inventory year)

(3) Implied emission factor based on HCB emission factors of advanced and conventional mixed-fuel boilers stock (see Table 171) weighted with fuel consumption by subcategory of heating type (additional advanced mixed-fuel boilers share relative to base year 2000 only) (see Table 151)

The following table shows HCB emission factors for advanced and conventional wood stoves and cooking stoves taken from (FTU, 2000).

Table 170: HCB emission factors of category 1.A.4 for new and conventional wood stoves and cooking stoves.

Pollutant			HCB	
NFR			1.A.4.a.i	1.A.4.b.i
Fuel	No.	Heating type (subcategory)	[mg/TJ]	
Fuel wood	#12	Wood stoves and cooking stoves (new)	100.0	100.0
		Wood stoves and cooking stoves (conventional)	160.0	160.0

The following table shows NO_x emission factors for advanced and conventional mixed-fuel boilers taken from (FTU, 2000).

Table 171: HCB emission factors of category 1.A.4 for advanced and conventional mixed-fuel boilers.

Pollutant			HCB	
NFR			1.A.4.a.i	1.A.4.b.i
Fuel	No.	Heating type (subcategory)	[kg/TJ]	
Fuel wood	#14	Mixed-fuel wood boilers (advanced)	100.0	100.0
		Mixed-fuel wood boilers (conventional)	160.0	160.0

3.1.9.3.3.3 PAH4 Emission Factors

Table 172: NFR 1.A.4. PAH4 emission factors for the year 2022.

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				PAH4	
Fuel	No.	Heating type		[g/TJ]	
Light fuel oil	#1	Fuel oil boilers	0.24	0.24	0.24
Medium fuel oil	#1	Fuel oil boilers	0.24	0.24	0.24
Heavy fuel oil	#1	Fuel oil boilers	0.24	0.24	0.24

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**PAH4**	
Fuel	**No.**	**Heating type**		**[g/TJ]**	
Diesel	#1	Fuel oil boilers	0.16	0.16	0.16
Petroleum	#1	Fuel oil boilers	0.18	0.18	0.18
Other petroleum products	#1	Fuel oil boilers	0.011	0.011	0.011
Gas oil	#2	Gas oil stoves	1.7	1.7	0.24
	#3	Vapourizing burners	0.35	0.35	0.24
	#4	Yellow burners	0.24	0.24	0.24
	#5	Blue burners with conventional technology	0.18	0.18	0.24
	#6	Blue burners with low temperature or condensing technology	0.04	0.04	0.24
Natural gas	#7	Natural gas convectors	0.2	0.2	0.047(1)
	#8	Atmospheric burners	0.04	0.04	0.047(1)
	#9	Forced-draft natural gas burners	0.01	0.01	0.047(1)
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	0.0032	0.0032	0.0032
	#9	Forced-draft natural gas burners	0.0032	0.0032	0.0032
Liquefied petroleum gases	#10	LPG stoves	0.2	0.2	0.11(1)
	#11	LPG boilers	0.011	0.04	0.11(1)
Fuel wood	#12	Wood stoves and cooking stoves	345.0	345.0	176.2(1)
	#13	Tiled wood stoves and masonry heaters	170.0	170.0	176.2(1)
	#14	Mixed-fuel wood boilers	27.0	85.0	176.2(1)
	#15	Natural-draft wood boilers	24.0	35.0	176.2(1)
	#16	Forced-draft wood boilers	2.0	2.0	176.2(1)
Wood waste	#17	Wood chips boilers with conventional technology	24.0	24.0	3.8(1)
	#18	Wood chips boilers with oxygen sensor emission control	2.0	2.0	3.8(1)
	#19	Pellet stoves	35.0	35.0	3.8(1)
	#20	Pellet boilers	2.0	2.0	3.8(1)
Hard coal and hard coal briquettes	#21	Coal stoves	170.0	170.0	120.2(1)
	#22	Coal boilers	25.0	85.0	120.2(1)
Lignite and brown coal	#21	Coal stoves	170.0	170.0	120.2(1)
	#22	Coal boilers	24.0	85.0	120.2(1)
Brown coal briquettes	#21	Coal stoves	170.0	170.0	120.2(1)
	#22	Coal boilers	24.0	85.0	120.2(1)
Coke	#21	Coal stoves	24.0	24.0	17.0(1)
	#22	Coal boilers	4.5	12.0	17.0(1)
Peat	#21	Coal stoves	170.0	170.0	170.0
	#22	Coal boilers	24.0	85.0	24.0
Industrial waste	#22	Coal boilers	26.0	26.0	26.0
Charcoal	–		170.0	170.0	170.0

[1])Implied emission factor based on fuel-dependent implied PAH4 emission factor of NFR 1.A.4.a.i (alternatively from NFR 1.A.4.b.i, if there is no fuel consumption from NFR 1.A.4.a.i in particular inventory year)

The resulting PAH emissions for category *1.A.4.a.i*, *1.A.4.b.i* and *1.A.4.c.i* were subdivided into the contributing PAH4 substances Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene considering the ratio of emission factors from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a) (see Table 173, Table 174 and Table 175).

Table 173: NFR 1.A.4.a.i share of total PAH4 emissions by heating type 2022.

NFR				1.A.4.a.i		
Pollutant		**Total**	**Benzo_a**	**Benzo_b**	**Benzo_k**	**Indeno**
No.	**Heating type**			**[% PAH4]**		
#1	Fuel oil boilers	100.0	30.8	34.6	23.1	11.5
#2	Gas oil stoves	100.0	22.9	11.4	20.0	45.7
#3	Vapourizing burners	100.0	22.9	11.4	20.0	45.7
#4	Yellow burners	100.0	22.9	11.4	20.0	45.7
#5	Blue burners with conventional technology	100.0	22.9	11.4	20.0	45.7
#6	Blue burners with low temperature or condensing technology	100.0	22.9	11.4	20.0	45.7
#7	Natural gas convectors	100.0	18.2	27.3	27.3	27.3
#8	Atmospheric burners	100.0	18.2	27.3	27.3	27.3
#9	Forced-draft natural gas burners	100.0	18.2	27.3	27.3	27.3
#10	LPG stoves	100.0	22.9	11.4	20.0	45.7
#11	LPG boilers	100.0	22.9	11.4	20.0	45.7
#12	Wood stoves and cooking stoves	100.0	35.1	32.2	12.2	20.6
#13	Tiled wood stoves and masonry heaters	100.0	28.6	45.7	14.3	11.4
#14	Mixed-fuel wood boilers	100.0	28.6	45.7	14.3	11.4
#15	Natural-draft wood boilers	100.0	28.6	45.7	14.3	11.4
#16	Forced-draft wood boilers	100.0	28.6	45.7	14.3	11.4
#17	Wood chips boilers with conventional technology	100.0	28.6	45.7	14.3	11.4
#18	Wood chips boilers with oxygen sensor emission control	100.0	28.6	45.7	14.3	11.4
#19	Pellet stoves	100.0	28.6	45.7	14.3	11.4
#20	Pellet boilers	100.0	28.6	45.7	14.3	11.4
#21	Coal stoves *(solid fuels)*	100.0	27.2	43.5	16.3	13.0
#22	Coal boilers *(solid fuels)*	100.0	38.0	35.2	14.1	12.7

Table 174: NFR 1.A.4.b.i share of total PAH4 emissions by heating type 2022.

NFR				1.A.4.b.i		
Pollutant		**Total**	**Benzo_a**	**Benzo_b**	**Benzo_k**	**Indeno**
No.	**Heating type**			**[% PAH4]**		
#1	Fuel oil boilers	100.0	30.8	34.6	23.1	11.5

NFR		1.A.4.b.i				
Pollutant		**Total**	**Benzo_a**	**Benzo_b**	**Benzo_k**	**Indeno**
No.	**Heating type**			**[% PAH4]**		
#2	Gas oil stoves	100.0	22.9	11.4	20.0	45.7
#3	Vapourizing burners	100.0	22.9	11.4	20.0	45.7
#4	Yellow burners	100.0	22.9	11.4	20.0	45.7
#5	Blue burners with conventional technology	100.0	22.9	11.4	20.0	45.7
#6	Blue burners with low temperature or condensing technology	100.0	22.9	11.4	20.0	45.7
#7	Natural gas convectors	100.0	18.2	27.3	27.3	27.3
#8	Atmospheric burners	100.0	18.2	27.3	27.3	27.3
#9	Forced-draft natural gas burners	100.0	18.2	27.3	27.3	27.3
#10	LPG stoves	100.0	22.9	11.4	20.0	45.7
#11	LPG boilers	100.0	22.9	11.4	20.0	45.7
#12	Wood stoves and cooking stoves	100.0	35.1	32.2	12.2	20.6
#13	Tiled wood stoves and masonry heaters	100.0	28.6	45.7	14.3	11.4
#14	Mixed-fuel wood boilers	100.0	35.1	32.2	12.2	20.6
#15	Natural-draft wood boilers	100.0	35.1	32.2	12.2	20.6
#16	Forced-draft wood boilers	100.0	9.8	15.7	4.9	69.6
#17	Wood chips boilers with conventional technology	100.0	35.1	32.2	12.2	20.6
#18	Wood chips boilers with oxygen sensor emission control	100.0	28.6	45.7	14.3	11.4
#19	Pellet stoves	100.0	28.6	45.7	14.3	11.4
#20	Pellet boilers	100.0	28.6	45.7	14.3	11.4
#21	Coal stoves *(solid fuels)*	100.0	27.2	43.5	16.3	13.0
#22	Coal boilers *(solid fuels)*	100.0	38.0	35.2	14.1	12.7

Table 175: NFR 1.A.4.c.i share of total PAH4 emissions by heating type 2022.

NFR		1.A.4.c.i				
Pollutant		**Total**	**Benzo_a**	**Benzo_b**	**Benzo_k**	**Indeno**
No.	**Heating type**			**[% PAH4]**		
#1	Fuel oil boilers	100.0	27.2	41.3	20.6	10.9
#2	Gas oil stoves	100.0	9.5	74.6	8.5	7.5
#3	Vapourizing burners	100.0	9.5	74.6	8.5	7.5
#4	Yellow burners	100.0	9.5	74.6	8.5	7.5
#5	Blue burners with conventional technology	100.0	9.5	74.6	8.5	7.5
#6	Blue burners with low temperature or condensing technology	100.0	9.5	74.6	8.5	7.5
#7	Natural gas convectors	100.0	18.2	27.3	27.3	27.3
#8	Atmospheric burners	100.0	18.2	27.3	27.3	27.3
#9	Forced-draft natural gas burners	100.0	18.2	27.3	27.3	27.3

NFR		1.A.4.c.i				
Pollutant		**Total**	**Benzo_a**	**Benzo_b**	**Benzo_k**	**Indeno**
No.	**Heating type**			**[% PAH4]**		
#10	LPG stoves	100.0	22.9	11.4	20.0	45.7
#11	LPG boilers	100.0	22.9	11.4	20.0	45.7
#12	Wood stoves and cooking stoves	100.0	29.0	44.8	14.1	12.1
#13	Tiled wood stoves and masonry heaters	100.0	29.0	44.8	14.1	12.1
#14	Mixed-fuel wood boilers	100.0	29.0	44.8	14.1	12.1
#15	Natural-draft wood boilers	100.0	29.0	44.8	14.1	12.1
#16	Forced-draft wood boilers	100.0	29.0	44.8	14.1	12.1
#17	Wood chips boilers with conventional technology	100.0	28.6	45.7	14.3	11.4
#18	Wood chips boilers with oxygen sensor emission control	100.0	28.6	45.7	14.3	11.4
#19	Pellet stoves	100.0	28.6	45.7	14.3	11.4
#20	Pellet boilers	100.0	28.6	45.7	14.3	11.4
#21	Coal stoves *(solid fuels)*	100.0	31.7	40.0	15.4	12.9
#22	Coal boilers *(solid fuels)*	100.0	31.7	40.0	15.4	12.9

Supplemental assumptions for the PAH4 substances share of fuel consumption of peat, other fuels and charcoal from category *1.A.4 Stationary* are given in Table 176.

Table 176: NFR 1.A.4 supplementary share of total PAH4 emissions by fuel 2022.

NFR	1.A.4. Stationary				
Pollutant	**Total**	**Benzo_a**	**Benzo_b**	**Benzo_k**	**Indeno**
Fuel			**[% PAH4]**		
Peat	100.0	28.6	45.7	14.3	11.4
Industrial waste	100.0	38.0	35.2	14.1	12.7
Charcoal	100.0	35.1	32.2	12.2	20.6

3.1.9.3.3.4 PCB Emission Factors

Table 177: NFR 1.A.4. PCB emission factors for the year 2022.

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**PCB**	
Fuel	**No.**	**Heating type**		**[mg/TJ]**	
Light fuel oil	#1	Fuel oil boilers	NA	NA	NA
Medium fuel oil	#1	Fuel oil boilers	NA	NA	NA
Heavy fuel oil	#1	Fuel oil boilers	85.0	85.0	85.0
Diesel	#1	Fuel oil boilers	NA	NA	NA
Petroleum	#1	Fuel oil boilers	NA	NA	NA
Other petroleum products	#1	Fuel oil boilers	NA	NA	NA

NFR			1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant				**PCB**	
Fuel	**No.**	**Heating type**		**[mg/TJ]**	
Gas oil	#2	Gas oil stoves	NA	NA	NA
	#3	Vapourizing burners	NA	NA	NA
	#4	Yellow burners	NA	NA	NA
	#5	Blue burners with conventional technology	NA	NA	NA
	#6	Blue burners with low temperature or condensing technology	NA	NA	NA
Natural gas	#7	Natural gas convectors	NA	NA	NA
	#8	Atmospheric burners	NA	NA	NA
	#9	Forced-draft natural gas burners	NA	NA	NA
Biogas, sewage sludge gas and landfill gas	#8	Atmospheric burners	NA	NA	NA
	#9	Forced-draft natural gas burners	NA	NA	NA
Liquefied petroleum gases	#10	LPG stoves	NA	NA	NA
	#11	LPG boilers	NA	NA	NA
Fuel wood	#12	Wood stoves and cooking stoves	0.0675	0.0675	0.024(1)
	#13	Tiled wood stoves and masonry heaters	0.0225	0.0225	0.024(1)
	#14	Mixed-fuel wood boilers	0.0216	0.0342	0.024(1)
	#15	Natural-draft wood boilers	0.009	0.009	0.024(1)
	#16	Forced-draft wood boilers	0.0009	0.0009	0.024(1)
Wood waste	#17	Wood chips boilers with conventional technology	0.0387	0.0387	0.012(1)
	#18	Wood chips boilers with oxygen sensor emission control	0.0216	0.0216	0.012(1)
	#19	Pellet stoves	0.009	0.009	0.012(1)
	#20	Pellet boilers	0.0009	0.0009	0.012(1)
Hard coal and hard coal briquettes	#21	Coal stoves	170.0	170.0	170.0(1)
	#22	Coal boilers	170.0	170.0	170.0(1)
Lignite and brown coal	#21	Coal stoves	170.0	170.0	170.0(1)
	#22	Coal boilers	170.0	170.0	170.0(1)
Brown coal briquettes	#21	Coal stoves	170.0	170.0	170.0(1)
	#22	Coal boilers	170.0	170.0	170.0(1)
Coke	#21	Coal stoves	170.0	170.0	170.0(1)
	#22	Coal boilers	170.0	170.0	170.0(1)
Peat	#21	Coal stoves	0.0675	0.0675	0.0675
	#22	Coal boilers	0.0342	0.0342	0.0342
Industrial waste	#22	Coal boilers	0.027	0.027	0.027
Charcoal	–		0.0675	0.0675	0.0675

(1)*Implied emission factor based on fuel-dependent implied PCB emission factor of NFR 1.A.4.a.i (alternatively from NFR 1.A.4.b.i, if there is no fuel consumption from NFR 1.A.4.a.i in particular inventory year)*

3.1.9.3.4 Emission Factors for PM (TSP, PM_{10}, $PM_{2.5}$)

1.A.4.a.i Commercial/Institutional: Stationary and 1.A.4.b.i Residential: Stationary

As already described in chapter 1.4 the emission inventories of PM for different years were prepared by contractors and incorporated into the inventory system afterwards (Winiwarter et al., 2001, 2007). For categories *1.A.4.a.i* and *1.A.4.b.i* additional PM emission factors were taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a), the Fact Sheet of the Swiss Federal Office for the Environment (FOEN, 2015), (German Environment Agency, 2008) and (Umweltbundesamt, 2006a) based on conlcusions from literature research (Umweltbundesamt, 2017b). This reflects the twenty-two technology and fuel dependent main sub categories (heating types). The shares of PM_{10} (90%) and $PM_{2.5}$ (80%) were also taken from (Winiwarter et al., 2001).

During the implementation of the energy demand model for space heating (see Methodology section above) assumptions were made on the emission factors of fuel wood consumption based on expert judgement:

- The former TSP emission factor for stoves of 148 g/TJ (Winiwarter et al. 2007) was assigned to *#12 Wood stoves and cooking stoves*.
- The PM emissions of *#13 Tiled wood stoves and masonry heaters* were considered to be lower than for *#12 Wood stoves and cooking stoves*. Subsequently the TSP emission factor for room wood stoves and tiled wood stoves of 100 g/TJ (FOEN, 2015) was chosen for *#13 Tiled wood stoves and masonry heaters*.
- The former TSP emission factor for central heating burning fuel wood of 55 g/TJ (Winiwarter et al. 2001) was considered not to be suitable for the comparatively poor combustion behaviour of *#14 Mixed fuel-wood boilers*. The upper range of TSP emissions was indicated by measurements of wood stoves at 148 g/TJ (Winiwarter et al., 2007). Thus, the TSP emission factor given in the EMEP/EEA Guidebook 2023, Table 3-43 (EEA, 2023a) (and its predecessor) for 'Conventional boilers < 50 kW' of 500 g/GJ was considered far too high even for *#14 Mixed fuel-wood boilers* at time of inventory preparation. To reflect this issue, the TSP emission factor given in the EMEP/EEA Guidebook 2023, Table 3-42 (EEA, 2023a) for 'Advanced / eco-labelled stoves and boilers' of 100 g/TJ was chosen but modified with additional +25% emissions by expert judgement for conventional equipment of *#14 Mixed fuel-wood boilers*.
- By expert judgement *#15 Natural-draft wood boilers* are expected to burn with less PM emissions than (advanced) *#14 Mixed fuel-wood boilers*. This decision made, a gradually lower TSP emission factor of 75 g/TJ was set at the lower limit of the 95% confidence interval from EMEP/EEA Guidebook 2023, Table 3-47 (EEA, 2023a) for 'Wood combustion <1MW - Manual Boilers' for *#15 Natural-draft wood boilers*. This reflects the filterable PM fraction only based on (Naturvårdsverket, undated) prior to adjustments of (Denier van der Gon et al., 2015).
- The emissions of *#16 Forced-draft wood boilers* were considered to be lower than for *#15 Natural-draft wood boilers*. Subsequently the TSP emission factor for log wood boilers of 50 g/TJ (FOEN, 2015) was chosen for *#16 Forced-draft wood boilers*.

Fuel consumption of *#14 Mixed fuel-wood boilers* was subdivided using additional information from (e7 Energie Markt Analyse GmbH 2017) (see section *Methodology* above) and corresponding TSP emission factors were assigned:

- The mixed-fuel wood boilers stock divides into appliances with (comparatively) advanced technology, which are considered with (slightly) lower PM emissions than conventional equipment. The TSP emission factor given in the EMEP/EEA Guidebook 2023, Table 3-42

(EEA, 2023a) for 'Advanced / ecolabelled stoves and boilers' of 100 g/TJ was chosen for advanced equipment of *#14 Mixed fuel-wood boilers*. This results in an implied emission factor based on PM emission factors of advanced and conventional mixed-fuel boilers stock (see Table 179) weighted with fuel consumption by subcategory of heating type (see Table 151).

3.1.9.3.4.1 Coverage of the combustion cycle

The PM emission factors used for inventory compilation for all heating types shall cover emissions during the start phase (ignition), the stationary phase (continuous) and end phase (ember) of the combustion cycle, to reflect the actual emission levels occurring during combustion. However, this is only fully transparent for *#12 Wood stoves and cooking stoves*, *#21 Coal stoves* and *#22 Coal boilers* and assumed for *#19 Pellet stoves*. For *#20 Pellet boilers* emission factors taken from (German Environment Agency, 2008) were determined by various operation modes weighted by proportion of final energy consumption. This includes full load and partially load cycles. The ignition phase is not discussed separately. Ember phase was assigned to partial load cases. It is assumed, that the emission factor covers the whole combustion cycle. Emission factors for heating types burning liquid and gaseous fuels covered by (Winiwarter et al. 2001) reflect the stationary phase of the combustion cycle. For further information on emission factors selected from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a) please refer to its referenced corresponding studies. There is no information available regarding the completeness of the combustion cycle covered by PM emission factor for any other heating type (see Table 182).

3.1.9.3.4.2 Measurement standards and user-related impact regarding PM emissions from biomass

The PM emission factors (for TSP, PM_{10} and $PM_{2.5}$) can represent the total primary PM emission (including filterable and condensable PM fraction), or the filterable PM fraction only depending on the sampling and measurement standards and equipment used. The methodologies vary in type and temperature of filtration media and can be split into dilution methods (including use of dilution tunnels or systems applying dilution after sampling) and direct sampling methods (EEA, 2023a). The user-related impact i.e. the use of wet/unclean wood or poor management of air circulation in the manually stoked stoves and boilers is crucial for real-life PM emissions. However, in many cases it remains unclear, whether the PM emission factor takes into account the user-related impact (and to what extent) and which measurement methods for biomass and solid fuels appliances were used.

- The study of (Winiwarter et al. 2007) quotes (Spitzer et al. 1998), which conducted field measurements of 29 wood stoves, 50 coal boilers and 22 coal stoves. The owners operated the appliances according to their habits. The duration of the measurement extended from heating up to the extinction of the fire (full combustion cycle). The PM measurements were taken at half-hourly intervals over the entire measurement period (gravimetric method). The measuring point was so close to the appliance, as was possible for technical and practical reasons. The amount of fuel used during the measurements was weighed and samples were taken to determine the moisture content using the drying cabinet method. The measurements were carried out in accordance with the standards of ÖNORM M5861-1. A high-temperature probe, Testo 0635-6045, and the handheld instrument Testo 0560-4910 were used for flow measurements. An ultrasonic bath, model T 310/H from ELMA - D 78224 Singen/Htw, was used. The emission factors represent the average PM emissions related to the fuel energy used as an annual average. Regarding the practices by users of biomass burning appliances, no systematical variation of user-related impact was taken into account. There is no further information on the measurement standard of emission factors taken from (Winiwarter et al. 2007) for *#12 Wood stoves and cooking stoves*, *#21 Coal stoves* and *#22 Coal boilers*.

- The fact sheet of (FOEN 2015) compiles emission factors for wood firing based on extensive literature research. Average values were adjusted for Swiss conditions. Automatic boilers usually show lower emissions in the end phase of the combustion cycle. Manually stoked wood furnaces show significantly higher emission factors because of the start phase and end phase of the combustion cycle. There is no further information on the measurement standard or about the practices by users of biomass burning appliances in emission factors taken from (FOEN 2015) for *#13 Tiled wood stoves and masonry heaters*, *#16 Forced-draft wood boilers* and *#17 Wood chips boilers with conventional technology*.
- The study of (Johansson et al., 2003) as cited in (EEA, 2023a) investigated the combustion behaviour and fluctuations in fuel quality. The measurements started after the ignition of a second batch of wood and continued until the final stage of the end phase (ember). Operation with one single large wood load (unattended prolonged combustion) and manually adding several small wood loads during daytime were compared in wood heating appliances with and without usage of buffer storage tanks. The particle number concentration and the size distribution were measured in hot diluted hot flue gas with an Electrical Low-Pressure Impactor (ELPI, Dekati Ltd.), while the mass size distribution was measured with a Dekati Low-Pressure Impactor (DLPI, Dekati Ltd.), both calibrated by the manufacturer. The total mass of particulate emissions was determined gravimetrically according to the Swedish standard method SS028426 from 1991. For further information on measurements method and consideration of the user-related impact in TSP emission factors for *#14 Mixed-fuel wood boilers* and *#15 Natural-draft wood boilers* selected from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a), please refer to its referenced corresponding studies.
- The study of (Winiwarter et al. 2007) by expert judgement sets the TSP emission factor for 'old' boilers at 55 g/GJ and for 'new' wood combustion equipment (year of installation from 1996 and later) at 30 g/GJ. This is because of stronger legislation for mandatory PM gravimetrical measurements (on the test bench) to enter the heating systems market (Artikel 15a B-VG, 1995). However, according to (Winiwarter et al. 2007), this value is high in comparison with the potential of pellet heating systems at test bench measurements at least suggesting, that the full combustion cycle was considered. On the other hand, the TSP emission factor given in the EMEP/EEA Guidebook 2023 (and its predecessor), Table 3-44 (EEA, 2023a) for 'Pellet stoves and boilers' of 31 g/GJ at the lower limit of the 95% confidence interval was about at the same level (solid particles only). Regarding the practices by users of biomass burning appliances, no systematical variation of user-related impact was taken into account. There is no further information on the measurement standard of emission factors taken from (Winiwarter et al. 2007) for *#18 Wood chips boilers with oxygen sensor emission control and masonry heaters* and *#19 Pellet stoves*.
- The study of (German Environment Agency 2008) considers 42% partial load and 58% full load to take into account the mode of operation in the calculation of TSP emission factors for pellet boilers. There is no further information on the measurement standard for the TSP emission factor chosen for *#20 Pellet boilers*.

The PM emission estimates for categories *1.A.4.a.i* and *1.A.4.b.i* in general do not provide information whether the condensable component is included or excluded. Only a few emission factors explicitly include or exclude the condensable fraction (see also chapter 12.3).

<u>1.A.4.c.i Agriculture/Forestry/Fishing: stationary</u>

All emission factors are derived from category *1.A.4.a.i* assuming similar structure of heating types in both categories (implied emission factors). Those values given in the following table are averaged values per fuel category. Supplemental implied emission factors derived from category *1.A.4.b.i* were assigned, if no activity data for the specific fuel in category *1.A.4.a.i* occurred.

The PM emission estimates for category *1.A.4.c.i* in general do not provide information whether the condensable component is included or excluded. Only a few emission factors explicitly include or exclude the condensable fraction (see also chapter 12.3).

3.1.9.3.4.3 PM Emission Factors

Table 178: NFR 1.A.4. PM emission factors with information on coverage of condensables and combustion cycle for the year 2022.

NFR					1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant						**PM**	
Fuel	**No.**	**Heating type**	**Condensables**	**Combustion cycle**		**[kg/TJ]**	
Light fuel oil	#1	Fuel oil boilers	Unclear(1)	(EEA, 2023a)(2)	6.67	6.67	6.67
Medium fuel oil	#1	Fuel oil boilers	Unclear(3)	Stationary phase	35.0	35.0	35.0
Heavy fuel oil	#1	Fuel oil boilers	Unclear(3)	Stationary phase	65.0	65.0	65.0
Diesel	#1	Fuel oil boilers	Unclear(4)	Unclear	50.0	50.0	50.0
Petroleum	#1	Fuel oil boilers	Unclear(1)	(EEA, 2023a)(2)	6.67	6.67	6.67
Other petroleum products	#1	Fuel oil boilers	Unclear(3)	Stationary phase	0.5	0.5	0.5
Gas oil	#2	Gas oil stoves	Unclear(3)	Stationary phase	3.0	3.0	2.09(4)
	#3	Vapourizing burners	Unclear(3)	Stationary phase	3.0	3.0	2.09(4)
	#4	Yellow burners	Unclear(3)	Stationary phase	3.0	3.0	2.09(4)
	#5	Blue burners with conventional technology	Excluded(6)	(EEA, 2023a)(2)	2.0	2.0	2.09(4)
	#6	Blue burners with low temperature or condensing technology	Excluded(7)	(EEA, 2023a)(2)	1.5	1.5	2.09(4)
Natural gas	#7	Natural gas convectors	Excluded(8)	(EEA, 2023a)(2)	2.2	2.2	0.58(5)
	#8	Atmospheric burners	Unclear(3)	Stationary phase	0.5	0.5	0.58(5)
	#9	Forced-draft natural gas burners	Unclear(9)	(EEA, 2023a)(2)	0.2	0.2	0.58(5)
	#8	Atmospheric burners	Unclear(3)	Stationary phase	0.5	0.5	0.5

NFR					1.A.4.a.i	1.A.4.b.i	1.A.4.c.i
Pollutant						**PM**	
Fuel	**No.**	**Heating type**	**Condensa-bles**	**Combustion cycle**		**[kg/TJ]**	
Biogas, sewage sludge gas and landfill gas	#9	Forced-draft natural gas burners	Unclear(9)	(EEA, 2023a)(2)	0.2	0.2	0.2
Liquefied petro-leum gases	#10	LPG stoves	Unclear(10)	(EEA, 2023a)(2)	2.2	2.2	1.42(5)
	#11	LPG boilers	Unclear(3)	Stationary phase	0.5	0.5	1.42(5)
Fuel wood	#12	Wood stoves and cooking stoves	Excluded(11)	Full cycle	148.0	148.0	101.71(5)
	#13	Tiled wood stoves and masonry heaters	Unclear(12)	Unclear	100.0	100.0	101.71(5)
	#14	Mixed-fuel wood boilers	Included13)	(EEA, 2023a)(2)	121.03(13)	121.76(13)	101.71(5)
	#15	Natural-draft wood boil-ers	Excluded(15)	(EEA, 2023a)(2)	75.0	75.0	101.71(5)
	#16	Forced-draft wood boil-ers	Unclear(16)	Unclear	50.0	50.0	101.71(5)
Wood waste	#17	Wood chips boilers with conventional tech-nology	Unclear(17)	Unclear	100.0	100.0	38.26(5)
	#18	Wood chips boilers with oxygen sensor emis-sion control	Unclear(11)	Unclear	55.0	55.0	38.26(5)
	#19	Pellet stoves	Unclear(11)	Full cycle	30.0	30.0	38.26(5)
	#20	Pellet boilers	Unclear(18)	Full cycle(19)	19.0	19.0	38.26(5)
Hard coal and hard coal bri-quettes	#21	Coal stoves	Excluded(11)	Full cycle	153.0	153.0	118.40(5)
	#22	Coal boilers	Unclear, Ex-cluded(11)	Full cycle	45.0	94.0	118.40(5)
Lignite and brown coal	#21	Coal stoves	Excluded(11)	Full cycle	153.0	153.0	118.40(5)
	#22	Coal boilers	Unclear, Ex-cluded(11)	Full cycle	50.0	94.0	118.40(5)
Brown coal bri-quettes	#21	Coal stoves	Excluded(11)	Full cycle	153.0	153.0	118.40(5)
	#22	Coal boilers	Unclear, Ex-cluded(11)	Full cycle	50.0	94.0	118.40(5)
Coke	#21	Coal stoves	Excluded(11)	Full cycle	153.0	153.0	118.40(5)
	#22	Coal boilers	Unclear, Ex-cluded(11)	Full cycle	45.0	94.0	118.40(5)
Peat	#21	Coal stoves	Unclear(3)	Full cycle	55.0	55.0	55.0
	#22	Coal boilers	Unclear(3)	Full cycle	55.0	55.0	55.0
Industrial waste	#22	Coal boilers	Unclear(3)	Full cycle	55.0	55.0	55.0
Charcoal	–		Excluded(11)	Full cycle	148.0	148.0	148.0

(1) *TSP from EMEP/EEA Guidebook 2023 (EEA, 2023a), Table 3-24 Tier 2 emission factors for non-residential sources, medium-sized (> 50 kW_{th} to ≤ 1 MW_{th}) boilers liquid fuels (upper value of 95% confidence interval for PM_{10} of 6 kg/TJ converted into TSP)*

(2) *For further information on TSP emission factors selected from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023 (EEA, 2023a), please refer to its referenced corresponding studies.*

(3) *TSP from (Winiwarter et al., 2001)*

(4) *TSP selected for diesel similar to locomotive diesel engines*

(5) *Implied emission factor based on fuel-dependent implied PM emission factor of NFR 1.A.4.a.i (alternatively from NFR 1.A.4.b.i, if there is no fuel consumption from NFR 1.A.4.a.i in particular inventory year)*

(6) TSP from EMEP/EEA Guidebook 2023 (EEA, 2023a), Table 3-18 Tier 2 emission factors for source category 1.A.4.b.i, boilers burning liquid fuels (upper value of 95% confidence interval for TSP)

(7) TSP from EMEP/EEA Guidebook 2023 (EEA, 2023a), Table 3-18 Tier 2 emission factors for source category 1.A.4.b.i, boilers burning liquid fuels (value for TSP)

(8) TSP from EMEP/EEA Guidebook 2023 (EEA, 2023a), Table 3-13 Tier 2 emission factors for source category 1.A.4.b.i, fireplaces burning natural gas (value for TSP)

(9) TSP from EMEP/EEA Guidebook 2023 (EEA, 2023a), Table 3-16 Tier 2 emission factors for source category 1.A.4.b.i, boilers burning natural gas (value for TSP)

(10) TSP from EMEP/EEA Guidebook 2023 (EEA, 2023a), Table 3-17 Tier 2 emission factors for source category 1.A.4.b.i, stoves burning liquid fuels (value for TSP)

(11) TSP from (Winiwarter et al., 2007). The authors endeavoured to target the whole PM emissions, i.e. after the initial reactions and after a possible dilution. The cited study of (Spitzer et al., 1998) states that the measuring point was as close to the appliance as possible for technical and practical reasons, indicating PM measurements in hot flue gas. Thus, the emission factors for #12 Wood stoves and cooking stoves, #21 Coal stoves, #22 Coal boilers (NFR 1.A.4.b.i only) and Charcoal represent filterable PM emissions. However, it remains unclear, whether the other TSP emission factors from (Winiwarter et al., 2007) represent filterable PM or total PM (filterable and condensable) emissions.

(12) TSP from (FOEN, 2015), room wood stoves and tiled wood stoves (value for TSP)

(13) TSP from EMEP/EEA Guidebook 2023 (EEA, 2023a), Table 3-42 Tier 2 emission factors for source category 1.A.4.b.i, advanced / ecolabelled stoves and boilers burning wood (value for TSP of 100 kg/TJ was selected for advanced mixed-fuel boiler stock and expert judgment of +25% higher emissions as expert judgment were assumed for conventional mixed-fuel wood boiler stock)

(14) Implied emission factor based on PM emission factors of advanced and conventional mixed-fuel boilers stock (see Table 179) weighted with fuel consumption by subcategory of heating type (see Table 151)

(15) TSP from EMEP/EEA Guidebook 2023 (EEA, 2023a), Table 3-47 Tier 2 emission factors for non-residential sources, manual boilers burning wood (lower value of 95% confidence interval for TSP of 75 kg/TJ with filterable PM fraction only based on (Naturvårdsverket, undated) prior to adjustments of (Denier van der Gon et al., 2015)

(16) TSP from (FOEN, 2015), log wood boiler (value for TSP)

(17) TSP from (FOEN, 2015), automatic boilers burning wood (value for TSP)

(18) TSP from (German Environment Agency, 2008), Annex A Device-related emission factors, boiler for pellets (derived from assumption of 60% share of 'Pellet boilers 4-25 kW nominal load' with TSP emission factor of 23 g/GJ and 40% share of 'Pellet boilers >25-50 kW nominal load' with TSP emission factor of 13 g/GJ)

(19) TSP from (German Environment Agency, 2008) was determined by various operation modes weighted by proportion of final energy consumption. This includes full load and partially load cycles. The ignition phase is not discussed separately. Ember phase was assigned to partial load cases. It is assumed, that the emission factor assigned to #20 Pellet Boilers covers the whole combustion cycle.

The following table shows PM emission factors for advanced and conventional mixed-fuel boilers taken from (EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023) (EEA, 2023a).

Table 179: PM emission factors of category 1.A.4 for advanced and conventional mixed-fuel boilers.

Pollutant			**PM**	
NFR			**1.A.4.a.i**	**1.A.4.b.i**
Fuel	**No.**	**Heating type (subcategory)**	**[kg/TJ]**	
Fuel wood	#14	Mixed-fuel wood boilers (advanced)(1)	100.0	100.0
		Mixed-fuel wood boilers (conventional)(1)	125.0	125.0

(1)*TSP from EMEP/EEA Guidebook 2023 (EEA, 2023a), Table 3-42 Tier 2 emission factors for source category 1.A.4.b.i, advanced / ecolabelled stoves and boilers burning wood (value for TSP of 100 kg/TJ was selected for advanced mixed-fuel boiler stock and +25% higher emissions as expert judgment were assumed for conventional mixed-fuel wood boiler stock)*

3.1.9.4 Other sources of PM emissions

For the following sources it is assumed that particle sizes are equal or smaller than $PM_{2.5}$.

Barbecue

For activity data 11 kt of charcoal has been calculated (Winiwarter et al., 2007) from foreign trade statistics and production data (Import 11 900 t, Export 1 900 t, Production 1 000 t). An emission factor of 2 237 g TSP/GJ charcoal has been selected which is 69 347 g/t charcoal assuming a calorific value of 31 GJ/t. This leads to 763 t PM/year for the whole time series. It has to be noted that, for reasons of time series consistency, constant activity data has been selected for the whole time series which is slightly different to actual energy statistics. However, because of the relatively high uncertainty of energy statistics regarding the trend in charcoal consumption (validation not possible at current) and the high uncertainty of PM estimates from this source it has been chosen to keep this approach.

Bonfire

It is assumed that one bonfire is sparked every year for each 5 000 rural inhabitants. This leads to 1 000 bonfires each year for all 5 Mio rural inhabitants. The average size of a fire is estimated to have 30 m³ of wood which is 10 m³ of solid wood. Assuming a heating value of 10 GJ/m³ wood and selecting an emission factor of 1 500 g/GJ (similar to open fire places, expert guess from literature) this leads to 150 kg PM for each fire and 150 t PM for each year.

Open fire pits

It is assumed that one open fire pit exists for each 2 500 inhabitants. Assuming 20 fires per year and fire pit this leads to 66 400 fires each year. Assuming 0.025 m³ of solid wood per fire which is 0.3 GJ and selecting an emission factor of 800 g/GJ (open fireplace) (EPA, 1999, Klimont et al., 2002) this leads to 240 g PM/fire and 16 t PM for each year.

3.1.9.5 Category-specific Recalculations

Updates of activity data and of NCVs follow the updates of the IEA-compliant energy balance compiled by the federal statistics authority *Statistik Austria* taken from (IEA JQ, 2023) and (Statistik Austria, 2023a) (for further details see section *Methodology* above).

1.A.4.a.i Commercial/Institutional: Stationary and 1.A.4.b.i Residential: Stationary

For 1990 to 2021, minor changes in air pollutant emissions are reported due to updated heating stock data and newly allocated energy shares of combustion technologies per energy carrier (updated energy demand model for space heating).

In particular, the following shares with an effect on certain implied emission factors have been revised:

- Share of new blue burners with low temperature or condensing technology stock 2001–2021 (NO_x) (see Table 148)
- Share of new forced-draft natural gas burners stock (NO_x) 2001–2021 (see Table 149)
- Share of new and conventional wood stoves and cooking stoves stock 2001–2021 (NMVOC, CH_4, CO and HCB) (see Table 150)

- Share of advanced and conventional mixed-fuel wood boilers stock 1990–2021 (NO_x, NMVOC, CH_4, CO, PM, PM_{10}, $PM_{2.5}$) and 2001–2021 (HCB) (see Table 151)

For further information on activity data and emission factors, see chapters 3.1.9.2 and 3.1.9.3 above.

1.A.4.c.i Agriculture/Forestry/Fishing: stationary

As far as implied emission factors derived from for categories *1.A.4.a.i* and *1.A.4.b.i* are concerned, the minor recalculations of categories *1.A.4.a.i* and *1.A.4.b.i* also effect category *1.A.4.c.i*.

3.1.9.6 Planned improvements

In order to improve the inventory on accurate heating type information it is planned to award a service-contract for an updated market survey of heating type stock, age distribution, final energy demand and type of heating use by NFR category. In order to determine the user-related impact on emissions from biomass (and coal), it is envisaged to collect data on national conditions within a household survey. It is planned to implement both survey results into the inventory of submission 2025.

Further investigation for all PM biomass (and coal) emission factors under consideration of total PM (filterable and condensable fraction) is planned to improve the inventory. This goes along with ensuring that the whole combustion cycle (including start and end phase) is included in PM emission factors. For overall transparency, more information on the sampling and measurement standards and/or equipment used will be collected. It is planned to implement the results into the inventory of submission 2025.

Further investigation on the sulphur content of filtered biogenic gas injected into the gas distribution net is planned in order to estimate SO_2 emissions. In addition, estimates of heavy metals emissions of other petroleum products will be included in the inventory of submission 2025.

3.2 NFR 1.A Mobile Fuel Combustion Activities

3.2.1 General description

In this chapter the methodology for estimating emissions of mobile sources in NFR *1.A.3,* transport and NRMM (Non-Road Mobile Machinery) of NFR *1.A.2.g*, NFR *1.A.4* and NFR *1.A.5*, is described.

NFR Category *1.A.3 Transport* comprises emissions from fuel combustion, gasoline evaporation, road abrasion, tyre and brake wear of road transport as well as abrasion and dust dispersion of railways.

Table 180: NFR and SNAP categories of 1.A Mobile Fuel Combustion Activities.

Activity	NFR Category	SNAP
NFR 1.A.2 Manufacturing Industry and Combustion		
Industry, Mobile Machinery	**NFR 1.A.2.g.7**	
		0808 Other Mobile Sources and Machinery-Industry
NFR 1.A.3 Transport		
Civil Aviation	**NFR 1.A.3.a**	
• Civil Aviation	NFR 1.A.3.a	0805
• Civil Aviation (Domestic, LTO)	NFR 1.A.3.a.2	080501 Domestic airport traffic (LTO cycles < 1 000 m)
International Aviation (LTO)	NFR 1.A.3.a.1	080502 International airport traffic (LTO cycles < 1 000 m)
Road Transportation	**NFR 1.A.3.b**	
• R.T., Passenger cars	NFR 1.A.3.b.1	0701_ Passenger cars
• R.T., Light duty vehicles	NFR 1.A.3.b.2	0702 Light duty vehicles < 3.5 t
• R.T., Heavy duty vehicles	NFR 1.A.3.b.3	0703 Heavy duty vehicles > 3.5 t and buses
• R.T., Mopeds & Motorcycles	NFR 1.A.3.b.4	0704 Mopeds and Motorcycles < 50 cm³
		0705 Motorcycles > 50 cm³
• Gasoline evaporation from vehicles	NFR 1.A.3.b.5	0706 Gasoline evaporation from vehicles
• Automobile tyre and brake wear	NFR 1.A.3.b.6	0707 Automobile tyre and brake wear
• Automobile road abrasion	NFR 1.A.3.b.7	0707 Automobile road abrasion
Railways	**NFR 1.A.3.c**	0802 Other Mobile Sources and Machinery-Railways
Navigation	**NFR 1.A.3.d**	0803 Other Mobile Sources and Machinery-Inland waterways
		0804 Other Mobile Sources and Machinery-Maritime activities
Other transportation	**NFR 1.A.3.e**	
	NFR 1.A.3.e.1	0810 Pipelines compressors and other transportation
	NFR 1.A.3.e.2	0810 Airport Ground Activities
NFR 1.A.4 Other Sectors		
• Residential	1.A.4.b.2	0809 Other Mobile Sources and Machinery-Household and gardening
• Agriculture/ Forestry/ Fisheries	1.A.4.c.2	0806 Other Mobile Sources and Machinery-Agriculture
		0807 Other Mobile Sources and Machinery-Forestry
NFR 1.A.5 Other		
	1.A.5.b	0801_Other Mobile Sources and Machinery-Military
Memo Items		
Civil Aviation (Domestic, cruise)	Mem 1.A.3.a.2	080503 Domestic cruise traffic (> 1 000 m)
International aviation (cruise)	Mem 1.A.3.a.1	080504 International cruise traffic (> 1 000 m)

3.2.1.1 Completeness

Table 181 provides information on the status of emission estimates of all sub categories. A "✓" indicates that emissions from this sub category have been estimated. Table 180 provides an overview about NFR categories and the corresponding SNAP codes.

Table 181: Completeness of 1.A Mobile Fuel Combustion Activities.

NFR Category		NO_x	CO	NMVOC	SO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$	Pb	Cd	Hg	DIOX	PAH	HCB	PCB
1.A.2.g.7	Industry, Mobile Machinery	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.3.a	Civil Aviation – LTO	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	NE	NE	NE	NE
1.A.3.b	Road Transportation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.3.c	Railways	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.3.d	Navigation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.3.e.2	Other transportation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.4.b.2	Residential: Household and gardening (mobile)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.4.c.2	Agriculture/ Forestry/Fishing: Off-road Vehicles and Other Machinery	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.A.5.b	Other, Mobile (Including military)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mem.1.A.3.a. Civil Aviation – Cruise		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	NE	NE	NE	NE
Mem.1.A.3.d International maritime Navigation		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

3.2.2 Key Categories

Key category analysis is presented in Chapter 1.5. This chapter includes information on the transport sector. Key sources within this category are presented in Table 182.

Table 182: Key sources of sector Transport.

NFR Category	Category Name	Key Categories	
		pollutant	KS Assessment
1.A.2.g.7	Industry, Mobile Machinery	NO_x 2)	LA
1.A.3.b.1	R.T., Passenger cars	NO_x, NMVOC1), CO, Pb1), TSP1), PM_{10} 1), $PM_{2.5}$	LA, TA
1.A.3.b.2	R.T., Light duty vehicles	NO_x 2), TSP1), PM_{10} 1), $PM_{2.5}$ 1)	LA, TA
1.A.3.b.3	R.T., Heavy duty vehicles	SO_2 1),NO_x, TSP1), PM_{10} 1), $PM_{2.5}$ 1)	LA, TA
1.A.3.b.5	R.T., Gasoline evaporation	NMVOC1)	TA
1.A.3.b.6	R.T., Automobile tyre and break wear	Pb2), TSP, PM_{10}, $PM_{2.5}$	LA, TA
1.A.3.b.7	R.T., Automobile road abrasion	TSP, PM_{10}, $PM_{2.5}$ 2)	LA, TA
1.A.3.c	Railways	TSP2), PM_{10} 2)	LA

LA = Level Assessment 2022

TA = Trend Assessment 1990–2022

Note: 1)only TA, 2)only LA

3.2.3 Uncertainty Assessment

The following chapter provides a quantitative estimate of uncertainties with respect to NO_x, NH_3, NMVOC, SO_2 and $PM_{2.5}$ emissions from Mobile Fuel Combustion Activities. In general, the method applied for the assessment of uncertainty is according to the EMEP/EEA Guidebook 2019 (EEA, 2019). For estimating the uncertainty of the emission factors of NMVOC, $PM_{2.5}$ and NH_3 for sector *1.A.3.b. Road Transport*, experts from TU Graz were consulted.

Table 183: Uncertainties for activity data, emission factors and combined uncertainties.

Sector	Pollutant	Uncertainty Activity Data [%]	Uncertainty Emission Factor [%]	Combined uncertainties [%]
1.A.3.a Civil Aviation – LTO	SO_2	3.0	20.0	20.22
	NO_x	3.0	40.0	40.11
	NMVOC	3.0	40.0	40.11
	NH_3	3.0	125.0	125.04
	$PM_{2.5}$	3.0	40.0	40.11
1.A.3.b Road Transportation	SO_2	3.1	20.0	20.24
	NO_x	3.1	40.0	40.12
	NMVOC	3.1	125.0	125.04
	NH_3	3.1	200.0	200.02
	$PM_{2.5}$	3.1	125.0	125.04
1.A.3.c Railways	SO_2	3.0	20.0	20.22
	NO_x	3.0	40.0	40.11
	NMVOC	3.0	40.0	40.11
	NH_3	3.0	125.0	125.04
	$PM_{2.5}$	3.0	40.0	40.11

Sector	Pollutant	Uncertainty Activity Data [%]	Uncertainty Emission Factor [%]	Combined uncertainties [%]
1.A.3.d Navigation	SO_2	3.0	20.0	20.22
	NO_x	3.0	40.0	40.11
	NMVOC	3.0	40.0	40.11
	NH_3	3.0	125.0	125.04
	$PM_{2.5}$	3.0	40.0	40.11
1.A.3.e Other transportation	SO_2	1.0	125.0	125.00
	NO_x	1.0	10.0	10.05
	NMVOC	1.0	200.0	200.00
	NH_3	1.0	750.0	750.00
	$PM_{2.5}$	1.0	125.0	125.00

3.2.4 NFR 1.A.3.a Civil Aviation – LTO

The category *1.A.3.a Civil Aviation-LTO* covers LTO cycles (landing/take-off) for domestic and international aviation.

For methodological reason it is distinguished between flights according to

- Visual Flight Rules (VFR) which include all flights using aviation gasoline
- Instrumental Flight Rules (IFR) which cover all flights using kerosene

Domestic cruise and international cruise is considered under Memo Item 1.A.3.a Civil Aviation – Cruise. Military Aviation is allocated to 1.A.5 Other.

Methodological Issues

IFR – Instrument Flight Rules

Until the submission 2020 Austria has used two different methodologies for calculating emissions of IFR flights:

- Tier 3B: For the years 1990–1999 a country-specific methodology was applied. The calculations were based on a study commissioned by the Umweltbundesamt finished in 2002 (Kalivoda & Kudrna, 2002). This methodology was consistent with the very detailed IPCC 2006 GL Tier 3B methodology (advanced version based on the MEET model (Kalivoda & Kudrna, 1997). For emission calculation air traffic movement data[86] (flight distance and destination per aircraft type) and aircraft/engine performances data were used.
- Tier 3A: For the years from 2000 onwards the IPCC 2006 GL Tier 3A methodology has been applied. Tier 3A takes into account average fuel consumption and emission data for LTO phases and various flight lengths, for an array of representative aircraft categories.

Based on a recommendation of the 2020 UNFCCC inventory review, Austria improved time series consistency by using the Tier 3A methodology as described above for the years from 2000 onwards and a trend extrapolation (as described in the IPCC 2006 GL volume 1 chapter 5.3.3) for 1990-1999.

[86] This data is also used for the split between domestic and international aviation.

Due to the lack of consistent data Austria was not able to use overlap or surrogate techniques. While the total amount of kerosene used in each year during the period 1990-1999 and the corresponding total emissions are out of question (Kalivoda & Kudrna, 2002), it was necessary for the trend extrapolation to determine the yearly ratios of kerosene used for domestic LTO, domestic cruise, international LTO and international cruise based on average shares of kerosene consumption over the three years of 2000, 2001 and 2002. As a result four fixed average ratios were used for determing the new kerosene consumption and emissions for the years 1990-1999 for domestic LTO and domestic cruise as well as international LTO and international cruise.

VFR – Visual Flight Rules

The EMEP/EEA 2019 simple methodology (Tier 1, fuel-based methodology) is applied.

Activity Data

IFR flights

For details of fuel consumption in the years 1990–1999 please refer to **'Methodological Issues'** above.

For the years from 2000 onwards fuel consumption for the different transport modes IFR domestic LTO, IFR international LTO, IFR domestic cruise and IFR international cruise was calculated according to the IPCC 2006 GL Tier 3A method, with average consumption data per aircraft types and flight distances. The fuel consumption of IFR international cruise is adjusted as explained below.

IFR flight movements are taken from Austro Control (Austro Control, 2023), fuel consumption data from the national energy balance (Statistik Austria, 2023a).

Bottom up Methodology – fuel consumed

Based on the number of flight movements per aircraft type and airport (national and international) departing Austria, the distances for each airport pair and the specific fuel consumption per aircraft type and distance class, FC (kerosene) and emissions are calculated bottom up.

For the inventory years 2000–2015 flight movements were obtained from special analyses by Statistik Austria (Statistik Austria, 2008[87], 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016). In addition, domestic flight movements were compared with a second data source for flight movements, Austro Control (Austro Control, 2007[88], 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016) and increased to meet these number of flight movements. Distances between airport pairs have been extracted based on IATA codes from single queries on the internet.[89]

Beginning with the inventory year 2016 flight movements have only been taken from Austro Control (AUSTRO CONTROL 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023) as they seem to be more representative compared with international data. Since then, distances between departure and arrival aerodrome have been calculated by an automatic distance generator using the following formula:

[87] for the years 2000–2007

[88] for the years 2000–2006

[89] www.world-airport-codes.com

$$D = r * \arccos(\sin(\pi*\varphi(A)/180) * \sin(\pi*\varphi(B)/180) * \cos(\pi*\varphi(A)/180) * \cos(\pi*\varphi(B)/180) * \cos(\pi*(\lambda(A)-\lambda(B))/180))$$

D ..Distance between aerodromes
r …Average radius of the earth (6371 km)
φ(A).. Geographical latitude of departure aerodrome A
φ(B).. Geographical latitude of arrival aerodrome B
λ(A).. Geographical longitude of departure aerodrome A
λ(B).. Geographical longitude of arrival aerodrome B

Therefore, *e*ach aerodrome being reported in the flight movements needs to be integrated in the calculation model with its geographical degree of latitude and longitude.

Top down Methodology – fuel sold

The calculated bottom up result for total kerosene consumption is being compared to the total fuel sold reported by the national energy balance:

- For the inventory years 2000–2015 the delta was fully allocated to international cruise, as the domestic flight movements had already been increased in line with Austrocontrol.
- Beginning with the inventory year 2016 any delta between the bottom up result and the official amount of kerosene sold has been allocated to domestic LTO, international LTO, national cruise and international cruise depending on their relative shares in total kerosene consumption.

The following table shows the fuel consumption for national and international LTO cycles and the numbers of international LTO (IFR).

Table 184: Fuel consumption and number for domestic and international LTO cycles: 1990–2022.

Year	Activity		
	Dom. LTO (IFR) Kerosene [kt]	**Dom. Cruise (IFR) Kerosene [kt]**	**Dom. LTO (IFR) [no. of flights]**
1990	2.94	6.75	-
1995	4.45	10.23	-
2000	6.11	13.18	22 611
2005	5.20	13.19	20 179
2010	6.16	11.07	20 532
2011	5.32	9.89	16 185
2012	5.37	9.43	16 405
2013	5.35	9.36	15 741
2014	4.87	8.56	14 776
2015	4.73	8.43	13 282
2016	4.70	7.15	15 515
2017	4.37	6.76	14 781
2018	5.11	7.24	19 735
2019	5.22	7.25	19 679
2020	2.45	3.13	14 196
2021	2.54	3.06	12 917
2022	3.30	4.40	13 294
1990–2022	**12%**	**-35%**	**-41%**[90]
2021–2022	**-15%**	**30%**	**60%**

VFR flights

Fuel consumption for VFR flights were directly obtained from the national energy balance, as total fuel consumption for this flight mode is represented by the total amount of aviation gasoline sold in Austria.

Table 185: Fuel consumption for VFR flights: 1990–2022.

Year	Activity
	Dom. LTO (VFR) Gasoline [kt]
1990	2.49
1995	2.24
2000	2.04
2005	2.79
2010	2.92
2011	4.40
2012	2.54
2013	2.61
2014	2.38
2015	2.65
2016	3.28
2017	2.39
2018	2.30
2019	2.20

[90] Trend 2000 - onwards

Year	Activity
	Dom. LTO (VFR) Gasoline [kt]
2020	1.83
2021	2.03
2022	1.73
1990–2022	**-30%**
2012–2022	**-15%**

Emission Factors

IFR flights

For details of emissions calculation for the years 1990–1999 please refer to '**Methodological Issues**' above.

The EFs from the old CORINAIR Guidebook (CORINAIR, 1997) have been used for the years 2000–2015 and will not be changed any more as they represent the state of the art of aircrafts for those years. In contrast to road transport, where EFs are differentiated by age and technology of the vehicle, this is not the case in aviation.

From the year 2016 onwards specific fuel consumption and emission factors per distance class were taken from the spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2019' – Annex 5 (EEA, 2019) for a huge number of aircraft types.

As in reality there are always flight movements with aircrafts which are not listed in the spreadsheet, an allocation of unknown aircrafts to listed aircrafts in the spreadsheet has to be undertaken based on research about engine type, number of engines, production series etc. If the unknown aircraft cannot be allocated, it is being labelled as UNKNOWN. The specific fuel consumption and emission factors are separately calculated on the basis of the national and international LTO and cruise averages of each year. This means the calculation distinguishes between:

- Unknown aircraft type for national flights – LTO
- Unknown aircraft type for national flights – cruise
- Unknown aircraft type for international flights – LTO
- Unknown aircraft type for international flights – cruise

For $LTO_{unknown}$ the equation is:

$$FC/LTO = \text{Sum } FC\_LTO_{unknown} / \text{Sum flights movements}_{unknown}$$

For $Cruise_{unknown}$ the equation is:

$$FC/km = (\text{Sum } FC\_cruise_{unknown} / \text{sum nm cruise}_{unknown}) * 125$$

125 nm (nautical miles) is the shortest distance class. For the other distance classes >125 nm the values are being extrapolated.

SO_2

For details of emissions calculation for the years 1990–1999 please refer to '**Methodological Issues**' above.

For the years 2000–2015 SO_2 emissions have been calculated with an EF from the CORINAIR Guidebook (CORINAIR, 1997) (1kg/t fuel for LTO and cruise).

For the years from 2016 onwards EFs from Annex 5 of the EMEP/EEA 2019 Guidebook (EEA, 2019) per aircraft type and distance class are applied.

NO_x, CO

For details emissions calculation for the years 1990–1999 please refer to '**Methodological Issues**' above.

For the years 2000–2015 EFs from CORINAIR Tier 3A were applied. Tier 3A takes into account average fuel consumption and emission data for LTO phases and various flight lengths, for an array of representative aircraft categories.

For the years from 2016 onwards EFs from Annex 5 of the EMEP/EEA 2019 Guidebook (EEA, 2019) per aircraft type and distance class are applied.

NMVOC

For details emissions calculation for the years 1990–1999 please refer to '**Methodological Issues**' above.

For the years 2000–2015 NMVOC emissions for IFR flights have been calculated in this way: Total VOC_HC emissions have been calculated with the implied emission factor for the year 1999 as obtained from the national aviation study (Kalivoda & Kudrna, 2002) and deducted by CH_4 emissions.

For the years from 2016 onwards EFs from Annex 5 of the EMEP/EEA 2019 Guidebook (EEA, 2019) per aircraft type and distance class are applied and deducted by CH_4 emissions to estimate NMVOC emissions.

NH_3

For details emissions calculation for the years 1990–1999 please refer to '**Methodological Issues**' above.

For the years from 2000 onwards NH_3 emissions for IFR flights have been calculated with an IEF from the year 2000 obtained from the study mentioned above (Kalivoda & Kudrna, 2002).

No NH_3 EFs are included in Annex 5 of the EMEP/EEA 2019 Guidebook (EEA, 2019) per aircraft type and distance class.

$PM_{2.5}$

$PM_{2.5}$ emissions for kerosene (25g/GJ) have been taken from (Winniwarter/Trenker & Höflinger, 2001).

VFR flights

For the years 1990–1999 emission estimates were taken from the national aviation study (Kalivoda & Kudrna, 2002).

For the years from 2000 onwards SO_2, NO_x, NMVOC and CO emissions of VFR flights have been calculated with the EFs provided in the EMEP/EEA 2019 Guidebook (EEA, 2019) (Tier 1). $PM_{2.5}$ emissions for aviation gasoline (3.5g/GJ) have been taken from (Winniwarter/Trenker & Höflinger, 2001). NH_3

and VOC_HC emissions are still being calculated with the IEFs of the year 2000 taken from (Kalivoda & Kudrna, 2002).

Table 186: Tier 1 EF according to the EMEP/EEA GB (2019).

EFs (EMEP/EEA 2019, Tier 1)	
	[kg/t fuel]
SO_x	1.0
NO_x	4.0
NMVOC	19.0
CO	1200.0

Table 187: IEF for the year 2000 according to Kalivoda & Kudrna (2002).

IEF (KALIVODA & KUDRNA 2002)		
2000	**[t]**	**[kg/t fuel]**
Fuel	2 039	
NH_3	0.06	0.03
VOC_HC	38	18.87

In the following tables the IEFs for *1.A.3.a. Civil Aviation* (domestic LTO + international LTO) are presented. Emission factors for heavy metals are presented in chapter 3.2.8. The jump from 2015 to 2016 for all gases except NH_3 and $PM_{2.5}$ is due to the changed activity data and emission factors which were being used for calculating IFR flights from the year 2016 onwards.

Table 188: Activities and Implied NEC emission factors for 1.A.3.a.ii Civil Aviation (dom.+int. LTO): 1990–2022.

Year	**Activity**	**IEF SO_2**	**IEF NO_x**	**IEF NMVOC**	**IEF NH_3**	**IEF $PM_{2.5}$**
	[TJ]			**[t/PJ]**		
1990	1 829	22.4	200.5	110.9	0.19	23.8
1995	2 706	22.6	208.4	98.9	0.18	24.3
2000	3 239	23.1	266.9	116.5	0.17	24.4
2005	4 055	23.1	270.2	115.5	0.17	24.4
2010	4 181	23.1	272.9	116.3	0.17	24.4
2011	4 726	23.1	272.3	118.6	0.18	24.2
2012	4 484	23.1	275.8	113.5	0.17	24.5
2013	4 375	23.1	283.8	114.0	0.17	24.5
2014	4 390	23.1	290.6	112.8	0.17	24.5
2015	4 624	23.1	295.9	113.0	0.17	24.5
2016	4 744	19.5	317.3	45.6	0.17	24.4
2017	4 555	19.5	324.2	41.0	0.17	24.5
2018	4 957	19.5	326.6	41.8	0.17	24.6
2019	5 570	19.4	332.7	38.4	0.17	24.6
2020	2 221	19.5	317.2	51.6	0.18	24.3
2021	2 583	18.3	317.0	51.7	0.18	24.3
2022	4 044	19.5	332.3	40.9	0.17	24.6

Quality Assurance and Quality Control (QA/QC)

Harmonization of inventory and IEA data

In 2013 the ERT detected inconsistencies of fuel consumption data of domestic aviation and domestic navigation between the CRF tables and the IEA data (ICR, 2013). In response to that it was explained that Austria uses a bottom-up approach to estimate fuel consumption whilst IEA relies on top-down approach based on fuel consumption statistics reported by Statistics Austria.

After having discussed this issue with Statistics Austria an Explanatory Note (30/09/2013) has been compiled by Statistics Austria declaring that a regular adoption of inventory data for the split between national and international fuel consumption in civil aviation and navigation in the national statistics will be adopted in the future, as far as the data can be submitted in time (early November).

As part of the regular QA/QC, the energy split between national and international aviation is provided to Statistics Austria for the IEA statistics based on the bottom-up model used to calculate the annual emission inventory.

Comparison IEA (military jet kerosene data)

In 2014, the ERT noted a significant difference in jet kerosene consumption (civil aviation) between IEA data and CRF Table 1.C. In response to the draft ARR 2014, Austria explained that the IEA value also includes military jet kerosene data and that this is the reason for the difference.

Completeness

In response to a question raised by the ERT (ICR, 2013) and based on a recommendation made by the UNFCCC in the course of the 2020 Review, fuel consumption and emissions of mobile sources used for aircraft handling at Austrian airports are now reported under NFR *1.A.3.e.2*.

Recalculations

No category-specific recalculations have been carried out.

Planned Improvements

The emission factor spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2019' (EEA, 2019) has been updated in autumn 2023 (EEA, 2023a). Austria will update its aviation calculation tool accordingly for the next submission 2025.

3.2.5 NFR Memo Item 1.A.3.a Civil Aviation – Cruise

In 2022 the share of Civil Aviation – Cruise in the total fuel consumption of Austria’s aviation sector amounted to around 85% (without kerosene of military aviation). Emissions and activity data from aviation assigned include the transport modes domestic and international cruise traffic for IFR-flights.

Methodological Issues

Emissions from International Bunkers have been calculated using the methodology and emission factors as described in Chapter *NFR 1.A.3.a Civil aviation - LTO*.

Activity Data

Activity data of domestic cruise decreased by 35% and activity data of international cruise increased by 121% over the period from 1990–2022.

Emission Factors

In the following tables activities and IEF for *Civil Aviation – Cruise* are presented. The jump from 2015 to 2016 for all gases except for NH_3 and $PM_{2.5}$ is due to the changed activity data and emission factors which were being used for calculating IFR flights from the year 2016 onwards. Emission factors for heavy metals are presented in chapter 3.2.8.

Table 189: Activities and Implied emission factors for NEC gases and CO for Civil Aviation – Cruise: 1990–2022.

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	10 791	23.1	229.9	16.9	0.157	25.00
1995	16 337	23.1	235.6	16.1	0.157	25.00
2000	20 977	23.1	307.2	19.8	0.157	25.00
2005	23 784	23.1	293.8	19.8	0.157	25.00
2010	24 846	23.1	305.7	19.8	0.157	25.00
2011	25 907	23.1	307.9	19.7	0.157	25.00
2012	24 739	23.1	310.4	19.7	0.157	25.00
2013	23 512	23.1	317.4	19.7	0.157	25.00
2014	23 469	23.1	319.1	19.7	0.157	25.00
2015	25 300	23.1	323.3	19.7	0.157	25.00
2016	27 860	19.4	369.1	8.2	0.157	25.00
2017	26 898	19.4	374.0	7.5	0.157	25.00
2018	30 451	19.4	378.9	7.3	0.157	25.00
2019	35 095	19.4	383.7	6.8	0.157	25.00
2020	12 479	19.4	363.7	8.0	0.157	25.00
2021	14 657	18.1	365.0	8.5	0.157	25.00
2022	23 401	19.4	380.9	7.9	0.157	25.00

Recalculations

No category-specific recalculations have been carried out.

Planned Improvements

The emission factor spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2019' (EEA, 2019) has been updated in autumn 2023 (EEA, 2023a). Austria will update its aviation calculation tool accordingly for the next submission 2025.

3.2.5.1 NFR Memo Item 1.A.3.d International maritime Navigation

Austria does not have any activities under *Memo 1 a 3 d International maritime navigation*. Activities under International inland waterways are included in the national total according to the reporting under CLRTAP.

3.2.6 NFR 1.A.3.b Road Transport

Emissions from road transportation are covered in this category. It includes emissions from passenger cars, light duty vehicles, heavy duty vehicles and busses, mopeds and motorcycles, gasoline evaporation from vehicles as well as vehicle tyre, brake and road surface wear.

Road Transport is the main emission source for NO_x, SO_2, NMVOC and NH_3 emissions of the transport sector. Up to 2005 especially classic air pollutants from road transport – NO_x and PM emissions – have increased with constantly rising vehicle kilometres mainly because of:

- steady increase of transport activity
- altered spatial structures: urban sprawl and centralization
- changing demand structures in the industry: growing division of labour and flexible production methods (just-in-time production) cause the inventory being replaced by means of transport
- disproportionately existing infrastructure for motorized individual transport and further development
- changed lifestyle and mobility needs of the population
- fuel exports by – especially in comparison with Germany and Italy – cheap fuel prices in Austria

Technical improvements and a stricter legislation led to a reduction of emissions mostly all other air pollutants. The pandemic year 2020 marked the lowest emission level in the whole time series.

Methodological Issues

Mobile road combustion is differentiated into the categories Passenger Cars, Light Duty Vehicles, Heavy Duty Vehicles and Buses, Mopeds and Motorcycles. In order to apply the EMEP/EEA methodology a split of the fuel consumption of different vehicle categories was carried out.

Bottom up Methodology – Fuel consumed

Energy consumption and emissions of the different vehicle categories are calculated by multiplying the yearly road performance per vehicle category (km/vehicle and year) by the specific energy use (g/km) and by the emission factors in g/km (Model: NEMO).

NEMO also models the road performance and emissions per vehicle size, age and motor type based on dynamic vehicle specific drop out- and road performance functions.

To determine fuel consumption and emissions of domestic road transport, vehicle stock and total annual road performance (mileage driven per year) of the vehicle categories should be recorded as precisely as possible by national statistics.

Vehicle registrations are being updated yearly. The last update of the specific yearly mileage of passenger cars, light duty vehicles, busses and motorcycles has been done for the years 2021 and 2022 according to data of the annual inspection of traffic and operational safety (according to §57a of the 1967 Motor Vehicle Act (KFG)) for the submission 2024.

For heavy duty vehicles the current traffic volumes up to 2007 are taken from the Austrian National Transport Model "VMOe 2025+" Verkehrs-Mengenmodell-Österreich (Federal Transport Model, Ministry of Transport, BMVIT, not published). Mileage data from 2008 onwards is calculated from the growth rates according to the final results of the automatic traffic counting stations and the toll data (ASFINAG, 2023, BMK, 2023a). For passenger cars, light duty vehicles, buses and motorcycles the mileage data from the periodical inspection database (ZBD - annual inspection of traffic and operational safety according to §57a of the 1967 Motor Vehicle Act (KFG)) is used.

Based on a recommendation made by the UNFCCC during the 2020 Review, Austria collected fuel consumption data of mobile sources used for aircraft handling at Austrian airports. On the basis of specific information from Vienna's International Airport an estimate for all Austrian airports was carried out. Emissions are now reported separately under NFR *1.A.3.e.2 Other*. Fuel and emissions from this source were previously included in NFR source category *1.A.3.b Road Transport.*

Top down Methodology – Fuel sold

Based on the NEMO model fuel consumption and emissions for road transport are calculated with a bottom-up approach. Calculated fuel consumption of road transport is then summed up with calculated fuel consumption of off road traffic and is compared with national total fuel sold.

The difference between the fuel consumption calculated in the bottom-up methodology for road traffic plus off-road transport within Austria and total fuel sales in Austria (obtained from the national energy balance) is allocated to fuel export (fuel sold in Austria but consumed abroad). Emissions reported also include the emissions from fuel export.

Fuel export[91]

Since the end of the nineties an increasing discrepancy between the total Austrian fuel sales and the computed domestic fuel consumption became apparent. From 2003 onward this gap accounts for roughly 30% of the total fuel sales. A possible explanation of this discrepancy is the „fuel export in the vehicle tank" – due to the relatively low fuel prices in Austria (in comparison to the neighbouring countries). Meaning that to a greater extent fuel is filled up in Austria and consumed abroad. This assumption is underpinned by two national studies (Molitor & Hausberger et al., 2004; Molitor & Schönfelder et al., 2009).

It is assumed that the fuel export fleet (mainly travelling on highways) is similar to the Austrian fleet on highways, which means that no different efficiency rates are assumed for the fuel export fleet. It is assumed that fuel export is assigned to three vehicles groups: gasoline PC, diesel PC and diesel trucks.

Gasoline fuel export is calculated from the inland gasoline consumption and the difference to the total sales of gasoline in Austria. The difference is being assigned to the gasoline fuel export in cars. Fuel consumption of diesel fuel export with cars is being calibrated in proportion to the diesel share of the foreign car fleet based on the relation between FC of gasoline cars in fuel export and FC of gasoline cars in inland. After having calculated the diesel export in cars the diesel export of trucks can be estimated by total diesel sales minus diesel FC inland minus diesel export in cars (Hausberger, Schwingshackl & Rexeis, 2015a, p.22).

NEMO – Network Emission Model

From the submission in 2015 onwards calculations are based on the model NEMO – Network Emission Model (Dippold, Rexeis & Hausberger, 2012, Hausberger, Schwingshackl & Rexeis, 2015a, 2015b; Schwingshackl & Rexeis, 2022). NEMO combines a detailed calculation of the fleet composition with the simulation of energy consumption and emission output on a vehicle level. It is fully

[91] Under the LRTAP Convention national emissions are reported based on fuel sold (including fuel export); under the NEC Directive national emissions are reported based on fuel used (excluding fuel export).

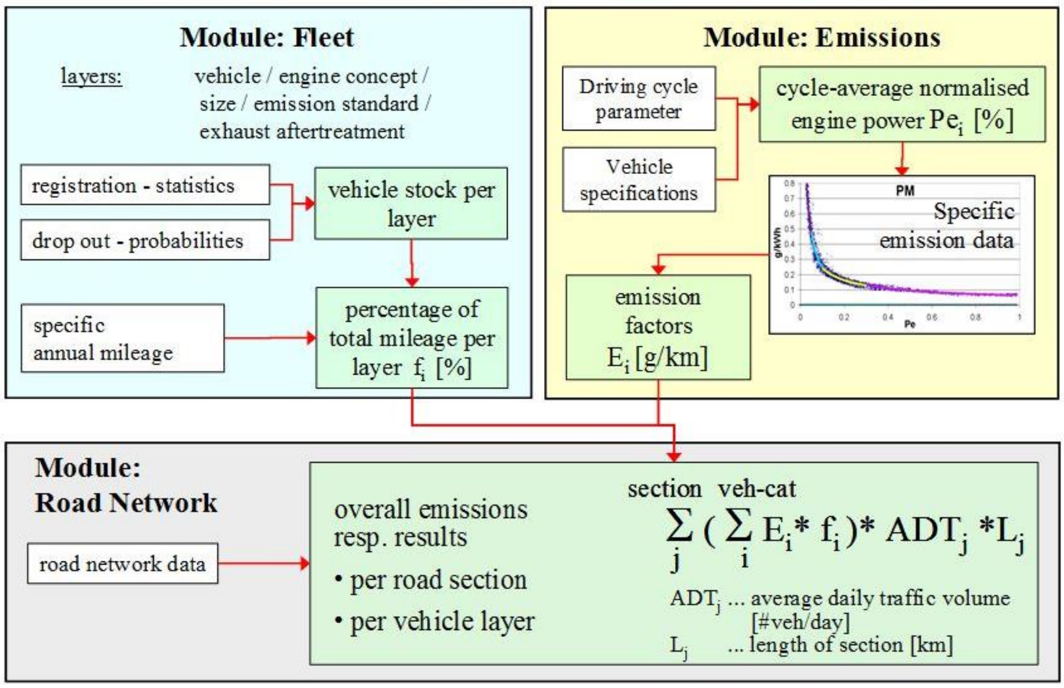
capable to depict the upcoming variety of possible combinations of propulsion systems (internal combustion engine, hybrid, plug-in-hybrid, electric propulsion, fuel cell …) and alternative fuels (CNG, biogas, FAME, Ethanol, GTL, BTL, H_2 …).

In addition, NEMO has been designed to be also suitable for all main application fields of simulation of energy consumption and emission output on a road-section based model approach. As there does not yet exist a complete road network for Austria on a highly resolved spatial level, the old methodology based on a categorisation of the traffic activity into "urban", "rural" and "motorway" has been currently also applied in NEMO. The model calculates vehicle mileages, passenger-km, ton-km, fuel consumption, all exhaust gas emissions, evaporative emissions and suspended TSP, PM_{10}, $PM_{2.5}$, PM_1 and $PM_{0.1}$ exhaust and non-exhaust emissions of road traffic.

Figure 44 shows a schematic picture of the methodology of NEMO.

Figure 44: Schematic picture of the NEMO model.

NEMO - Network Emission Model



Source: Hausberger, Schwingshackl & Rexeis (2015a, 2015b)

Model input

1. Yearly vehicle registrations (STATAT) and an algorithm for drop-out probabilities form the vehicle stock of each vehicle category split into layers according to the propulsion system (SI, CI,..), cylinder capacity classes or vehicle mass;
2. Emission factors of the vehicles according to the year of first registration and the layers from 1);
3. Yearly specific mileages of PCs, LDVs, mopeds and motorcycles (BMK)
4. Yearly growth rates of kilometres driven by PCs and HDVs separated for the federal street network (motorways) and the federal county network (urban, rural) (AUSTRIA TECH)
5. Yearly absolute number of vehicle kilometres (trucks and busses) on Austrian motorways (BMK)

6. Number of passengers per vehicle and tons payload per vehicle;
7. Optional either/or
   - total gasoline and diesel consumption of the area under consideration,
   - average km per vehicle and year.

Model output

a. Km driven per vehicle and year,
b. Total fuel consumption of road traffic,
c. Total vehicle mileages,
d. Total passenger-km and ton-km,
e. Specific emission values for the vehicle fleets [g/km], [g/tkm], [g/pkm],
f. Total emissions (evaporative emissions and suspended TSP, PM_{10}, $PM_{2.5}$, PM_1 and $PM_{0.1}$ exhaust and non-exhaust emissions, CO, HC, NO_x, CO_2, SO_2 and several unregulated pollutants among them CH_4 and N_2O) of road traffic.

The calculation is done according to the following method for each year

1. Assessment of the vehicle stock split into layers according to the propulsion system (SI, CI,..), cylinder capacity classes (or vehicle mass for HDV) and year of first registration using the vehicle survival probabilities and the vehicle stock of the year before.

$$stock_{\mathrm{Jg_i,year\,i}} = stock_{\mathrm{Jg_i,year\,i-1}} \times \text{survival probability}_{\mathrm{Jg_i}}$$

2. Assessment of the km per vehicle for each vehicle layer using age and size dependent functions of the average mileage driven. If option switched on, iterative adaptation of the km per vehicle to meet the total fuel consumption targets.
3. Calculation of the total mileage of each emission category (e.g. passenger car diesel, EURO 3)

$$\text{total mileage}_{\mathrm{E_i}} = \sum_{\mathrm{Jg=start.}}^{\mathrm{end}} (\text{stock}_{\mathrm{Jg,year\,i}} \times \text{km/vehicle}_{\mathrm{Jg_i,year\,i}})$$

4. Calculation of the total fuel consumption and emissions of each emission category

$$\text{Emission}_{\mathrm{E_i}} = \text{total mileage}_{\mathrm{E_i}} \times \text{emission factor}_{\mathrm{K_j},E_i}$$

5. Calculation of the total fuel consumption and emissions of each vehicle category

$$\text{Emission}_{\text{veh.category}} = \sum_{\mathrm{E_i=1}}^{end} \text{Emission}_{\mathrm{E_i}}$$

6. Calculation of the total passenger-km and ton-km

$$\text{transport volumes}_{\text{veh.category}} = \sum_{\mathrm{E_i=1}}^{end} (\text{vehicle mileage}_{\mathrm{E_i}} \times \text{loading}_{\mathrm{E_i}})$$

7. Summation over all vehicle categories with…

Jg_i Index for a vehicle layer (defined size class, propulsion type, year of first registration)

E_i Index for vehicles within a emission category (defined size class, propulsion type and exhaust certification level)

Module: Fleet

The composition of the vehicle fleet in NEMO is being simulated based on annual Austrian registration statistics per vehicle category and propulsion system as well as age-dependent survival (drop-out) probabilities. Vehicle technologies (exhaust standards or “EURO classes”) are assigned to vehicle registrations based on the year of registration.

NEMO combines both detailed calculation of the vehicle fleet composition and simulation of emission factors on a vehicle level. NEMO calculates the percentages of different vehicle layers on the overall traffic volume as a function of year and considered road type based on data on vehicle stock, composition of new registrations and vehicle usage. The simulation of the emissions of the different vehicle layers is based on the correlation of the specific engine emission behaviour (emissions in grams per kilowatt-hour engine work) with the cycle average engine power in a normalised format. The calculation of the required engine power is based on average speed and additional kinematic parameters for the description of the cycle dynamics for a given road section.

Module: Road Network

Starting point for the road network files currently used in the inventory for the three road categories "urban", "rural" and "motorway" are the mileage distributions stored in HBEFA for Austria according to different traffic situations. Within the road categories the average speed is a product of x different driving patterns per vehicle category (dependant on y road types in each of the three road categories with specific inclinations, speed limits, actual traffic flows, average measured speeds, etc.). The resulting average speeds for Austrian "urban", "rural" and "motorway" road category weighted by traffic volume in the attachment can be found in the following table.

Table 190: Resulting average speeds per vehicle category in NEMO (based on HBEFA 4.2 traffic situations).

	Speed [km/h] per road category		
Vehicle category	**urban**	**rural**	**motorway**
Passenger Car	32.6	71.2	116.3
Light Duty Vehicle	32.6	71.2	116.2
Heavy Duty Vehicle-Road Truck	29.5	63.5	79.9
Heavy Duty Vehicle-Tow Truck	29.5	63.5	79.9
Coach	29.5	64.3	90.5
Urban Bus	23.7	49.8	-
Motorcycle-2 cylinders	33.7	68.3	-
Motorcycle-4 cylinders	33.7	68.3	-
Moped	33.7	48.8	-

Activity Data

From 2021 to 2022 fuel consumption of road transport in TJ (gasoline, diesel and alternative fuels including liquid biomass) decreased by 5.0%. Specific consumption per average vehicle kilometer and vehicle category did not improve for light duty vehicles; it declined by 0.1% for diesel passenger cars, by 1.1% for gasoline passenger cars, and by 1% for heavy duty vehicles.

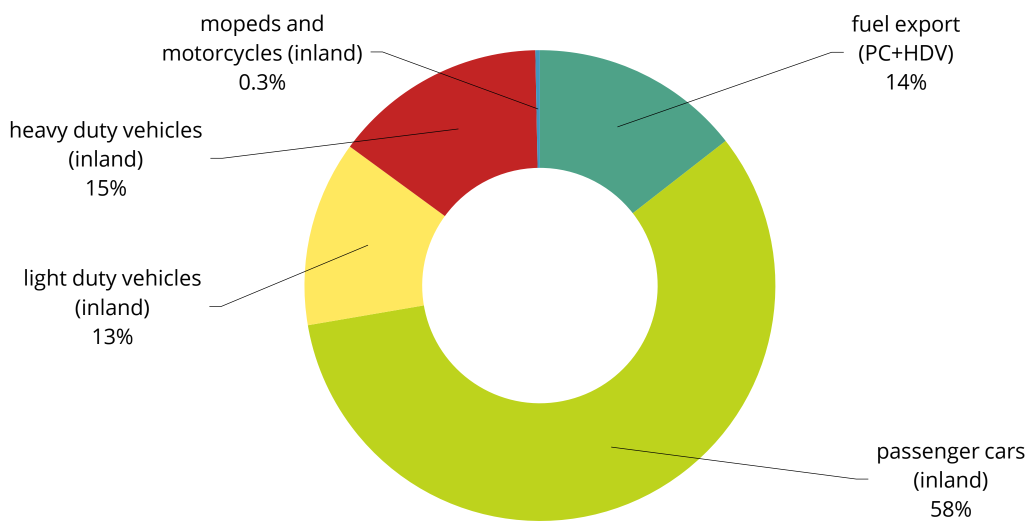
In the following table NO_x emissions are disaggregated by means of road transportation. Inland emissions and those from fuel export are shown separately in the two relevant vehicle categories passenger cars and heavy duty vehicles and must be summed up to get the total emissions for each vehicle category. The phenomenon of fuel export is explained in the subchapter *Methodological Issues*.

Table 191: NO_x emissions from 1.A.3.b Road Transport differentiated by means of transportation 1990–2022.

Year	Passenger cars		light duty vehicles	heavy duty vehicles		mopeds & motorcycles
	inland	**fuel export**	**inland**	**inland**	**fuel export**	**inland**
	NO_x [kt]					
1990	56.45	3.49	7.30	35.82	12.95	0.13
1995	46.28	0.76	8.02	38.70	16.26	0.15
2000	43.69	-2.13	8.38	41.31	33.69	0.21
2005	48.57	12.55	10.12	39.71	44.39	0.26
2010	47.01	12.61	10.96	27.00	23.48	0.25
2011	47.74	11.57	11.13	25.97	17.45	0.25
2012	47.68	11.20	11.06	24.06	16.77	0.25
2013	48.51	10.39	11.09	22.65	21.01	0.25
2014	49.91	10.04	11.20	21.28	17.35	0.24
2015	50.64	11.29	11.29	19.03	14.90	0.24
2016	49.79	11.64	11.11	16.98	10.96	0.24
2017	46.93	11.44	10.43	14.92	8.81	0.23
2018	42.53	11.35	9.53	13.22	7.34	0.22
2019	38.28	10.37	8.81	11.50	6.63	0.21
2020	32.22	4.12	7.61	9.39	4.75	0.18
2021	29.75	5.21	7.10	8.65	3.91	0.16
2022	28.54	5.00	6.29	7.22	2.14	0.15
1990–2022	**-49%**	**43%**	**-14%**	**-80%**	**-83%**	**23%**
2021–2022	**-4%**	**-4%**	**-11%**	**-16%**	**-45%**	**-6%**

In 2022, the total share of fuel export in NFR *1.A.3.b* amounted to 14% or 7.1 kt NO_x of which 70% are attributed to passenger road transport and 30% to road freight transport.

Figure 45: Share of fuel export (NO_x) in 1.A.3.b Road Transport in 2022.



Source: Umweltbundesamt

The general equal distribution of pure biofuels to relevant vehicle categories was changed in the calculations of the 2016 submission. The allocation has been done based on expert judgement and was implemented in the model NEMO according to the road performance of each vehicle category:

- biodiesel B100 is assigned to HDV to 100%
- vegetable oil is assigned to HDV to 100%[92]
- bioethanol (E85) is assigned to PC to 100%

The allocation of alternative fuels like liquefied petroleum gas (LPG) and compressed natural gas (CNG) is assumed in the model as follows:

- LPG is assigned to PC, HDV and LDV (only otto-motorised) according to their road performance.
- Natural gas (CNG) is distributed to passenger cars, HDV and LDV (only otto-motorised) according to their road performance.

Biofuels

Since 2005 biogenic fuel (biodiesel, bioethanol, plant oil) has been used in the Austrian road transport sector. Biodiesel and bioethanol are mainly used for blending fossil fuels, whereas plant oil is distributed in pure form. In 2022, the energetic substitution by biofuels in the road transport sector amounted to 5.8% (BMK, 2024).[93] 2005, the first year of blending biofuels, the substitution amounted to only 0.8% (Umweltbundesamt, 2006c).

[92] An allocation to agriculture is not possible at the moment, because of the technical model framework.

[93] The required substitution target amounts to 5.75%, measured by energy content.

The following data is used as direct input data in the calculation models based on NEMO and GEORG (see 1.A.2.g.7).

In 2022 a total of 5 816 134 tonnes of fossil diesel was sold based on the calculation of the substitution target according to the Austrian Fuel Ordinance. Based on data from the national biofuel register *elNa* (electronic sustainability certificates), a total of 391 265 tonnes of biodiesel and 7 093 tonnes of hydrotreated vegetable oil (HVO) were **added by blending**. In addition, 28 349 tonnes of biodiesel and 132 tonnes of HVO were put on the market in their **pure form** or as fuel with a higher percentage of biogenic admixture in diesel. In addition, 1 414 600 tonnes of fossil gasoline were sold. A total of 78 995 tonnes of sustainable bioethanol was added to these fuels, of which 6 135 tonnes were biogenic ethyl tertiary butyl ether (ETBE). As in previous years, accounting for 209 tonnes, vegetable oil was used in agriculture. In addition, 527 tonnes of bio-methane (biogas) were sold to the transport sector in the year 2022 (BMK, 2024a). The table below shows total absolute numbers of biofuels used in Austria for mobile sources.

Table 192: Use of biofuels in absolute figures 2005–2022.

Year	**Pure [t]**			**Blended [t]**	
	Biofuels	**Biogas**	**Vegetable oil**	**Biodiesel+HVO**	**Bioethanol**
2005	17 000	-	-	75 000	-
2010	74 984	2	17 393	427 000	105 872
2011	85 093	6	16 731	422 072	102 744
2012	58 160	9	16 823	440 938	105 366
2013	62 694	15	17 842	443 389	88 833
2014	143 125	463	16 028	474 692	87 676
2015	158 267	350	15 988	528 944	89 541
2016	65 280	344	15 595	495 764	86 893
2017	31 052	214	15 561	459 032	85 208
2018	62 914	306	263	462 396	88 186
2019	58 502	349	135	448 328	86 290
2020	34 542	278	107	390 273	82 019
2021	26 145	213	149	416 461	75 511
2022	28 482	527	209	398 358	78 995
2005–2022	**68%**	**29 713%**[94]	**-99%**	**431%**	**-25%**[95]
2021–2022	**9%**	**147%**	**40%**	**-4%**	**5%**

Emission Factors

Emission factors used for NEMO 5.0.3 are based on a representative number of vehicles and engines measured in real-world driving situations taken from the "Handbook of Emission Factors" (HBEFA) (Hausberger/Keller et al., 1998) and on ARTEMIS measurements (basically for passenger cars, light duty vehicles and motorcycles) which are taken into account in HBEFA. The latest HBEFA Version V4.2 (INFRAS 2022) published in January 2022 has been applied since the submission 2023 and replaced Version V4.1 (Matzer/Weller et al., 2019).

[94] Trend 2010-onwards

[95] Trend 2010-onwards

For category *1.A.3.b.ii Road transport* light duty vehicles show a high NO_X Implied Emission Factor (IEF) when compared to the other Member States for the year 2005. This is due to the dominant share of Euro 2 and 3 diesel LDVs with emissions calculated based on real world emission factors from HBEFA which have higher IEFs than the default values from the 2019 EMEP/EEA Guidebook.

Software updates

The update in HBEFA V4.2 contains the detailed mapping of the emission development of diesel vehicles with and without a software update in addition to the emission factors for diesel PCs with EA 189 engines, which have already been integrated in HBEFA V4.1. There the effect of the mandatory software update of VW vehicles with the EA189 engine ("Diesel Gate") on the average EURO 5 emission factor has been analysed in several measurement series.

The development of the emission factors and temperature dependencies for the additional software update vehicle layers can be read in a study by TU Graz (Dippold/Hausberger 2021) and is also integrated in HBEFA V4.2.

Ambient temperature influence

Ambient temperature influences on NOx emission factors have been checked, but there have been no changes compared to HBEFA V4.1. Therefore, it is still valid to say that the lower the ambient temperature, the worse NO_x exhaust-aftertreatment systems work.

Cold-start emissions

The cold-start emission module has been checked, but there have been no changes compared to HBEFA V4.1.

Cold-start emissions are calculated as an extra emission over the emissions that would be expected if all vehicles were only operated with hot engines and warmed-up catalysts. Cold-start emissions are only allocated for urban and rural driving, as the number of starts in highway conditions seems to be relatively limited. Cold-start emissions are calculated in NEMO for each vehicle category and each pollutant as follows:

Additional impact per start [g / km] =
cold-start surcharge [g / start] / average trip length per cold start [km / start]

The cold start influence is in NEMO included in the calculation of fuel consumption and emissions of CO_2, NO_x, CO, hydrocarbons and PM. For N_2O and NH_3 no cold start emission factors were found in the literature.

The values used for cold-start surcharges come from:

- *PC and LDV*: cold-start model (updated in HBEFA V4.1)
- *HDV*: cold-start study commissioned by Umweltbundesamt (Rexeis et al., 2013)
- *2-wheelers*: derived from cold-start emissions of PC gasoline

Exhaust emissions – PM

Emission factors used for ($PM_{2.5}$ and PM_{10}) include the condensable component. As condensable means "condensing on the filter at < 52° C", this definition is exactly in line with the PM measurement rules on the emission test benches for road vehicles and NRMM. Also see Table "Information on PM emission factors" in the Annex (chapter 12.3).

Up to submission 2018 PM emissions of mopeds and motorcycles were reported as IE which should have been NE. These emissions were not reported, as no country-specific measurements for mopeds and motorcycles are available.

For the submission 2019, NEMO 4.0.3 has used the Tier 2 method from the EMEP/EEA 2016 Guidebook (EEA, 2016) for particulate matter emissions (exhaust) in two-wheeled vehicles. This improvement has been made following a recommendation of the stage 3 CLRTAP Review 2017.

From the submission 2020 onwards the newest NEMO version uses emission factors from the newest HBEFA Version. The emission factors are based on vehicle measurements.

Non-exhaust emissions – PM

From the submission 2018 onwards non-exhaust emissions from tyre and brake wear and road abrasion (road surface wear) are reported separately under *1.A.3.b.6 and 1.A.3.b.7.* This improvement was made following a recommendation of the stage 3 CLRTAP Review 2017 and the NEC Review 2017.

Regarding non-exhaust emissions, the EMEP/EEA 2019 Guidebook (EEA, 2019) puts a focus on primary particles. Following, road resuspension of previously deposited material, is not being reported any longer from the submission 2017 onwards, but can be provided when needed.

No information is given in the EMEP/EEA 2019 Guidebook (EEA, 2019) though, if the condensable fraction is relevant in non-exhaust emission factors ($PM_{2.5}$ and PM_{10}). Also see Table "Information on PM emission factors" in the Annex (chapter 12.3).

Gasoline evaporation – NMVOC

In the submission 2018 Austria has adopted the method for *1.A.3.b.v* according to the EMEP/EEA 2019 Guidebook (EEA, 2019). Total evaporative emissions from all gasoline vehicle categories (excl. CNG or biogas) are now including

- diurnal losses
- hot soak
- running losses

The emissions of these three subcategories of NFR *1.A.3.b* are displayed below and can be reported separately. This improvement was made following a recommendation of the NEC Review 2017.

Table 193: NMVOC emissions from evaporation in 1.A.3.b. Road Transport: 1990–2022.

Year	diurnal losses	Hot soak	running losses
		[kt]	
1990	0.72	5.21	14.86
1995	0.46	2.71	7.73
2000	0.26	1.02	2.75

Year	diurnial losses	Hot soak	running losses
		[kt]	
2005	0.22	0.48	1.36
2010	0.14	0.14	0.41
2011	0.13	0.12	0.37
2012	0.12	0.10	0.34
2013	0.11	0.09	0.30
2014	0.11	0.09	0.29
2015	0.11	0.08	0.28
2016	0.11	0.08	0.26
2017	0.11	0.08	0.25
2018	0.10	0.07	0.24
2019	0.10	0.06	0.22
2020	0.08	0.05	0.19
2021	0.08	0.05	0.19
2022	0.09	0.05	0.19

Relative factors on top of commercial fuels incl. blending of biofuels (=reference fuels)

All emission factors of alternative and pure biofuels used in NEMO are considered in the model by relative factors compared to commercial fuels. This allows to include any other fuels in the NEMO calculations.

The following table provides the used relative factors compared to the reference fuels. The reference fuels are blended gasoline and blended diesel, because these fuels are commercially launched by fuelling stations on the market. The relative factors are multiplied with the EFs (in g/km) of every EURO-class and vehicle category per year. The relative factors are kept constant for the whole time series, but of course the final EFs change over time, because the basic EFs per EURO class improve as a consequence of the vehicles' advanced exhaust gas technologies. The relative factors are derived from literature research (e.g. EMEP Guidebook) or exhaust measurements.

Table 194: Relative factors used for bioethanol E85, LPG, CNG and biogas.

Gasoline	blended gasoline	bioethanol E85	LPG	CNG	biogas
FC	1.00	1.00	1.00	0.84	0.84
NOx	1.00	1.51	1.22	0.67	0.67
HC	1.00	1.37	0.85	0.44	0.44
CO	1.00	0.88	1.25	0.70	0.70
PM exhaust	1.00	1.00	1.00	0.71	0.71
Nox_raw	1.00	1.51	1.22	0.67	0.67
N_2O	1.00	0.64	1.00	0.34	0.34
NO_2	1.00	1.51	1.22	1.11	1.11
NH_3	1.00	1.00	1.00	0.68	0.68
CH_4	1.00	1.94	1.00	2.94	2.94
Benzol	1.00	1.00	1.00	1.00	1.00
C22H12	1.00	1.00	0.03	1.00	1.00
C20H12 (k)	1.00	1.00	0.04	1.00	1.00
C20H12 (b)	1.00	1.00	0.00	1.00	1.00
C20H12 (a)	1.00	1.00	0.03	1.00	1.00

Table 195: Relative factors used for biodiesel, plant oil and diesel B20.

Diesel	blended diesel	biodiesel (RME)	plant oil	diesel B20
FC	1.00	1.00	1.00	1.00
NO_x	1.00	1.20	1.20	1.04
HC	1.00	1.00	1.00	1.00
CO	1.00	0.74	0.74	0.95
PM exhaust	1.00	0.61	0.61	0.92
Nox_raw	1.00	1.20	1.20	1.04
N_2O	1.00	1.20	1.20	1.04
NO_2	1.00	1.00	1.00	1.00
NH_3	1.00	1.00	1.00	1.00
CH_4	1.00	1.15	1.15	1.03
Benzol	1.00	1.00	1.00	1.00
C22H12	1.00	1.00	1.00	1.00
C20H12 (k)	1.00	1.00	1.00	1.00
C20H12 (b)	1.00	1.00	1.00	1.00
C20H12 (a)	1.00	1.00	1.00	1.00

The following tables present the IEFs for *1.A.3.b Road Transport*. The IEFs change over time due to new technologies. Emission factors for heavy metals and POPs are presented in 0.

Table 196: Activities and Implied emission factors for NEC gases for 1.A.3.b Road Transport: 1990–2022.

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	176 192	27.0	659.1	552.9	4.5	4.22
1995	202 065	28.0	545.3	288.8	9.8	4.08
2000	240 968	9.6	519.4	121.1	10.4	3.44
2005	324 765	0.5	479.1	63.8	7.9	5.36
2010	305 776	0.4	396.7	33.4	6.0	6.02
2011	295 549	0.4	386.1	30.5	5.5	6.10
2012	295 346	0.4	375.9	27.5	5.0	6.03
2013	309 053	0.4	368.5	24.2	4.3	5.63
2014	301 633	0.4	364.8	22.5	4.0	5.81
2015	308 877	0.4	347.7	20.6	3.8	6.08
2016	318 645	0.4	316.0	18.5	3.6	6.22
2017	326 427	0.4	284.2	16.7	3.4	6.30
2018	329 481	0.4	255.5	14.8	3.4	6.43
2019	329 930	0.4	229.7	14.0	3.3	6.34
2020	286 316	0.4	203.5	13.8	3.1	5.30
2021	298 104	0.4	183.8	12.5	3.2	5.68
2022	283 166	0.4	174.3	12.3	3.4	6.05

Quality Assurance and Quality Control (QA/QC)

Quality management for input data of NFR *1.A.3.b* is implemented by carrying out the following checklist:

- ✓ Are the correct values used (check for transcription errors)?
- ✓ Check of plausibility of input data (time-series order of magnitude)!
- ✓ Is the data set complete for the whole time series?
- ✓ Check of calculation units!
- ✓ Check of plausibility of results (time-series order of magnitude)!
- ✓ Are all references clearly made?
- ✓ Are all assumptions documented?

Recalculations

- *Update of the NEMO fleet model*

  1.A.3.b.3 gasoline: 2017–2021: Road trucks size I (RT I <18t) have been a statistical residual number, with a fleet smaller than one from 2017 onwards. This was due to the algorithm for the probability of failure, but no new registrations of gasoline RT I were reported. Thus they were set to zero in the fleet model from 2017 onwards in the 2024 submission.

  1.A.3.b.3 gaseous: 2004–2021: Energy consumption of CNG has been revised in accordance with the revisions of the national Energy Balance.

  1.A.3.b.3 diesel, gasoline & LPG: 1990–2021: RT I driving resistances were adjusted to comply with HBEFA 4.2 (all EFAs have increased slightly except for EURO 6 with a slight reduction).

  1.A.3.b.3 diesel: 2021: For 2021, more efficient EURO V and EURO VI diesel trucks have increased total HDV mileage, resulting in a reduced fuel consumption in category HDV (-733.26 TJ).

- *Revision of real fuel consumption for PC and LDV PHEV*

  The energy consumption in hybrid vehicles is subject to high uncertainties. The fact is that in reality there are use cases with a high proportion of kilometres driven electrically, but also with the almost exclusive use of the combustion engine (ITNA, 2023[96], p.9). For this reason, a more pessimistic charging behaviour for PHEV vehicles has been assumed, which increased the real gasoline consumption of PHEV cars and LDV, especially in 2021. On an overall level the reduction cannot be seen in category "gasoline cars", because of an overlapping effect caused by the update of specific mileage per year.

- *Update of specific vehicle mileage per year*

  Improvement of data evaluation in the central vehicle assessment database (ZBD - annual "sticker check" in accordance with §57a KFG). An update of the relevant input data made it

[96] SCHWINGSHACKL, M. & REXEIS, M. (2023): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2022. ITNA – Institut für Nachhaltige Antriebe und Thermodynamik. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2023.

possible to evaluate half-years for 2021 and 2022 and thus define the specific annual mileage of vehicles more precisely. This has led to an increase for diesel cars, diesel LDV, 2-wheelers (gasoline) for 2021 compared to last year's inventory.

For NFR *1.A.3.b Road Transport* all these changes result in recalculations of: NO_x between +0.03 kt (1990: -0.1% of national total and -0.3% of category *1.A.3.b*) and +0.28 kt (2021: +0.23% of national total and +0.52% of category *1.A.3.b*); SO_2 between -0.002 kt (1990: -0.002% of national total and -0.04% of category *1.A.3.b*) and +0.00004 kt (2021: +0.0004% of national total and +0.03% of category *1.A.3.b*); NMVOC between +1.05 kt (1990: +0.3% of national total and +1.09% of category *1.A.3.b*) and -0.02 kt (2021: +0.02% of national total and +0.66% of category *1.A.3.*b); NH_3 between -0.001 kt (1990: -0.001% of national total and -0.08% of category *1.A.3.b*) and +0.002 kt (2021: +0.004% of national total and +0.26% of category *1.A.3.*b); $PM_{2.5}$ between +0.08 kt (1990: +0.3% of national total and +1.4% of category *1.A.3.b*) and +0.55 kt (2021: +3.7% of national total and +27.8% of category *1.A.3.*b).

Planned Improvements

The implementation of emission factors for emission standard (e.g. EURO 7) is planned with the next HBEFA update.

3.2.7 Other mobile sources – Off Road

Off-road sources are mobile engines and mobile machinery in the NFR sectors *1.A.2.g.7 Industry*, *1.A.3.c Railways*, *1.A.3.d Navigation*, *1.A.4.b.2 Household and Gardening*, *1.A.4.c.2 Agriculture and Forestry* and *1.A.5.b Military activities*. For completeness NFR *1.A.3.e.2 Other Transportation – Airport Ground Activities* is included in this chapter.

3.2.7.1 NFR 1.A.2.g.7 Off-road vehicles and other machinery

Methodological Issues

Energy consumption and emissions of off-road traffic in Austria are calculated with the model GEORG (**G**razer **E**missionsmodell für **O**ff-**R**oad **G**eräte). This model has been developed within a study about off-road emissions in Austria (Hausberger, 2000). The study was prepared to improve the poor data quality in this sector. The following categories were taken into account:

- *1.A.2.g.7 Industry,*
- *1.A.3.c Railways,*
- *1.A.3.d Navigation,*
- *1.A.4.b.2 Household and Gardening,*
- *1.A.4.c.2 Agriculture and Forestry,*
- *1.A.5.b Military activities.*

Activities of mobile machinery in NFR *1.A.2.g.7 Industry* also contain commercially/institutionally used machinery. Emissions from these machines cannot be reported separately under *NFR 1.A.4.a.2* as the split into commercial/institutional and non-commercial/non-institutional use is not possible due to a lack of data.

Input data to the model are:

- Machinery stock data (obtained from data on licences, through inquiries and statistical extrapolation);
- Assumptions on drop-out rates of machinery (broken down machinery will be replaced);
- Operating time (obtained through inquiries), related to age of machinery.

From machinery stock data and drop-out rates an age structure of the off-road machinery was obtained by GEORG. Four categories of engine types were considered. Depending on the fuel consumption of the engine the ratio power of the engine was calculated. Emissions were calculated by multiplying an engine specific emission factor (expressed in g/kWh) by the average engine power, the operating time and the number of vehicles.

With this method national fuel consumption and national emissions are calculated (bottom-up). Calculated fuel consumption of off-road traffic is then summed up with total fuel consumption of inland road transport and is compared with total fuel sold in Austria according to the national energy balance. The difference is allocated to fuel export (for details concerning fuel export see *1.A.3.b Road Transport*). The emissions reported for Austria also include the emissions from fuel exports assuming that the fuel export fleet (mainly travelling on highways) is similar to the Austrian fleet on highways. The used methodology conforms to the requirements of the the EMEP/EEA 2019 Guidebook (EEA, 2019) Tier 3 methodology.

Activity Data

Activity data, vehicle stock and specific fuel consumption for vehicles and machinery (e.g. leaders, diggers etc.), were taken from:

- Statistik Austria (national energy balance),
- Questionnaire to vehicle and machinery users (Hausberger, 2000),
- Interviews with experts and expert judgment
  validating the questionnaire results (Hausberger, 2000) and
- Information from vehicle and machinery manufacturers (Hausberger, 2000).

An allocation of pure biofuels in the off-road sector has not been performed due to lack of data.

Emission Factors

In submission 2021 specific emission factors for NO_x, PM, CO and HC of diesel engines stage 3b, 4 and 5 (mobile machinery and equipment) used in *1.A.2.g.7 Industry* and *1.A.4.c.2 Agriculture and Forestry* were updated on the basis of a new country-specific study study (Schwingshackl/Rexeis & Weller, 2020). The update of specific emission factors for NO_x, PM, CO and HC of diesel engines stage IIIb, IV and V (mobile machinery and equipment) used in *1.A.2.g.7 Industry*, *1.A.4.b.2 Household and gardening* und *1.A.4.c.2 Agriculture and Forestry* resulted in significantly increased NMVOC emissions from 2002 onwards (e.g. 2008: +0.54 kt).

The following tables show the exhaust emission factors for the smallest (< 56kW) and the strongest (>130kW) diesel engine types (average motor capacity) and for 2- and 4-stroke petrol engines depending on the year of construction used in the GEORG model for *1.A.2.g.7 Industry* and *1.A.4.c.2 Agriculture and Forestry*.

Table 197: Emission factors for small diesel engines < 56kW.

Year	CO	NO_x	NH_3	NMVOC	PM
			[g/kwh]		
AG1	10.58	12.0	0.0060	1.894	2.184
AG2	8.85	10.9	0.0045	1.446	1.682
Stage 1	2.55	6.6	0.0039	0.795	0.308
Stage 2	2.25	6.0	0.0029	0.671	0.166
Stage 3a	1.12	8.9	0.0020	0.221	0.079
Stage 3b	0.67	5.7	0.0020	0.048	0.034
Stage 4	0.67	5.7	0.0020	0.048	0.034
Stage 4 SCR	0.67	5.7	0.0020	0.048	0.034
Stage 5	0.44	3.3	0.0020	0.046	0.010

Table 198: Emission factors for big diesel engines > 130kW.

Year	CO	NO_x	NH_3	NMVOC	PM
			[g/kwh]		
AG1	9.24	10.19	0.0030	1.58	1.623
AG2	7.70	12.39	0.0024	1.18	0.885
Stage 1	2.55	6.56	0.0020	0.79	0.174
Stage 2	2.25	4.83	0.0014	0.67	0.153
Stage 3a	1.12	5.86	0.0010	0.22	0.079
Stage 3b	0.67	2.55	0.0010	0.05	0.034
Stage 4	0.35	1.52	0.0010	0.00	0.027
Stage 4 SCR	0.35	1.52	0.0010	0.00	0.027
Stage 5	0.31	0.55	0.0010	0.02	0.010

Table 199: Emission factors for 4-stroke-petrol engines.

Year	NO_x	NH_3	NMVOC	PM
		[g/kwh]		
AG1	3.070	0.0019	15.917	0.025
AG2	4.110	0.0017	12.738	0.025
Stage 1	4.490	0.0016	12.167	0.025
Stage 2	4.490	0.0018	11.748	0.025
Stage 3a	4.490	0.0018	10.844	0.025
Stage 3b	4.490	0.0018	10.844	0.025
Stage 4	4.490	0.0018	10.844	0.025
Stage 4 SCR	4.490	0.0018	10.844	0.025
Stage 5	4.490	0.0018	10.844	0.025

Table 200: Emission factors for small 2-stroke-petrol engines.

Year	NO_x	NH_3	NMVOC	PM
		[g/kwh]		
AG1	1.035	0.0017	247.8	0.439
AG2	1.135	0.0015	174.3	0.291
Stage 1	1.675	0.0013	164.6	0.291
Stage 2	1.395	0.0012	50.49	0.291
Stage 3a	1.395	0.0004	50.49	0.291
Stage 3b	1.395	0.0004	50.49	0.291
Stage 4	1.395	0.0004	50.49	0.291
Stage 4 SCR	1.395	0.0004	50.49	0.291
Stage 5	1.395	0.0004	50.49	0.291

Exhaust emissions – PM

Emission factors used for ($PM_{2.5}$ and PM_{10}) include the condensable component. As condensable means "condensing on the filter at < 52°C", this definition is exactly in line with the PM measurement rules on the emission test benches for road vehicles and NRMM. Also see Table "Information on PM emission factors" in the Annex (chapter 12.3).

Non-exhaust emissions – PM

Regarding non-exhaust emissions, also the EMEP/EEA 2019 Guidebook (EEA, 2019) puts a focus on primary particles, e.g. tyre- and brake-wear. Following, road resuspension ("Aufwirbelung") of previously deposited material, is not being reported any longer from the submission 2017 onwards, but can be provided when needed.

No information is provided in the EMEP/EEA 2019 Guidebook (EEA, 2019) regarding the relevance of the condensable fraction in non-exhaust emission factors ($PM_{2.5}$ and PM_{10}). Please also refer to Table "Information on PM emission factors" in the Annex (chapter 12.3).

Activity data and implied emission factors of *1.A.2.g.7* are presented below. Activities include liquid fuels (diesel, gasoline and biofuels). Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Table 201: Activities and Implied emission factors for NEC gases for 1.A.2.g.7 Off-road – Industry: 1990–2022.

Year	Activity	IEF SO2	IEF NOx	IEF NMVOC	IEF NH3	IEF PM2.5
	[TJ]			[t/PJ]		
1990	3 448	59.5	878.5	149.8	0.32	152.2
1995	4 821	50.4	921.3	142.2	0.31	138.3
2000	7 426	13.6	1 027.9	124.3	0.28	106.6
2005	11 016	0.6	736.9	93.4	0.23	58.9
2010	15 324	0.5	556.8	59.7	0.17	24.3
2011	15 401	0.5	559.1	56.0	0.16	22.4
2012	15 960	0.5	544.3	49.0	0.15	19.7
2013	16 051	0.5	512.1	42.4	0.15	16.9
2014	15 722	0.5	487.1	38.2	0.14	15.1
2015	15 318	0.5	463.1	34.5	0.14	13.4
2016	15 424	0.5	428.2	30.4	0.14	11.5
2017	16 193	0.5	378.1	25.3	0.13	9.3

Year	Activity	IEF SO2	IEF NOx	IEF NMVOC	IEF NH3	IEF PM2.5
	[TJ]			[t/PJ]		
2018	17 343	0.5	330.4	20.2	0.13	7.4
2019	18 264	0.5	294.0	16.1	0.12	5.9
2020	17 535	0.5	273.6	13.9	0.12	5.2
2021	19 303	0.5	246.4	11.7	0.12	4.4
2022	20 692	0.5	217.6	9.7	0.12	3.6

Recalculations

Energy consumption for non-road mobile machinery in the industrial sector has been revised for 2021 due to an update of the industrial production index. Instead of 19,148,55 TJ the revised value for energy consumption is 19,302.87 TJ. For NFR *1.A.2.g.7* all this change results in recalculations of: **NO_x** of +0.02 kt (2021: +0.02% of national total and +0.5% of category 1.A.2.g). **SO_2**: +0.0001 kt (2021: +0.0001% of national total and +0.8% of category 1.A.2.g). **NMVOC**: +0.001 kt (2021: +0.001% of national total and +0.3% of category 1.A.2.g). **NH_3**: +0.00002 kt (2021: +0.00003% of national total and +0.8% of category 1.A.2.g). **$PM_{2.5}$**: +0.0003 kt (2021: +0.0027% of national total and +0.4% of category 1.A.2.g). Moreover, NMVOC emissions have been revised for the whole time series due to a correction of a bug in the GEORG model.

Planned Improvements

No category-specific improvements are planned.

3.2.7.2 NFR 1.A.3.c Railways

Methodological Issues

The applied methodology is described in the subchapter on mobile sources of NFR *1.A.2.g.7* above.

Activity Data

In this category emissions from diesel railcars and steam engines are considered. Activities used for estimating the emissions of NFR *1.A.3.c* are presented below. Activities include liquid fuels (diesel and biodiesel) as well as solid fuels (hard coal) yearly taken from the national energy balance.

Emission Factors

Emission factors were taken from (Hausberger, 2006). PM_{10} emission factors for brake-wear (0.3g/km) and rail abrasion (2.75g/km) are included, multiplied by 3 for TSP and multiplied by 30% to get a $PM_{2.5}$ emission factor of 915g/1.000km (Winiwarter, Trenker & Höflinger, 2001).[97] Implied emission factors of NFR *1.A.3.c* are listed in the table below. Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Table 202: Activities and Implied emission factors for NEC gases for 1.A.3.c Railways: 1990–2022.

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	2 380.2	110.8	764.1	153.4	0.3	250.2
1995	1 986.9	104.3	784.9	150.6	0.3	256.8

[97] PM_{10} consists of 30% $PM_{2.5}$ (Winiwarter, Trenker & Höflinger 2001)

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
2000	1 815.4	49.7	824.9	143.9	0.3	249.2
2005	2 187.4	31.3	825.7	128.2	0.2	212.0
2010	2 026.2	27.8	740.3	91.9	0.2	166.5
2011	1 713.9	28.6	718.8	83.8	0.2	155.2
2012	1 763.4	28.7	696.9	79.6	0.2	145.2
2013	1 510.1	29.6	663.9	72.2	0.2	147.3
2014	1 637.1	29.2	633.1	64.7	0.2	130.7
2015	1 245.4	30.8	612.1	61.5	0.2	152.2
2016	1 254.0	30.8	600.4	60.6	0.2	151.5
2017	1 368.0	29.9	576.9	56.9	0.2	140.1
2018	1 307.1	29.8	564.4	55.4	0.2	147.4
2019	1 307.2	29.6	552.8	54.0	0.2	147.4
2020	1 149.5	30.0	536.3	52.6	0.2	153.7
2021	1 139.7	29.7	520.7	51.2	0.1	161.2
2022	1 135.9	29.1	505.5	49.8	0.1	166.0

The increased IEF for $PM_{2.5}$ in 2020 is a result of taking into account exhaust and non-exhaust emission from break wear and rail abrasion which are calculated assuming constant yearly vehicles kilometers. The underlying train kilometers are set constant with 170,000,000 km per year (Winiwarter et al., 2001). For 2021, for instance, the Federal Austrian Railways report on their website 156,600,000 km, which is 7.9 % less than assumed in the calculation. As mileage of private and small local railways (not known, but assumed to be very small) is not included, Austria assumes that the original value is still valid. As planned, *1.A.3.c.* has been improved by considering the latest yearly train mileage in the calculation of $PM_{2.5}$ (Federal Austrian Railways, 2023).

Recalculations

Energy consumption for category "liquid" (blended diesel) was updated according to revised numbers in the national energy balance for 2016 and 2018–2021, leading to revised emissions in the respective years.

Planned Improvements

No category-specific improvements are planned.

3.2.7.3 NFR 1.A.3.d Navigation

This sector includes emissions from fuels used by vessels of all flags that depart and arrive per trip within Austria (*1.A.3.d.ii National navigation*) and emissions from international inland waterways (*1.A.3.d.i.(ii)*) including emissions from journeys that depart in Austria and arrive in a different country. Fishing is excluded.

Methodological Issues

The used methodology conforms to the requirements of the IPCC 2006 GL Tier 2 methodology.

Austria uses the bottom-up model GEORG (Hausberger, 2000) to calculate fuel consumption in navigation which is made up of freight transport activities on the River Danube and passenger transport on rivers and lakes in Austria. Passenger transport is conducted with passenger ships, private motor boats and sailing boats. The inland navigation fleet (stock) was obtained from registration statistics from provincial governments, the average yearly operating time as well as the average fuel consumption per hour from questionnaires to fleet operators and/or manufacturers' data. Statistical data (tkm) for freight activities on the River Danube were obtained from (Via Donau, 2022). Additionally, fuel consumption for working boats is taken into account in the national fuel consumption of navigation.

Based on data from the model GEORG (see *1.A.2.g.7*), domestic navigation has been calculated following a bottom-up approach assuming that domestic navigation comprises the navigation between two harbours located in Austria, expressed in

tons x kilometer → (GWh/tkm*tkm; t_{EMI}/tkm*tkm etc.)

As the inland tkm on the Danube are used for the bottom-up calculation of national navigation, the tkm from import, export and transit-activities on the Danube are used to calculate the international share of inland navigation on the Danube.

General methodological issues of the model GEORG are described in the subchapter on mobile sources of *1.A.2.g.7 (*see Chapter *3.2.7.1).*

Activity Data & Emission Factors

Statistical data (tkm) for freight activities on the River Danube were obtained from (Statistik Austria, 2000–2020). Additionally, fuel consumption of working boats is taken into account. For detailed methodological issues regarding the model GEORG see *1.A.2 g.7.*

Emission factors were taken from (Hausberger, 2006) and a new country-specific study (Schwingshackl/Rexeis & Weller, 2020) which resulted in

- Updated fuel consumption factors (in g/tkm) of Danube freight shipping. According to studies of real fuel consumption (including empty runs, including secondary consumers) current consumption in the upper Danube region amounts to 8.5 g/tkm.
- Updated activities of passenger shipping (Danube, other rivers and lakes), which reflects the trend towards significantly higher activities than assumed before.

Activities and implied emission factors of *1.A.3.d* Navigation (as a sum of national navigation and international inland waterways) are listed below. Activities include liquid fuels (diesel, gasoline and biofuels). Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Table 203: Activities and Implied emission factors for NEC gases for 1.A.3.d Navigation: 1990–2022.

Year	**Activities**	**IEF SO_2**	**IEF NO_x**	**IEF NMVOC**	**IEF NH_3**	**IEF $PM_{2.5}$**
	[TJ]			**[t/PJ]**		
1990	53.2	1 155.5	945.1	0.3	57.2	53.2
1995	46.3	1 190.1	839.8	0.3	57.6	46.3
2000	19.1	1 215.9	728.4	0.3	56.5	19.1
2005	14.6	1 171.9	590.0	0.3	53.3	14.6
2010	13.1	1 040.4	458.9	0.2	45.5	13.1
2011	2.6	1 019.7	445.6	0.2	44.2	2.6
2012	2.7	1 000.6	428.6	0.2	43.1	2.7

Year	Activities	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
2013	2.7	990.2	404.6	0.2	42.4	2.7
2014	2.5	979.7	392.0	0.2	41.7	2.5
2015	2.3	963.4	389.3	0.2	40.8	2.3
2016	2.3	952.9	368.7	0.2	40.1	2.3
2017	2.3	938.1	353.3	0.2	39.3	2.3
2018	1.9	927.0	361.1	0.2	38.9	1.9
2019	1.9	920.1	341.4	0.2	38.5	1.9
2020	3.2	837.5	363.9	0.2	34.4	3.2
2021	2.7	851.2	354.3	0.2	35.1	2.7
2022	1.8	892.0	346.3	0.2	37.3	1.8

The increased SO_2 IEF from 2019 to 2020 is a result of a steep fall in overall fuel consumption (diesel and gasoline), whereas the group of very inefficient small gasoline driven ships and boats with a per se higher SO_2 EF decreased to a much smaller extent than diesel driven navigation.

Quality Assurance and Quality Control (QA/QC)

Harmonization of CRF and IEA data

In 2013 the ERT detected inconsistencies of fuel consumption data of domestic aviation and domestic navigation between the CRF tables and the IEA data (ICR, 2013). In response to that it was explained that Austria uses a bottom-up approach to estimate fuel consumption whilst IEA relies on top-down approach based on fuel consumption statistics reported by Statistics Austria.

After having discussed this issue with Statistics Austria, an Explanatory Note (30/09/2013) has been compiled by Statistics Austria declaring that a regular adoption of inventory data for the split between national and international fuel consumption in civil aviation and navigation in the national statistics will be adopted in the future, as far as the data can be submitted in time (early November).

As part of regular QA/QC the energy split between national and international navigation is provided to Statistics Austria for the IEA statistics based on the bottom up model used to calculate the annual emission inventory.

Completeness

In response to a question raised by the ERT (ICR, 2013) it was explained that emissions of ground activities at domestic harbours are also included, even if they are not separately reported under *1.A.3.e.2 Other*. All registered road vehicles – including those in ports - are taken into account in the emission calculation of NFR *1.A.3.b*. Fuel consumption and emissions of any other port handling equipment is included in the overall calculation. This can be assured as Austria reports emissions from **total fuel sold** from the national energy balance (see chapter on *1.A.3.b. Road Transport - Top down Methodology – Fuel sold*).

Recalculations

Energy consumption was updated after a linking error has been corrected in the GEORG model for 2021, leading to revised emissions in the respective year. Moreover, NMVOC emissions have been revised for the whole time series due to a correction of a bug in the GEORG model.

Planned Improvements

No category-specific improvements are planned.

3.2.7.4 NFR 1.A.4.a.2 Commercial/institutional – mobile sources

Currently there is neither a statistical basis nor any new study on NRMM which would enable Austria to report emissions from mobile sources of *1.A.4.a.2 Commercial/Institutional* separately. Commercial and institutional NRMM are reported as IE and are included in *1.A.2.g.7 Industry* and *1.A.4.c.2 Agriculture and Forestry*.

3.2.7.5 NFR 1.A.4.b.2 Household and gardening – mobile sources

In addition to NRMM used in household and gardening, this category contains mobile machinery such as ski slope machineries, skidoos or mowers.

Methodological Issues

The applied methodology is described in the subchapter on mobile sources of *1.*A.2.*g.7* (see Chapter 3.2.7.1*)*.

Activity Data & Emission Factors

In addition to vehicles used in household and gardening this category contains ski slope machineries and snow vehicles. Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of *1.A.2.g.7* (see Chapter 3.2.7.1).

Activities and implied emission factors of *1.A.4.b.2 Household and gardening – mobile sources* are listed below. Activities include liquid fuels (diesel, gasoline and biofuels). Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Table 204: Activities and Implied emission factors for NEC gases for 1.A.4.b.ii Off-road – Household and gardening: 1990–2022.

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	2 286	25.6	364.9	2 651.6	0.14	60.1
1995	2 286	22.0	396.4	2 495.2	0.14	55.1
2000	2 173	6.18	446.0	2 107.6	0.13	45.4
2005	2 071	0.38	441.6	1 762.9	0.12	32.1
2010	1 870	0.35	404.7	1 024.3	0.11	19.5
2011	1 842	0.35	392.5	909.4	0.10	17.3
2012	1 807	0.35	375.8	820.9	0.10	15.3
2013	1 773	0.35	354.9	773.8	0.09	13.4
2014	1 739	0.35	335.6	744.4	0.09	11.8
2015	1 689	0.36	319.1	718.3	0.09	10.3
2016	1 631	0.36	303.8	695.4	0.09	9.1
2017	1 583	0.37	286.7	668.6	0.08	7.9
2018	1 547	0.37	268.3	639.6	0.08	6.9

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
2019	1 510	0.37	252.5	618.3	0.08	6.3
2020	1 481	0.37	237.2	601.7	0.08	5.8
2021	1 459	0.38	222.0	587.3	0.08	5.4
2022	1 442	0.38	207.5	580.8	0.08	5.1

Recalculations

Energy consumption was updated after a linking error has been corrected in the GEORG model for 2021, leading to revised emissions in the respective year. Moreover, NMVOC emissions have been revised for the whole time series due to a correction of a bug in the GEORG model.

Planned Improvements

No category-specific improvements are planned.

3.2.7.6 NFR 1.A.4.c.2 Agriculture and forestry – mobile sources

In this category emissions from NRMM used in agriculture and forestry (mainly tractors) are considered.

Methodological Issues

The general methodology applied is described in the subchapter on mobile sources of *1.A.2.g.7 (*see Chapter 3.2.7.1*).*

Activity Data & Emission Factors

In this category emissions from off-road machinery in agriculture and forestry (mainly tractors) are considered. Activities of mobile machinery in *1.A.4.c.2* also contain commercially/institutionally used machinery. They could not be split into commercial/institutional and non-commercial/non-institutional use due to a lack of data. Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of *1.A.2.g.7* (see Chapter 3.2.7.1).

Activities and implied emission factors of *1.A.4.c.2 Agriculture and Forestry – mobile sources* are presented below. Activities include liquid fuels (diesel, gasoline and biofuels). Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Table 205: Activities and Implied emission factors for NEC gases for 1.A.4.c.2 Off-road Vehicles and Other Machinery – Agriculture/Forestry/Fishing: 1990–2022.

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	10 366	58.0	908.6	370.6	0.45	198.3
1995	10 106	49.2	923.0	341.3	0.44	185.3
2000	10 610	13.3	932.0	300.6	0.41	165.6
2005	11 434	0.58	843.8	269.0	0.37	131.5
2010	10 901	0.47	758.2	195.0	0.31	92.4
2011	11 818	0.47	746.6	175.0	0.30	84.8
2012	10 909	0.47	733.3	165.7	0.29	78.0

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
2013	10 560	0.47	712.3	153.6	0.28	71.1
2014	11 667	0.47	690.4	134.7	0.27	64.3
2015	10 793	0.47	664.8	132.6	0.26	59.2
2016	11 611	0.47	638.2	118.1	0.25	53.4
2017	10 775	0.47	609.6	118.7	0.24	49.3
2018	10 872	0.47	580.4	116.0	0.23	45.3
2019	11 455	0.47	553.8	106.6	0.23	41.1
2020	11 592	0.47	528.8	96.4	0.22	37.3
2021	11 307	0.47	502.7	97.7	0.21	35.1
2022	11 221	0.47	477.1	96.7	0.21	33.1

Recalculations

Energy consumption was updated after a linking error has been corrected in the GEORG model for 2021, leading to revised emissions in the respective year. Moreover, NMVOC emissions have been revised for the whole time series due to a correction of a bug in the GEORG model.

Planned Improvements

No category-specific improvements are planned.

3.2.7.7 NFR 1.A.3.e.2 Other – Airport Ground Activities

This sector includes emissions from airport ground activities at all Austrian airports. Freight and car traffic to and from the airport is excluded and part of NFR *1.A.3.b*.

Methodological Issues

Applied methodology conforms to the requirements of the IPCC 2006 GL Tier 3 methodology. Country-specific technology-based emission factors (IEFs taken from NFR *1.A.3.b*) are available.

Based on a recommendation made by the UNFCCC during the 2020 Review, Austria collected fuel consumption data of mobile sources used for aircraft handling at Austrian airports. On the basis of specific information from Vienna's International Airport an estimate for all Austrian airports was carried out. Emissions are now reported separately under NFR *1.A.3.e.2 Other*. Fuel and emissions from this source were previously included in NFR source category *1.A.3.b Road Transport.*

The share between the biggest airport VIE (Vienna) and the other five Austrian airports (GRZ, INN, KLU, LNZ, SZG) was calculated on the basis of the most recent evaluation of FC and CO_2 emissions from all Austrian airports for 2010 (Mathä & Ellinger, 2011). With the help of absolute FC numbers at VIE airport in 2019 (Ellinger & Kracher, 2020) and the share for the sum of the other Austrian airports in 2010, the total activity data for NFR *1.A.3.e.2* was calculated for 2019. Second, a constant fuel consumption factor per flight movement was calculated and multiplied with yearly IFR flight movements (with departure airport in Austria) to create the FC time series for 1990 - 2020. Third, for the calculation of emissions time series, the activity data of each fuel type have been multiplied with yearly fuel type specific IEFs for road trucks (RT) and passenger cars (PC) taken from NFR *1.A.3.b*:

- HDV-RT Gasoline Size I

- HDV-RT Diesel Size II
- PC CNG Average

Activity Data & Emission Factors

Activities include liquid fuels (diesel, gasoline and biofuels) and gaseous fuels (CNG). The quantities of liquid and gaseous fuels used at airports represent only a very small proportion of total national fuel sales (0.01% petrol; 0.03% diesel; 0.3% natural gas).

Due to the minor dimension of NFR *1.A.3.e.2* the IEFs for all years and air pollutants are not being displayed separately.

Recalculations

No recalculations have been carried out.

Planned Improvements

No category-specific improvements are planned.

3.2.7.8 NFR 1.A.5.b Other – mobile

In this category emissions of NRMM used for military transport (off-road and aviation) are reported.

Military Off-Road Transport (ground operations)

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 3 methodology for road transport. The applied methodology is described in the subchapter on mobile sources of *1.A.2.g.7* (see Chapter 3.2.7.1*)*.

Activity Data

Emission estimates for military activities were taken from (Hausberger, 2000). Information on the fleet composition was taken from official data presented in the internet as for reasons of confidentiality no other data were available. In 2023, our efforts to improve inventory data quality in this area were successful.
For the 2024 submission the Austrian Ministry made some key data available like diesel consumption and vehicle fleet for the year 2021. For the model GEORG this vehicles fleet was grouped into two groups: <130 kW and >130 kW with an average nominal power of 95 kW (<130kW) and 422 kW (>130kW). Activities of 142 h/year (<130kW) and 29 h/year (>130kW) were assumed. Further assumptions were that a) the vehicle fleet remains constant due to long service life (confirmed by expert assessment) and b) the split of new registrations is 40% for <130 kW and 60% for >130 kW nominal power vehicles over the entire time series.

With these assumptions the model result was calibrated with the operating hours in 2021 to meet the diesel consumption of 2021. For time series consistency surrogate data (the statistical time series of the number of military personell) was used to scale the operating hours over the time series and calculate the new amounts of diesel consumption per year.

Emission Factors

For tanks and other special military vehicles the emission factors for diesel engines > 80 kW was used (for these vehicles a power of 300 kW was assumed). Details concerning emission factors are described in the subchapter on mobile sources of *1.A.2.g.7* (see Chapter 3.2.7.1*).*

Military Aviation

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 1 (simple) methodology for aviation with country specific emission factors. The methodology is based on operation hours and average fuel consumption per hour for the years 1990-1998 with a linear trend extrapolation for the years from 1998 onwards. The calculation of emissions from military aviation does not distinguish between LTO and cruise.

Activity Data

For the years 1990–1998, fuel consumption for military flights was reported once by the Austrian Ministry of Defence and used to calculate emissions from military aviation as part of of the general flight study (Kalivoda/Kudrna, 2002).

In response to a recommendation made by the UNFCCC 2020 on Austria's methodology for estimating emissions from military aviation 2000–2018, the data on kerosene consumption was re-evaluated.

However, after several official attempts to allocate data from the Austrian Ministry of Defence, no data was provided. Therefore, the historical number of aircrafts (fighter jets, airplanes, helicopters) was compared with current data found on the Internet on the number of operating military aircraft assuming constant flight hours.[98]

Starting with the year 2009, fuel consumption was interpolated according to the trend until the year 2020. The latest inventory year is being updated yearly via this source (last update autumn 2023 for the 2024 submission). According to the trend shown in the table below fuel consumption is now declining from 2009 onwards.

Table 206: Military aircraft stock 2008 and 2020 and 2022.

	Helicopters	**Fighter jets and airplanes**	**Total number of military aircraft**
2008	78	96	174
2020	64 (prev. 82)	43	107 (prev. 125)
2022	60	43	103
Trend 2008–2022	**-23%**	**-55%**	**-41%**

As no aircraft data prior to 2008 could be found (PÖTSCHER 2008), the subsequent revision of activity data refers to the years 2009–2019 only; for the years 1999–2008 the previously applied method (linear extrapolation) has been retained, while for the years 1990-1998 the results of the flight study have been used directly as in previous submissions.

[98] https://de.wikipedia.org/wiki/Luftstreitkr%C3%A4fte_(Bundesheer); 5.12.2021

Emission Factors

For the years from 2000 onwards, emissions for military flights have been calculated with IEFs from the year 2000 taken from (Kalivoda & Kudrna, 2002).

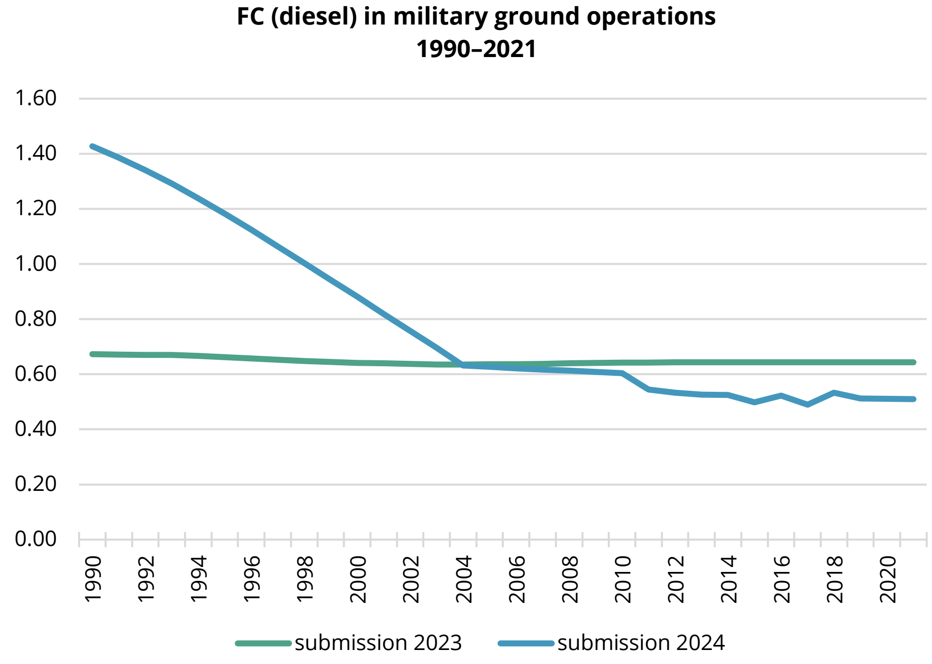
Table 207: IEF for the year 2000.

IEFs		
2000	**[t]**	**[kg/t fuel]**
Fuel	13 613	
SO_2	13.68	1.0
NO_x	66	4.9
NH_3	0.08	0.0
VOC_HC	15	1.1
NMVOC	13.25	1.0
$PM_{2.5}$	13	1.0
CO	258	18.9

Recalculations

For military ground operations the whole time series has been changed due to new fuel consumption data for 2021 provided by the Austrian Ministry of Defense. In the submission 2024 diesel fuel consumption is 1.43 kt for 1990 (previous value 0.67 kt): +0.8 kt; for 2021 it is 0.51 kt (previous value 0.64 kt): -0.1 kt. The following graph shows the revision over the whole time series.

Figure 46: Comparison of diesel consumption for military ground operations with previous submission.

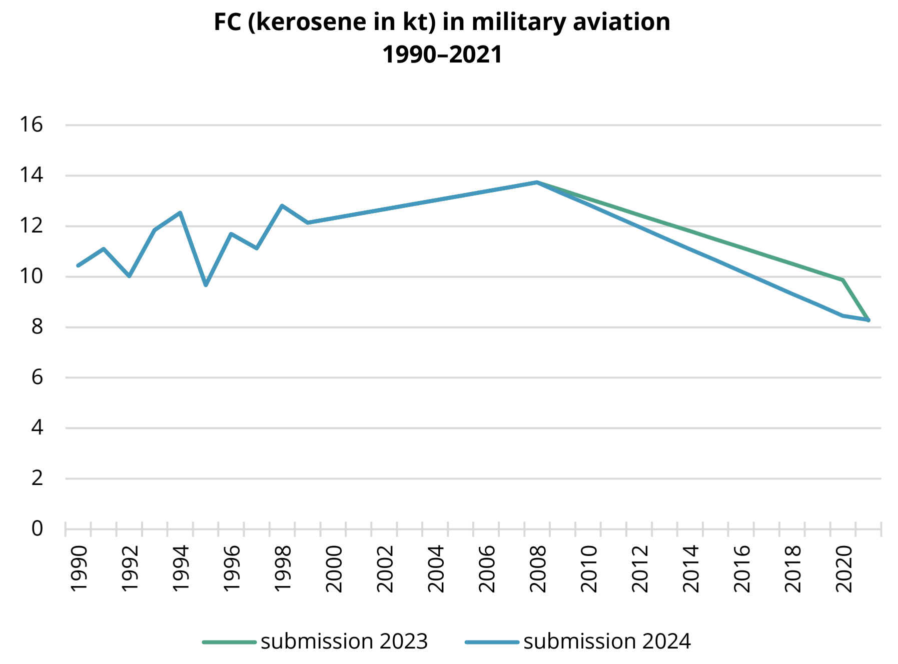


Source: Umweltbundesamt

umweltbundesamt

For military aviation a misinterpretation in the data source was corrected regarding the fleet number of helicopters for 2020 (64 instead of 82). This changed the total number of military aircraft in 2020. As data for the years 2009 to 2019 and for 2021 are determined by interpolation these are affected by recalculation as well (2009: -0.12 kt kerosene; 2021: +0.02 kt kerosene). The following graph shows the revision over the whole time series.

Figure 47: Comparison of kerosene consumption for military aviation with previous submission.



Source: Umweltbundesamt

For NFR *1.A.5.b Military* (all mobile combustion) the following recalculations occur: NO_x between +0.02 kt (1990: +0.01% of national total and +33.02% of category *1.A.5.b*) and +0.002 kt (2021: +0.001% of national total and +3.84% of category *1.A.5.b*). SO_2: +0.002 kt (1990: +0.003% of national total and +15.81% of category *1.A.5.b*) and -0.001 kt (2021: -0.01% of national total and -6.23% of category *1.A.5.b*). NMVOC: +0.005 kt (1990: +0.001% of national total and +34.04% of category *1.A.5.b*) and -0.0002 kt (2021: -0.0002% of national total and -1.80% of category *1.A.5.*b). NH_3: +0.00001 kt (1990: +0.00001% of national total and +10.05% of category *1.A.5.b*) and +0.0000003 kt (2021: +0.0000004% of national total and +0.48% of category *1.A.5.*b). $PM_{2.5}$: +0.01 kt (1990: +0.02% of national total and +36,44% of category *1.A.5.b*) and +0.0004 kt (2021: +0.003% of national total and +4,69% of category *1.A.5.*b).

Planned Improvements

In contrast to military ground operations, it was not possible to obtain actual data for military aviation. Austria will launch a new attempt to receive updated activity data for military aviation from the Austrian Ministry of Defence for its next submission.

3.2.8 Emission factors for heavy metals and POPs used in *NFR 1.A.3 Transport*

In the following chapter the emission factors for heavy metals and POPs used in *NFR 1.A.3* are described. For *1.A.3.a Civil Aviation* and *1.A.5.b Military (Aviation)* POPs emissions are not estimated (NE).

3.2.8.1 Heavy metals

As can be seen in Table 81, the HM content of lighter oil products in Austria are below the detection limit. For Cd, Hg and for Pb from 1995 onwards 50% of the detection limit was used as emission factor for all years.

Pb emission factors before 1995 for gasoline were calculated from the legal content limit for the different types of gasoline and the amounts of different types sold in the respective year. Furthermore, it was considered that according to the CORINAIR 1997 Guidebook (CORINAIR, 1997) the emission rate for conventional engines is 75% and for engines with catalyst 40% (the type of fuel used in the different engine types was also considered).

The production and import of leaded gasoline has been prohibited in Austria since 1993. Earlier emission estimates are based on a lead content of 0.56 g Pb/litre for aviation gasoline. From 1996 on a lead content of 0,1 mg/GJ has been estimated for gasoline due to the assumed use of lead additives for old non-catalyst vehicles and that a lead content of 0.02 mg/GJ has been assumed for diesel oil and kerosene.

The same emission factors were also used for mobile combustion in Categories NFR *1.A.2,* NFR *1.A.4 and NFR 1.A.5.b Military (Off-road sources).*

For coal fired steam locomotives in NFR *1.A.3.c* the emission factor for uncontrolled coal combustion from the CORINAIR 1997 Guidebook (CORINAIR, 1997) was used.

Table 208: HM emission factors for Sector 1.A.3 Transport and SNAP 08 Off-Road Machinery.

EF [mg/GJ]	Cd	Hg	Pb
Diesel, kerosene, gasoline, aviation gasoline *(see also following table)*	0.02	0.01	0.02
Coal (railways)	5.4	10.7	89
Automobile tyre- and break-wear: passenger cars, motorcycles	0.5	–	–
Automobile tyre- and break-wear: LDV and HDV	5.0	–	–

Table 209: Pb emission factors for gasoline for Sector 1.A.3 Transport and SNAP 08 Off-Road Machinery.

Pb EF [mg/GJ]	1985	1990	1995
gasoline (conventional)	2 200	2 060	0.1
gasoline (catalyst)	130	130	0.1
gasoline type jet fuel	23 990	15 915	0.1

Hg, Cd and Pb emissions have been integrated in the model NEMO using the mean values of the emission factors provided in the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA, 2019).

The result contains shares of Cd and Pb emissions for road traffic according to the guidebook for the following components:

- engine (exhaust emissions of cylinder abrasion, abrasion of coating of pistons and seals)
- liquids (exhaust emissions of lubricants)
- tyre wear (non-exhaust emissions)
- brake abrasion (non-exhaust emissions)

Table 210: Pb non-exhaust emission factors for 1A3bvi Tyre and Break wear (SNAP 070700X7A, 070700X7B, 070700X7C)

Pb EF [mg/1000 vehicle km]	**1985**
2-Wheelers	486.7
Passenger cars	47.4
LDV & HDV	108.5

For Hg the model NEMO only calculates emissions of the following component

- engine (exhaust emissions of cylinder abrasion, abrasion of coating of pistons and seals) due to missing non-exhaust emission factors in the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA, 2019).

3.2.8.2 POPs emissions

In the following the emission factors for POPs (PAH, Dioxin, HCB and PCB) used in NFR *1.A.3* and in the off-road transport are described.[99]

PAH emission factors

The Austrian transport model NEMO includes emission factors for the following four PAHs relevant for NFR *1.A.3.b Road Transport* in accordance with the UNECE POPs protocol:

- indeno(1,2,3-cd)pyrene
- benzo(k)fluoranthene
- benzo(b)fluoranthene
- benzo(a)pyrene

According to the EMEP/EEA Guidebook 2013 (EEA, 2013) specific exhaust emission factors were taken for each vehicle category and emission class given in [µg/km]. The non-exhaust emission factors (abrasion and suspension) were also taken from (EEA, 2013) and implemented in the model NEMO as ratio factors of TSP non-exhaust (from tires and brake) in ppm (mass related). These emission factors are calculated in NEMO according to the Tier 2 methodology (Hausberger/Schwingshackl & Rexeis, 2015a) via relationship factors from the tyre and brake TSP emission values.

[99] Emissions from off-road machinery are reported under *1.A.2.g.7* (machinery in industry), *1.A.4.b.2* (machinery in household and gardening), *1.A.4.c.2* (machinery in agriculture/forestry/fishing) and *1.A.5.b.* (Military mobile sources).

- For estimating PAK emissions from mobile off-road sources in NFR *1.A.2,* NFR *1.A.3.c,* NFR *1.A.3.d,* NFR *1.A.4 and* NFR *1.A.5.b* trimmed averages from emission factors in (Umweltbundesamt Berlin, 1998), (Scheidl, 1996) and (Orthofer & Vesely, 1990) as well as measurements of emissions of a tractor engine by FTU (FTU, 2000) were applied.
- For diesel fuelled mobile off-road sources the HDV emission factor was taken;
- For gasoline driven mobile sources in NFR *1.A.3.d* and NFR *1.A.4.c* (agriculture) the PC gasoline value;
- For gasoline fuelled mobile sources in NFR *1.A.2*, NFR *1.A.4.b* and NFR *1.A.4.c.2* (forestry) the motorcycles < 50 ccm value was taken.
- For coal fired steam locomotives in NFR *1.A.3.c* the same emission factor as for NFR *1.A.4.b – stoves* were used.

Table 211: POP emission factors for Sector SNAP 08 Off-Road Machinery.

	PCDD/F EF [µgTE/GJ]	**PAK4 [mg/GJ]**
Passenger cars gasoline	0.046	5.3
PC. gasoline with catalyst	0.0012	0.32
Passenger cars diesel	0.0007	6.4
LDV	0.0007	6.4
HDV	0.0055	6.4
Motorcycles < 50 ccm	0.0031	21
Motorcycles < 50 ccm with catalyst	0.0012	2.1
Motorcycles > 50 ccm	0.0031	33
Coal fired steam locomotives	0.38	0.085

Dioxin emissions

Dioxin emission factors are presented in Table 211 and based on findings from (Hübner, 2000).

HCB emissions

HCB emissions were calculated on the basis of dioxin emissions and assuming a factor of 200 (Hübner, 2001b).

PCB emission factors

For the calculation of PCB emissions in the model NEMO specific emission factors were taken from (EEA, 2013) for each vehicle category and emission class given in [picograms/km]. Due to the low emission factors given in the guidebook, the calculated PCB emissions from NFR *1.A.3.b Road Transport* are a minor source (Hausberger/Schwingshackl & Rexeis 2015a).

Since no calculation method or values for PCB emissions from mobile off-road machinery in NFR *1.A.2,* NFR *1.A.3.c,* NFR *1.A.3.d,* NFR *1.A.4 and* NFR *1.A.5* are given in the literature for diesel machines they were derived from truck emissions from road transport (approach: PCB emissions related to engine work). For gasoline-powered equipment, motorcycles have been used (approach: PCB emissions as a percentage of the HC emissions) (Hausberger/Schwingshackl & Rexeis, 2015a).

3.2.8.3 Implied emission factors per subcategory

NFR 1.A.3.a Civil Aviation – LTO

Emissions of lead are only relevant for aviation gasoline (only used for national VFR flights) and have significantly dropped between 1994 and 1995 in consequence of a prohibition of the production and import of leaded gasoline in Austria (also see chapter 3.2.8.1).

Table 212: Activities and Implied emission factors for heavy metals for 1.A.3.a.ii Civil Aviation (domestic LTO + international LTO): 1990–2022.

Year	**Activity**	**IEF Cd**	**IEF Hg**	**IEF Pb**
	[TJ]		**[kg/PJ]**	
1990	1 829	0.020	0.007	894.96
1995	2 706	0.020	0.007	0.023
2000	3 239	0.020	0.007	0.022
2005	4 055	0.020	0.007	0.022
2010	4 181	0.020	0.007	0.022
2011	4 726	0.020	0.007	0.023
2012	4 484	0.020	0.007	0.022
2013	4 375	0.020	0.007	0.022
2014	4 390	0.020	0.007	0.022
2015	4 624	0.020	0.007	0.022
2016	4 744	0.020	0.007	0.051
2017	4 555	0.020	0.007	0.065
2018	4 957	0.020	0.007	0.060
2019	5 570	0.020	0.007	0.071
2020	2 221	0.020	0.007	0.161
2021	2 583	0.020	0.007	0.154
2022	4 044	0.020	0.007	0.093

Recalculations

No category specific recalculations have been carried out.

Memo Item 1.A.3.a Civil Aviation – Cruise

As aviation gasoline is only used for domestic VFR flights the significant drop of lead emissions in the 90ies is not visible in the cruise emissions. PAH, Dioxin, HCB and PCB emissions are not estimated.

Table 213: Activities and Implied emission factors for heavy metals for International Bunkers (domestic + international cruise traffic): 1990–2022.

Year	**Activity**	**IEF Cd**	**IEF Hg**	**IEF Pb**
	[TJ]		**[kg/PJ]**	
1990	10 791	0.020	0.007	0.020
1995	16 337	0.020	0.007	0.020
2000	20 977	0.020	0.007	0.020
2005	23 784	0.020	0.007	0.020
2010	24 846	0.020	0.007	0.020

Year	Activity	IEF Cd	IEF Hg	IEF Pb
2011	25 907	0.020	0.007	0.020
2012	24 739	0.020	0.007	0.020
2013	23 512	0.020	0.007	0.020
2014	23 469	0.020	0.007	0.020
2015	25 300	0.020	0.007	0.020
2016	27 860	0.020	0.007	0.020
2017	26 898	0.020	0.007	0.020
2018	30 451	0.020	0.007	0.020
2019	35 095	0.020	0.007	0.020
2020	12 479	0.020	0.007	0.020
2021	14 657	0.020	0.007	0.020
2022	23 401	0.020	0.007	0.020

Recalculations

No category specific recalculations have been carried out.

NFR 1.A.3.b Road Transport

Emissions of lead are only relevant for gasoline and have significantly dropped in the mid 90ies as a result of unleaded gasoline introduction.

Table 214: Activities and Implied emission factors for heavy metals and POPs for 1.A.3.b Road Transport: 1990–2022.

Year	Activity [TJ]	IEF Cd [kg/PJ]	IEF Hg [kg/PJ]	IEF Pb [kg/PJ]	IEF PAH [kg/PJ]	IEF Diox [g/PJ]	IEF HCB [g/PJ]	IEF PCB [g/PJ]
1990	176 192	0.098	0.007	1 006.70	1.51	0.023	4.65	0.002
1995	202 065	0.100	0.007	17.22	1.69	0.012	2.36	0.002
2000	240 968	0.100	0.007	16.97	1.45	0.006	1.11	0.003
2005	324 765	0.101	0.007	17.21	1.17	0.004	0.79	0.003
2010	305 776	0.105	0.007	18.23	1.08	0.005	1.01	0.003
2011	295 549	0.106	0.007	18.52	1.06	0.005	1.00	0.002
2012	295 346	0.106	0.007	18.50	1.04	0.005	1.02	0.002
2013	309 053	0.105	0.007	18.25	1.04	0.005	1.02	0.002
2014	301 633	0.108	0.007	18.82	1.05	0.005	1.03	0.002
2015	308 877	0.108	0.007	19.02	1.05	0.005	1.05	0.002
2016	318 645	0.107	0.007	18.83	1.02	0.005	1.00	0.002
2017	326 427	0.107	0.007	18.78	1.01	0.005	0.96	0.001
2018	329 481	0.108	0.007	18.83	1.01	0.005	0.96	0.001
2019	329 930	0.108	0.007	18.79	1.02	0.005	0.95	0.001
2020	286 316	0.108	0.007	18.80	1.02	0.005	0.98	0.001
2021	298 104	0.108	0.007	18.92	1.02	0.005	0.98	0.001
2022	283 166	0.110	0.007	19.48	1.01	0.005	0.94	0.001

Recalculations

No category specific recalculations have been carried out.

NFR 1.A.3.c Railways

Table 215: Activities and Implied emission factors for heavy metals and POPs for 1.A.3.c Railways 1990–2022.

Year	Activity [TJ]	IEF Cd [kg/PJ]	IEF Hg [kg/PJ]	IEF Pb [kg/PJ]	IEF PAH [kg/PJ]	IEF Diox [g/PJ]	IEF HCB [g/PJ]	IEF PCB [g/PJ]
1990	2 380	0.178	0.320	2.63	8.70	0.0165	3.294	0.00116
1995	1 987	0.185	0.335	2.75	8.81	0.0170	3.399	0.00117
2000	1 815	0.100	0.166	1.34	7.57	0.0111	2.212	0.00104
2005	2 187	0.043	0.054	0.41	6.73	0.0075	1.500	0.00098
2010	2 026	0.031	0.031	0.22	6.50	0.0084	1.689	0.00105
2011	1 714	0.033	0.036	0.26	6.53	0.0086	1.728	0.00107
2012	1 763	0.034	0.036	0.26	6.53	0.0087	1.749	0.00108
2013	1 510	0.036	0.041	0.31	6.58	0.0088	1.763	0.00107
2014	1 637	0.035	0.039	0.29	6.55	0.0089	1.784	0.00106
2015	1 245	0.040	0.048	0.36	6.62	0.0095	1.894	0.00105
2016	1 254	0.040	0.048	0.36	6.62	0.0092	1.842	0.00102
2017	1 368	0.037	0.043	0.32	6.59	0.0088	1.758	0.00098
2018	1 307	0.037	0.043	0.32	6.59	0.0088	1.757	0.00095
2019	1 307	0.036	0.041	0.30	6.58	0.0087	1.730	0.00092
2020	1 149	0.038	0.044	0.33	6.60	0.0087	1.744	0.00090
2021	1 140	0.037	0.042	0.31	6.59	0.0087	1.741	0.00087
2022	1 136	0.035	0.038	0.28	6.56	0.0086	1.711	0.00084

Recalculations

No category specific recalculations have been carried out.

3.2.8.3.1 NFR 1.A.3.d Navigation

Table 216: Activities and Implied emission factors for heavy metals and POPs for 1.A.3.d Navigation 1990–2022.

Year	Activity [TJ]	IEF Cd [kg/PJ]	IEF Hg [kg/PJ]	IEF Pb [kg/PJ]	IEF PAH [kg/PJ]	IEF Diox [g/PJ]	IEF HCB [g/PJ]	IEF PCB [g/PJ]
1990	993	0.020	0.007	261.921	6.260	0.011	2.130	0.005
1995	1 229	0.020	0.007	0.028	6.289	0.010	1.918	0.004
2000	1 469	0.020	0.007	0.027	6.310	0.009	1.764	0.003
2005	1 747	0.020	0.007	0.025	6.324	0.008	1.654	0.003
2010	1 664	0.019	0.007	0.024	6.298	0.009	1.793	0.002
2011	1 617	0.019	0.007	0.024	6.293	0.009	1.821	0.002
2012	1 562	0.019	0.007	0.024	6.292	0.009	1.825	0.002
2013	1 663	0.019	0.007	0.024	6.300	0.009	1.776	0.002
2014	1 694	0.019	0.007	0.024	6.295	0.009	1.804	0.002
2015	1 581	0.019	0.007	0.024	6.283	0.009	1.879	0.002
2016	1 678	0.019	0.007	0.024	6.293	0.009	1.810	0.002
2017	1 754	0.019	0.007	0.023	6.299	0.009	1.766	0.002
2018	1 591	0.019	0.007	0.024	6.287	0.009	1.845	0.002
2019	1 792	0.019	0.007	0.023	6.297	0.009	1.776	0.002
2020	902	0.020	0.007	0.027	6.264	0.010	2.068	0.002
2021	1 024	0.019	0.007	0.026	6.269	0.010	2.008	0.002
2022	1 406	0.019	0.007	0.024	6.281	0.009	1.889	0.002

Recalculations

No category specific recalculations have been carried out.

3.3 NFR 1.B Fugitive Emissions

Fugitive Emissions arise from the production and extraction of coal, oil and natural gas; their storage, processing and distribution. These emissions are fugitive emissions and are reported in NFR Category 1.B. Emissions from fuel combustion during these processes are reported in NFR Category 1.A.

3.3.1 Completeness

Table 217 gives an overview of the NFR categories included in this chapter and on the status of emission estimates of all sub categories. A "✓" indicates that emissions from this sub category have been estimated.

Table 217: Overview of sub categories of category 1.B Fugitive Emissions and status of estimation.

NFR Category			Status													
			NEC gas				CO	PM			Heavy metals			POPs		
			NO_x	SO_x	NH_3	NMVOC	CO	TSP	PM_{10}	$PM_{2.5}$	Cd	Hg	Pb	PCDD/F	PAH	HCB
1.B.1.a	Fugitive emissions from solid fuels: Coal mining and handling															
1.B.1.a.i	Coal Mining and Handling: Underground mines	050102 Underground mining	NA	NA	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA
		050103 Storage of solid fuels - Postmining activities	NA	NA	NA	NA	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA
1.B.1.a.ii	Coal Mining and Handling: Surface mines	050101 Open cast mining	NA	NA	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA
		050103 Storage of solid fuels - Postmining activities	NA	NA	NA	NA	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA
1.B.1.b	Solid fuel transformation(1)		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1.B.1.c	Other - Other fugitive emissions from solid fuels (NFR - only Non-GHG)	050121 Peat production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

NFR Category			Status													
			NEC gas				CO	PM			Heavy metals			POPs		
			NO_x	SO_x	NH_3	NMVOC	CO	TSP	PM_{10}	$PM_{2.5}$	Cd	Hg	Pb	PCDD/F	PAH	HCB
1.B.2.a.i	Exploration, Production, Transport	050201 Extraction, 1st treatment and loading of liquid fossil fuels – land based activities 050601_X50 Oil pipelines	NA	NA	NA	IE, ✓(4)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.a.iv	Refining /Storage	050501 Refinary dispatch station 0401 Processes in petroleum industries	NA	IE	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.a.v	Distribution of oil products	050502 Transport and depots 050503 Service stations	NA	NA	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.b	Natural gas	050301 Extraction - Land-based desulfuration 050302 Extraction - Land-based activities (other than desulfuration) 050601X51 Transmission fugitive and venting 050601X52 Storing 050603 Gas distribution networks	NA	✓	NA	✓(3)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.c	Venting and flaring(2)	090206 Flaring in gas and oil extraction	IE	IE	IE	IE	IE	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.d	Other fugitive emissions	0507 Geothermal Energy Extraction	NA	NA	✓	NA	NA	NA	NA	NA	NA	✓	NA	NA	NA	NA

(1) *included in 1.A.2.a Iron and Steel*

(2) *included in 1.A.1.b Petroleum Refining*

(3) *050302 includes NMVOC emissions from 050201*

(4) *NMVOC from 050601_X50 estimated and reported under this category; NMVOC from 050201 are included in 1.B.2.b (050302)*

3.3.2 NFR 1.B.1.a Coal mining and handling – Methodological issues

In this category NMVOC, TSP, PM_{10} and $PM_{2.5}$ emissions from coal mining and handling and TSP, PM_{10} and $PM_{2.5}$ emissions from storage of solid fuels, including coke oven coke, bituminous coal and anthracite, lignite and brown coal are considered.

NMVOC emissions were calculated based on activity data available in national statistics and reports (e.g. a report on mining (Montanhandbuch) by the Federal Ministry of Economy, Family and Youth (BMWFJ, 1991–2014) and the Tier 2 emission factors for open cast mining and underground mining given in the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA, 2019). Before coal mining was stopped in 2007 emissions decreased sharply 2003–2004 (-80%) as well as 2004–2005 (- 97%).

The emissions of TSP, PM_{10} and $PM_{2.5}$ for Open Cast Mining were calculated by using the Tier 2 emission factors of the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA, 2019). For the calculation of particulate matter emissions from Underground Mining the Tier 1 emission factors were applied as there is no activity data available to apply the Tier 2.

TSP, PM_{10} and $PM_{2.5}$ emissions for the storage of solid fuels were calculated with the simple CORINAIR methodology. Activity data were taken from the national energy balance (STATISTIK AUSTRIA, 2023a) and are presented in Table 218. The emission factors from a national study (WINIWARTER, W., TRENKER, C. und W. HÖFLINGER, 2001) were converted by multiplying the emission factor with the respective net calorific value (Bituminous coal/Anthracite: 29.07 GJ/t, Lignite/Brown coal 10 GJ/t, Coke oven coke 29 GJ/t) to obtain emission factors in kg/kt.

Table 218: Emission factors fugitive TSP, PM_{10} and $PM_{2.5}$ and NMVOC emissions from NFR category 1.B.1.a.

	Storage of solid fuels			Coal Mining and Handling	
PM	**Bituminous coal/Anthracite**	**Lignite/ Brown coal**	**Coke oven coke**	**Open Cast Mining**	**Underground Mining**
	EF [kg/kt]			**EF [g/t]**	**EF [g/t]**
TSP	96	85	108	82	89
PM_{10}	45	39	51	39	42
$PM_{2.5}$	14	12	16	6	5
NMVOC	-	-	-	200	3 000

Table 219: Activity data for fugitive TSP, PM_{10} and $PM_{2.5}$ and NMVOC emissions from NFR category 1.B.1.a.

Year	**Activity [kt]**			**Activity [kt]**	
	Storage of solid fuels			**Mining activities**	
	Bituminous coal	**Lignite**	**Coke Oven Coke**	**Lignite**	**Bituminous coal**
1990	1 822	2 504	2 403	1 577	870
1995	1 484	1 743	2 354	1 271	27
2000	1 847	1 381	2 436	1 249	NO
2001	2 039	1 630	2 320	1 206	NO
2002	1 943	1 561	2 590	1 412	NO
2003	2 412	1 655	2 481	1 152	NO
2004	2 424	1 215	2 443	235	NO
2005	2 146	1 272	2 684	6	NO
2006	2 341	753	2 700	7	NO
2007	2 385	95	2 711	NO	NO
2008	2 195	88	2 836	NO	NO
2009	1 527	84	2 111	NO	NO
2010	1 902	82	2 555	NO	NO
2011	2 045	88	2 568	NO	NO
2012	1 698	88	2 521	NO	NO
2013	1 693	84	2 626	NO	NO
2014	1 341	94	2 534	NO	NO
2015	1 916	94	2 343	NO	NO

Year	Activity [kt]			Activity [kt]	
	Storage of solid fuels			Mining activities	
	Bituminous coal	Lignite	Coke Oven Coke	Lignite	Bituminous coal
2016	1 715	79	2 260	NO	NO
2017	1 617	76	2 530	NO	NO
2018	1 484	79	2 095	NO	NO
2019	1 370	68	2 359	NO	NO
2020	1 090	64	2 095	NO	NO
2021	1 010	59	2 281	NO	NO
2022	777	68	2 217	NO	NO
1990–2022	**-57%**	**-97%**	**-7.7%**	**-100%**	**-100%**

3.3.3 NFR 1.B.2.a Oil – Methodological issues

In this category, NMVOC emissions from the transport and distribution of crude oil, oil products as well as from oil refining are considered.

Activity data and NMVOC emissions data from natural gas and crude oil extraction and treatment are reported from the „Fachverband Mineralöl" (Austrian association of oil industry; FVMI, 2023). NMVOC emissions are reported from 1992 onwards, for the years before the emission value of 1992 was taken.

Activity data for the transport of crude oil (crude oil throughput) is reported by the „Fachverband Mineralöl" (Austrian association of oil industry; FVMI, 2023). For the calculation of NMVOC emissions from this source an emission factor of 54 000 g/1 000m^3 was used, taken from the 2006 IPCC Guidelines (Volume 2: Energy, p. 4.52, Table 4.2.4).

Emissions and activity data for refinery dispatch stations, transport and depots and from service stations and refuelling of cars (petrol) were reported directly from „Fachverband Mineralöl" (FVMI, 2023). For transport and depots from 2010 onwards, data from a further operator of storage tanks are included additionally.

Activity data for oil refining (crude oil refined) were taken from national statistics. An implied emission factor was calculated on the basis of emission and activity data. Activity data and implied emission factors are presented in Table 220.

Table 220: Activity data and implied emission factors for fugitive NMVOC emissions from NFR category 1.B.2.a.

Year	Transport of crude oil[100]	Refinery dispatch station		Oil refining	
	Activity [1 000m^3]	NMVOC IEF [g/t]	Gasoline [kt]	NMVOC IEF [g/t]	Crude oil refined [kt]
1990	9 404	1 109	2 554	472	7 952
1995	10 260	916	2 402	174	8 619
2000	10 259	811	1 980	168	8 240
2005	10 588	205	2 073	59	8 743

[100] Refinery crude oil throughput

Year	Transport of crude oil[100]	Refinery dispatch station		Oil refining	
	Activity [1 000m³]	NMVOC IEF [g/t]	Gasoline [kt]	NMVOC IEF [g/t]	Crude oil refined [kt]
2010	9 765	171	1 821	55	7 719
2011	10 471	181	1 756	50	8 170
2012	10 824	173	1 715	47	8 349
2013	10 941	169	1 665	40	8 584
2014	10 941	183	1 624	48	8 435
2015	11 176	161	1 640	44	8 853
2016	10 471	139	1 638	50	8 184
2017	10 588	157	1 619	58	8 064
2018	11 529	128	1 658	41	8 970
2019	11 765	128	1 650	38	9 124
2020	10 235	136	1 377	38	8 168
2021	9 882	128	1 441	37	8 243
2022	6 824	115	1 500	57	5 617

Year	Transport and depots		Service stations	
	NMVOC IEF [g/t]	Gasoline [kt]	NMVOC IEF [g/t]	Petrol [kt]
1990	995	2 554	736	2 554
1995	986	2 402	662	2 402
2000	241	1 980	270	1 980
2005	206	2 073	270	2 073
2010	120	1 897	270	1 821
2011	112	1 822	270	1 756
2012	135	1 785	270	1 715
2013	137	1 732	270	1 665
2014	154	1 678	270	1 624
2015	144	1 683	270	1 640
2016	147	1 681	270	1 638
2017	127	1 682	270	1 619
2018	128	1 727	270	1 658
2019	151	1 698	270	1 650
2020	119	1 428	270	1 377
2021	119	1 492	270	1 441
2022	137	1 546	270	1 500

Between 1990 and 2022 NMVOC emissions from the transport of crude oil (oil pipelines) decreased by 27.4% due to the decreased refinery activity.

NMVOC emissions from refinery dispatch stations, transport and depots and from service stations and refuelling of cars decreased remarkably (-94%, -92% and -78% respectively) between 1990 and 2022 due to installation of gas recovery units.

NMVOC emissions from oil refining also shows a notable decrease of 91% between 1990 and 2022. This emission reduction has been achieved through technical improvements (e.g. improved tanks and loading units).

3.3.4 NFR 1.B.2.b Natural Gas – Methodological issues

In this category, SO_2 emissions from the first treatment of sour gas and NMVOC emissions from gas production and the gas distribution networks are considered.

SO_2 emissions and activity data for the first treatment of sour gas are reported from „Fachverband Mineralöl" (Austrian association of oil industry; FVMI, 2023). The drop in SO_2 emissions after 1996 is due to the implementation of pollution control measures. Emission data for 1990–1998 as well as for 2013–2021 were taken from the „Fachverband Mineralöl", for the years in between (1999–2012) an EF of 120 g/1 000m^3 was used, based on an expert opinion on the sulphur emission level of desulfurization in Austria's refinery plant. The drop of -36% of raw gas throughput in 2016 was due to the failure of one sour gas tube in one plant.

Activity data and NMVOC emissions from gas extraction are reported by the „Fachverband Mineralöl" (Austrian association of oil industry; FVMI, 2023). NMVOC emissions from gas distribution networks were calculated by applying a country-specific share of NMVOC in natural gas. This share is based on the natural gas composition in Austria and increases over time. Emissions were directly linked to CH_4 emissions that were calculated applying a tier 2 method based on the material specific distribution pipeline lengths reported by the Association of Gas- and District Heating Supply Companies reported by "Fachverband der Gas- und Wärmeversorgungsunternehmungen", "Association of Gas- and District Heating Supply Companies" (FVGW, 2023) and material specific emission factors (WARTHA, 2005).

Table 221: Activity data and implied emission factors for fugitive NMVOC and SO_2 emissions from NFR category 1.B.2.b.

Year	First treatment desulfuration		Gas extraction		Gas distribution	
	SO_2 IEF [g/1 000 m^3]	Raw gas Throughput [1 000 m^3]	NMVOC IEF [g/1000m^3]	Gas production [1000m^3]	NMVOC IEF [g/km]	Distribution mains [km]
1990	8 062	248 090	849	1 288 000	4 793	11 672
1995	3 772	405 638	676	1 482 000	2 928	17 778
2000	120	358 357	525	1 805 000	2 027	24 099
2005	120	338 349	557	1 637 000	1 995	26 958
2010	120	397 132	288	1 816 000	2 273	28 733
2011	120	375 168	295	1 684 000	2 354	29 023
2012	120	375 420	270	1 807 000	2 407	29 260
2013	116	335 874	319	1 467 000	2 439	29 496
2014	117	307 475	397	1 247 000	2 812	29 826
2015	140	279 102	383	1 166 000	3 203	30 067
2016	128	179 474	352	1 253 000	3 242	30 215
2017	142	252 837	235	1 742 000	3 271	30 507
2018	97	237 622	379	969 000	3 354	30 089

Year	First treatment desulfuration		Gas extraction		Gas distribution	
	SO_2 IEF [g/1 000 m³]	Raw gas Throughput [1 000 m³]	NMVOC IEF [g/1000m³]	Gas production [1000m³]	NMVOC IEF [g/km]	Distribution mains [km]
2019	101	227 559	457	891 000	3 384	30 279
2020	109	219 605	448	743 000	3 404	30 569
2021	188	159 693	496	655 000	3 438	30 591
2022	211	151 733	580	483 000	3 382	30 670
1990–2022	**-97%**	**-39%**	**-32%**	**-63%**	**-29%**	**+163%**

3.3.5 NFR 1.B.2.d Other fugitive emissions from energy production – Methodological issues

In this category, NH_3- and Hg-emissions from energy production from geothermal energy are considered.

NH_3- and Hg-emissions were calculated based on activity data available in the national energy balance (Table 222) and the Tier 1 emission factors for other fugitive emissions from energy productions in Table 3-1 of the EMEP/EEA air pollutant emission inventory guidebook 2019 (2 100 g NH_3/MWh electricity produced and 0.44g Hg/MWh electricity produced).

Table 222: Activity data for fugitive NH_3- and Hg- emissions from NFR category 1.B.2.d

Year	Geothermal energy extraction [GWh]	Year	Geothermal energy extraction [GWh]
1990	NO	2015	0.06
1995	NO	2016	0.02
2000	NO	2017	0.09
2005	2.30	2018	0.24
2010	1.40	2019	0.20
2011	1.05	2020	0.07
2012	0.68	2021	0.03
2013	0.31	2022	0.00
2014	0.38		

3.3.6 Category-specific QA/QC

Activity Data received from the Austrian Association of oil industry (Fachverband der Mineralölindustrie) is compared with Energy Balance data on a regular basis. If differences occur these are clarified with external experts and are well explained and documented.

3.3.7 Uncertainty Assessment

Table 223 gives an overview of uncertainties for fugitive emissions, estimated according to the EMEP/EEA Emission Inventory Guidebook 2019 (EEA, 2019). An average of the default values, based on the definitions of the qualitative ratings given in (EEA, 2019) is used (see also chapter 1.7).

Table 223: Uncertainties for activity data, emission factors and combined uncertainties for SO_2, NMVOC and $PM_{2.5}$ for fugitive emissions.

Sector	Pollutant	Uncertainty AD	Uncertainty EF	Combined uncertainties
1.B.2.b	SO_2	5.0%	20.0%	20.62%
1.B.1.a	NMVOC	5.0%	20.0%	20.62%
1.B.2.a	NMVOC	0.5%	20.0%	20.01%
1.B.2.b	NMVOC	5.0%	20.0%	20.62%
1.B.1.a	$PM_{2.5}$	5.0%	200.0%	200.06%

3.3.8 Category-specific Recalculations

3.3.8.1 Distribution of oil products (1.B.2.a.5)

Activity data (gasoline) in *1.B.2.a.5 Distribution of oil products* (transport and depots except service stations) had to be corrected by one data supplier for the year 2021, resulting in slightly revised NMVOC emissions for 2021 (-0.3 t).

3.3.8.2 Storage of solid fuels (1.B.1.a)

PM emissions for 2021 were revised by +0.9% (+3.1 t TSP, +1.5 t PM_{10}, + 0.5 t $PM_{2.5}$) due to revised coal consumption activity data.

3.3.9 Planned Improvements

In order to improve the inventory on natural gas transmission, storage and distribution, a service contract was awarded to an Austrian research institute (Forschung Burgenland GmbH) to collect emissions and other relevant data via a comprehensive survey among the Austrian gas supply network. It is planned to implement the study results in the 2025 inventory submission.

4 INDUSTRIAL PROCESSES AND PRODUCT USE (NFR SECTOR 2)

4.1 Sector overview

This chapter includes information on the estimation of emissions of NEC gases, CO, particulate matter (PM), heavy metals (HM) and persistent organic pollutants (POPs) as well as references for activity data and emission factors reported under NFR Category *2 Industrial Processes and Product Use* for the period from 1990 to 2022.

Emissions from this sector arise from the following categories:

- Mineral Products (2.A)
- Chemical Industry (2.B)
- Metal Production (2.C)
- Solvent use (2.D.3)
- Other product use (2.G)
- Other production (2.H)
- Wood processing (2.I)

Only process related emissions are considered in this sector; emissions due to fuel combustion in manufacturing industries are allocated to NFR Category *1.A.2 Fuel Combustion – Manufacturing Industries and Construction* (see Chapter 3.1.4).

4.2 General description

4.2.1 Completeness

Table 224 gives an overview of the NFR categories included in this chapter. A "✓" indicates that emissions from this sub category have been estimated, "NA" indicates that the pollutant in question is not emitted during the respective industrial process.

Some categories in this sector are not occurring (NO) in Austria as there is no such production/use. For some categories, emissions are included elsewhere (IE). In Chapter 1.8, a general description regarding completeness is given.

Table 224: Completeness of sub categories in sector 2 Industrial Processes and Product Use.

NFR Category		**Status**														
		NEC gas				**CO**	**PM**			**Heavy metals**			**POPs**			
		NO_x	**SO_2**	**NH_3**	**NMVOC**	**CO**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**Cd**	**Hg**	**Pb**	**Dioxin**	**PAH(8)**	**HCB**	**PCB**
2.A.1	Cement Production(7)	IE	IE	IE	IE	IE	✓	✓	✓	IE	IE	IE	IE	IE	IE	IE
2.A.2	Lime Production	NA	NA	NA	NA	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
2.A.3	Glass production	IE	IE	IE	IE	IE	✓	✓	✓	IE	IE	IE	IE	IE	IE	IE
2.A.5	Mining, construction/demolition and handling of products(5)	NA	NA	NA	NA	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
2.A.6	Other Mineral products	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B.1	Ammonia Production	✓	IE	✓	IE(1)	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B.2	Nitric Acid Production	✓	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B.3	Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B.5	Carbide Production	NA	NA	NA	NA	NA	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.B.6	Titanium Dioxide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B.7	Soda Ash Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B.10	Chemical Industry: Other(4)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	NA	NE(2)	NA	NA(3)
2.C.1	Iron and steel production	✓	✓	IE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2.C.2	Ferroalloys production	NA	NA	NA	NA	NA	✓	✓	✓	NE	NE	NE	NE	NE	NE	NA
2.C.3	Aluminium production	NA	NA	NA	NA	NA	✓	✓	✓	NA	NA	✓	✓	NE	✓	NA
2.C.4	Magnesium production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.5	Lead production(6)	NA	IE	NA	NA	NA	✓	✓	✓	✓	NE	✓	✓	NA	NA	✓
2.C.6	Zinc production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.7.a	Copper production	NA	✓	NA	NE	NE	✓	✓	✓	✓	✓	✓	✓	NE	✓	✓
2.C.7.b	Nickel production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.7.c	Other metal production	✓	✓	NA	✓	✓	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA
2.C.7.d	Storage, handling and transport of metal products	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D.3.a	Domestic solvent use (incl. fungicides)	NA	NA	NA	✓	NA	NA	NA	NA	NA	✓	NA	NA	NA	NA	NA
2.D.3.b	Road paving with asphalt	NA	NA	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
2.D.3.c	Asphalt roofing	NA	NA	NA	✓	✓	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
2.D.3.d	Coating application	NA	NA	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3.e	Degreasing	NA	NA	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3.f	Dry Cleaning	NA	NA	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3.g	Chemical Products	NA	NA	NA	✓	NA	NA	NA	NA	✓	NA	✓	NA	NA	NA	NA
2.D.3.h	Printing	NA	NA	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3.i	Other solvent use	NA	NA	NA	✓	NA	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.G	Other product use	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	NE	NA
2.H	OTHER PROCESSES	NA	NA	NA	✓	NA	✓	✓	✓	NA	NA	NA	✓	✓	✓	NA
2.I	WOOD PROCESSING	NA	NA	NA	NA	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
2.J	PRODUCTION OF POPs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

NFR Category		Status														
		NEC gas				CO	PM			Heavy metals			POPs			
		NO_x	SO_2	NH_3	NMVOC	CO	TSP	PM_{10}	$PM_{2.5}$	Cd	Hg	Pb	Dioxin	PAH[8]	HCB	PCB
2.K	CONSUMPTION OF POPs AND HEAVY METALS	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.L	OTHER	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

(1) included in 2.B.10 Other
(2) PAH emissions from graphite production (production of graphite electrodes only) are not estimated, as no emission factor is available.
(3) until 1992 from Tri-, Perchlorethylene Production; later NO
(4)2.B.10.b is included in 2.B.10.a
(5)2.A.5.c is included in 2.A.5.a
(6) included in 1.A.2.b
(7) included in 1.A.2.f
(8) this includes the separation into benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and ideno[1,2,3-c,d]pyrene

4.2.2 Key Categories

The key category analysis is presented in Chapter 1.5. This chapter includes information on the IPPU sector. Key sources within this category are presented in Table 225.

Table 225: Key sources of sector IPPU.

NFR Category	Source Categories	Key Categories	
		Pollutant	KS-Assessment
2.A.5	Mining, construction/demolition and handling of products	TSP[2)], PM_{10}[2)], $PM_{2.5}$[2)]	LA
2.B.10	Handling of products and other chemical industry	Hg	TA
2.C.1	Iron and Steel Production	Cd, Pb, Hg, PAH[1)], DIOX[1)], PCB, TSP[1)], PM_{10}[1)], $PM_{2,5}$[1)]	LA, TA
2.C.3	Aluminium production	DIOX, HCB	LA
2.C.5	Lead production	Cd[1)], Pb[2)], PCB[1)]	LA, TA
2.C.7	Other metal production	DIOX	LA
2.D.3.a	Domestic solvent use including fungicides	NMVOC	LA
2.D.3.d	Coating applications	NMVOC	LA,TA
2.D.3.e	Degreasing	NMVOC	LA, TA
2.D.3.g	Chemical Products	NMVOC	TA
2.D.3.h	Printing	NMVOC	TA
2.D.3.i	Other solvent use	NMVOC	TA
2.G	Other product manufacture and use	Cd, Pb, PM_{10}, $PM_{2,5}$	LA
2.H	Other Processes	NMVOC	LA
2 I	Wood Processing	TSP, PM_{10}	LA

LA = Level Assessment 2022
TA = Trend Assessment 1990–2022
Note: 1)only TA, 2)only LA

4.2.3 Methodology

The general method for estimating emissions for the industrial processes and product use sector is multiplying production data for each process by an emission factor per unit of production (CORINAIR simple methodology).

In some categories, emission and production data were reported directly by industry or by associations of industries and thus represent plant-specific data.

Information on which NFR categories of IPPU sector include the condensable component of PM_{10} and $PM_{2.5}$ can be found in chapter 12.3.

4.2.4 Uncertainty Assessment

The table below gives an overview of uncertainties for *Industrial Processes and Product Use* for selected pollutants. Uncertainty assessed following the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA, 2019). Further information on the uncertainty assessment of activity data can be found in Austria`s National Inventory Report (Umweltbundesamt, 2024). Where no specific information on uncertainties of emission factors was available, an average of the default values, based on the definitions of the qualitative ratings given in the EMEP/EEA Emission Inventory Guidebook 2019 is used. For more details on uncertainties, please refer to 1.7.

Table 226: Uncertainties for activity data, emission factor and combined uncertainties for NO_x, SO_2, NMVOC, NH_3 and $PM_{2.5}$ for Industrial Processes and Product Use.

NRF sector	Pollutant	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty (%)
2.A.1	$PM_{2.5}$	1.1	40.0	40.0
2.A.2	$PM_{2.5}$	1.6	125.0	125.0
2.A.5	$PM_{2.5}$	5.0	200.0	200.1
2.B.1	NO_x	2.0	40.0	40.0
2.B.1	NH_3	2.0	20.0	20.1
2.B.2	NO_x	2.0	40.0	40.0
2.B.2	NH_3	2.0	20.0	20.1
2.B-10	SO_2	2.0	40.0	40.0
2.B-10	NO_x	2.0	40.0	40.0
2.B-10	NMVOC	2.0	20.0	20.1
2.B-10	$PM_{2.5}$	2.0	20.0	20.1
2.B-10	NH_3	2.0	20.0	20.1
2.C.1	SO_2	0.5	125.0	125.0
2.C.1	NO_x	0.5	40.0	40.0
2.C.1	NMVOC	0.5	125.0	125.0
2.C.1	$PM_{2.5}$	0.5	20.0	20.0
2.C.2	$PM_{2.5}$	5.0	40.0	40.3
2.C.3	$PM_{2.5}$	2.0	40.0	40.0
2.C.5	$PM_{2.5}$	10.0	40.0	41.2
2.C.7	SO_2	5.0	125.0	125.1
2.C.7	NO_x	5.0	40.0	40.3

NRF sector	Pollutant	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty (%)
2.C.7	NMVOC	5.0	125.0	125.1
2.C.7	$PM_{2.5}$	5.0	40.0	40.3
2.D	NMVOC	20.0	30.0	30.4
2.D	$PM_{2.5}$	20.0	40.0	44.7
2.G	SO_2	20.0	125.0	126.6
2.G	NO_x	20.0	125.0	126.6
2.G	NMVOC	20.0	125.0	126.6
2.G	$PM_{2.5}$	20.0	125.0	126.6
2.G	NH_3	20.0	40.0	44.7
2.H	NMVOC	10.0	40.0	41.2
2.H	$PM_{2.5}$	10.0	200.0	200.2
2.I	$PM_{2.5}$	1.0	40.0	40.0

4.2.5 Quality Assurance and Quality Control (QA/QC)

For the Austrian inventory, a quality management system is in place. For further information see Chapter 1.6. Concerning measurement and documentation of emission data there are also specific regulations in the Austrian legislation as presented in Table 227. Some plants that report emission data have quality management systems according to the ISO 9000 series or similar systems in place.

Table 227: Austrian legislation with specific regulations concerning measurement and documentation of emission data.

Source Category	Austrian legislation
2.A.1	BGBl. II Nr. 60/2007 Zementverordnung 2007
2.A.7	BGBI 1994/498 Verordnung für Anlagen zur Glaserzeugung
2.C.1	BGBl. II Nr. 264/2014 Gießerei-Verordnung 2014
2.C.1	BGBI II 1997/160 Verordnung für Anlagen zur Erzeugung von Eisen und Stahl BGBl. II 2007/290 Änderung der Verordnung über die Begrenzung der Emission von luftverunreinigenden Stoffen aus Anlagen zur Erzeugung von Eisen und Stahl
2.C.1	BGBl. II Nr. 160/1997 Begrenzung der Emission von luftverunreinigenden Stoffen
2.C.1	BGBl. III Nr. 141/2004 Protokoll zu dem Übereinkommen von 1979 über weiträumige grenzüberschreitende Luftverunreinigung betreffend Schwermetalle samt Anhängen und Erklärungen (in Anhang 2 angeführt)
2.D.3	BGBl. I Nr. 111/2002 VOC-Anlagen-Verordnung
2.A/2.B/2.C/2.D	BGBI II 1997/331 Feuerungsanlagen-Verordnung
2.C 2/2.C 3/2.C 5	BGBl. II Nr. 86/2008 Begrenzung der Emission von luftverunreinigenden Stoffen aus Anlagen zur Erzeugung von Nichteisenmetallen und Refraktärmetallen – NER-V
2.A/2.B/2.C/2.D	BGBL I 115/1997 Immissionsschutzgesetz – Luft, IG-L
2.A/2.B/2.C/2.D	BGBl I 127/2013 Emissionsschutzgesetz für Kesselanlagen – EG-K 2013

4.2.6 Planned Improvements

Further assessments of the Domestic Solvent Use sector are currently underway. Results are planned to be included in the next submission.

4.3 NFR 2.A Mineral Products

4.3.1 Source Category Description

This category includes diffuse PM emissions from bulk material handling. Emissions almost exclusively arise from *NFR categories 2.A.5 Quarrying and mining of minerals other than coal* and *2.A.5.b Construction and demolition*. Minor PM emissions arise from the production of mineral products reported in *2.A.1 Cement* and *2.A.2 Lime* and *2.A.3 Glass production*.

Emissions from the handling of agricultural bulk materials are reported in NFR category 3.D.

4.3.2 Methodological Issues

Quarring and Mining, bulk material handling

The general method for estimating diffuse particulate matter emissions is multiplying the amount of bulk material by an emission factor (CORINAIR simple methodology). All emission factors were taken from a national study (Winiwarter et al., 2001) that has been partly updated or amended (Winiwarter et al., 2007):

- new emission factors for handling bulk materials and updated methodology according to VDI[101] guidelines 3790;
- the inclusion of PM emissions from cement and limestone kilns from 1.A.2.f Other Industry under 2.A.1 and 2.A.2;
- updated methodology and emission factors for construction and demolition based on the CEPMEIP project[102].

In 2011, a confidential study was commissioned by the Association for Building Materials and Ceramic Industries, which contains a new EF for PM_{10} for limestone (Amann & Dämon, 2011). The calculation was based on the evaluation of 20 studies, comparing different quarries, also for dolomite and basaltic rocks. It showed that the EF can be used for all three types of material. For the calculation of emission factors for $PM_{2.5}$ and TSP, the relation TSP 100%, PM_{10} 46.51%, $PM_{2.5}$ 4.65% was used (Winiwarter et al., 2007). For data before 2000, EFs were calculated using the same ratio, but a higher EF for dolomite, based on the study by Winiwarter et al. (2001). Changes in emission factors over time can be explained by changes in material handling and dust abatement technology.

Mining activities for the years 1990, 1995 and 1999 were taken from Winiwarter et al. (2001). From 2000 onwards, annual data from the Austrian mining handbook (e.g. BMWFW, 2018) were used.

[101] Association of German Engineers – VDI Verein Deutscher Ingenieure

[102] http://www.air.sk/tno/cepmeip/

Particulate matter emission factors for gypsum and anhydrite mining were taken from Winiwarter et al. (2007).

Emission factors are presented in Table 228. Activity data are mainly taken from national statistics and presented in Table 229.

Mineral production

For lime and cement procution, emission factors were taken from Winiwarter 2007 (cf. Table 228). Emission factors are based on plant specific data.

In order to obtain an emission factor, PM emissions from glass production for 2017 were obtained by summing up emissions from all relevant glass production sites. Emissions were calculated from flue gas volumes and TSP measurement data of flue gas. Emissions due to combustion reported in 1.A.2.f (calculated from fuel inputs and default EFs) were subtracted from total emissions, and remaining emissions were reported as process-specific under 2.A.3. For 1990 and 1995 emissions were calculated accordingly, using 2/3 of the limit in PM flue gas concentration of the austrian ordinance for glass production and 1995 a mean value for PM flue gas concentration at Austrian production sites (Umweltbundesamt, 1999).

Construction and demolition

Emissions were calculated for houses, apartment houses, non-residential construction and road construction. Acivity data (area newly constructed for the different types of buildings) from 2010 onwards was taken from national statistics. For 2001, a value was available from an Austrian study (Winiwarter et al. 2007). The value for 2001 was used for all years between 1990–2001, for years between 2001 and 2010 the mean value of the two years was used. For road construction only a single value for 2001 from the Austrian study was available, the other years were modeled using a correlation with statistical data on costs of road construction taken from national statistics too. For calculating emissions, EFs and parameters as used by Germany following the EMEP/EEA Guidebook are applied ("Moisture Level Correction factor" = 0,2, and "Silt Content Correction" = 2.22; default values for duration of construction activites and for PM_{10}/$PM_{2.5}$ share are used).

Table 228: Emission factors (EF) for diffuse PM emissions from quarrying and mining, mineral production, bulk material handling, as well as construction/demolition.

Bulk material	EF TSP [g/t]	EF PM_{10} [g/t]	EF $PM_{2.5}$ [g/t]
Magnesite (1)	216.20	101.61	10.81
Sand (1)	525.00	246.75	26.25
Gravel (1)	135.00	63.45	6.75
Silicates (1)	191.00	89.77	9.55
Dolomite (4) (3)	141.90 (184.45)	66.00 (85.80)	6.60 (8.58)
Limestone (3)	141.90	66.00	6.60
Basaltic rocks (3)	141.90	66.00	6.60
Iron ore	216.78	104.70	30.43
Tungsten ore	25.12	11.86	3.75
Gypsum. Anhydride (1)	85.60	40.23	4.28
Lime (1)	122.70	110.43	79.76
Cement (2)(1)	11.4 (21.8)(41.9)	10.3 (19.6)(37.7)	9.2 (17.4)(33.5)
Glass	11.16	10.05	9.15
Cement & Lime milling	7.75	6.98	6.20

Bulk material	**EF TSP [g/t]**	**EF PM_{10} [g/t]**	**EF $PM_{2.5}$ [g/t]**
Rye flour	43.59	20.62	6.50
Wheat flour	43.59	20.62	6.50
Sunflower and rapeseed grist	24.76	11.85	3.79
Wheat bran and grist	10.90	5.16	1.63
Rye bran and grist	10.90	5.16	1.63
Concentrated feedingstuffs	30.28	14.32	4.51
Construction and demolition (5)	**EF TSP [g/m²]**	**EF PM_{10} [g/m²]**	**EF $PM_{2.5}$ [g/m²]**
Houses	64.4	19.3	1.9
Appartment buildings	333	100	10
Non-residential construction	608	182	18.2
Road construction	1 709	513	51.3

(1) *Source: Winiwarter et al., 2007*

(2) *Decreasing EF values are given for 2012 (2006)(1990)*

(3) *Source: Amann & Dämon, 2011*

(4) *Decreasing EF values are given for 2012 (1990)*

(5) *EMEP/EEA Guidebook 2019 with parameters from Germany*

Table 229: Activity data for diffuse PM emissions from quarrying and mining, mineral production, bulk material handling, as well as construction/demolition

Activity data [t]	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2022**
Magnesite	1 179 162	783 497	725 832	693 754	757 063	702 504	816 370
Sand	2 517 296	3 033 907	3 692 910	3 660 228	2 001 407	2 169 684	1 092 119
Gravel	14 264 676	17 192 140	20 978 974	25 361 797	28 304 033	27 550 482	26 876 495
Silicates	1 484 527	810 520	1 991 018	2 580 295	2 593 863	2 017 977	2 357 605
Dolomite	1 879 837	8 789 688	7 152 245	6 291 413	3 914 859	3 963 986	3 897 414
Limestone	15 371 451	19 079 581	23 823 529	22 643 754	21 189 887	21 059 817	21 576 968
Basaltic rocks	3 673 535	4 202 244	4 933 202	3 166 281	3 234 408	3 543 675	3 818 368
Iron ore	2 310 710	2 116 099	1 859 449	2 047 950	2 068 853	2 783 327	3 043 237
Tungsten ore	191 306	411 417	416 456	472 964	429 748	535 762	549 518
Gypsum, Anhydride	751 645	958 430	946 044	911 162	872 273	715 195	900 619
Lime, quick, slacked	512 610	522 934	654 437	788 328	764 845	772 225	746 733
Cement	3 693 539	2 929 973	3 052 974	3 221 167	3 097 043	3 256 561	3 522 299
Glass	398 515	435 094	375 348	417 685	498 156	497 368	503 490
Cement & Lime milling	2 450 000	2 450 000	2 450 000	2 450 000	2 450 000	2 450 000	2 450 000
Rye flour	61 427	55 846	48 054	62 387	84 997	86 926	51 167
Wheat flour	259 123	287 461	291 482	324 160	451 086	516 638	367 752
Sunflower and rapeseed grist	19 900	108 600	121 200	121 200	121 200	121 200	121 200
Wheat bran and grist	64 781	71 865	73 303	100 185	126 075	134 681	127 420
Rye bran and grist	15 357	13 962	13 139	13 139	13 139	13 139	13 139
Concentrated feeding stuff	638 014	720 972	980 808	1 018 649	988 371	1 113 408	1 199 471

Activity data [t]	1990	1995	2000	2005	2010	2015	2022
Constructed floor space /area [m²]	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2022**
Construction and demolition: Buildings	11 340 000	11 340 000	11 340 000	11 221 621	9 908 820	10 405 481	11 470 405
Road construction	5 130 000	5 130 000	5 130 000	5 130 000	3 935 579	3 890 662	4 638 997

4.3.3 Quality Assurance and Quality Control (QA/QC)

In the course of the NEC review 2022, EFs for 2.A.5.a (also including emissions from 2.A.5.c) were compared with the EFs of the EMEP GB. The inclusion of emissions from 2.A.5.c can be explained as follows:

The emission factors were determined for 23 different types of bulk materials. The different steps of quarring/mining, as well as the handling of the materials were considered separately, based on methodologies and parameters of the "VDI-Richtline" (BAT), summed up and reported together. The methodology can be considered as equivalent to the T2 methodology of the GL for all categories exept limestone, where a T3 methodology was applied (data of 20 facilities was considered; the resulting EF was also used for dolomite and basaltic stone). The EFs for different bulk materials are above or below the default T1 EF but the avererage EF for all categories (TSP/PM_{10}/$PM_{2.5}$: 112/56/12 g / t bulk material) is in the range of the EMEP default EFs (102/50/5 g/t bulk material). For comparison purposes, it should be noted that the default EFs listed only consider quarring and mining, and that emissions from handling have to be added - there is no default T1 EF for handling but looking at the T2 EF for handling for mineral products 12/6/0.6 g/t it can be seen that 10% can be added as a rough estimate, resulting in a good correlation.

4.3.4 Category-specific Recalculations

4.3.4.1 NFR 2.A.1 Cement production

Emissions data for the years from 2011 onwards were updated using available data based on measurements (-0.02 kt TSP in 2021).

4.3.4.2 NFR 2.A.5.b Construction and demolition

Activity data taken from national statistics for the years from 2010 onwards were updated, which also impacted the extrapolation back to 1990. This resulted in minor recalculations of the whole time series (+ 0.00001 kt TSP in 1990, + 0.09 kt TSP in 2021).

4.4 NFR 2.B Chemical Products

4.4.1 NFR 2.B.1 Ammonia and 2.B.2 Nitric Acid Production

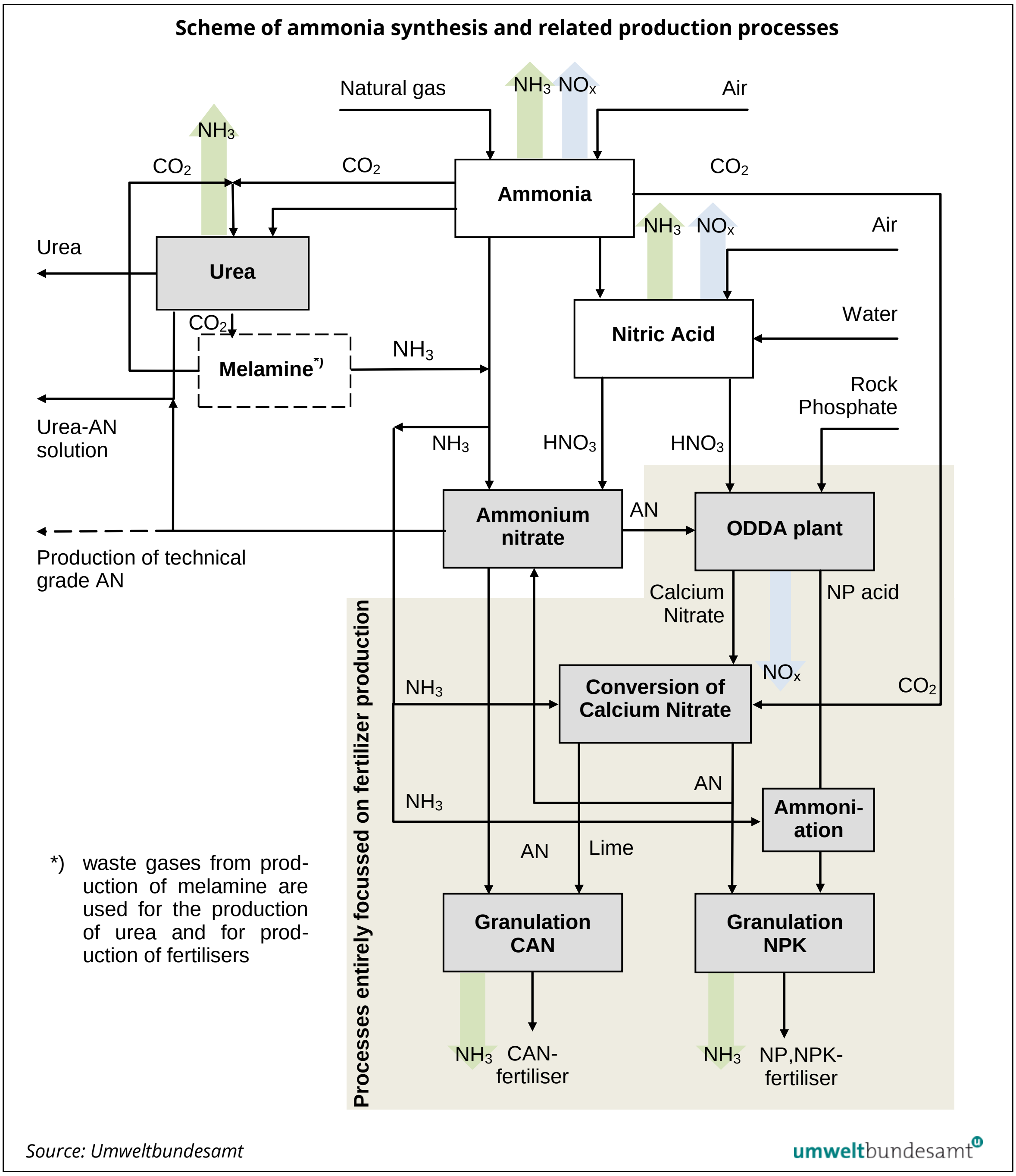
4.4.1.1 Source Category Description

Ammonia (NH_3) is produced by catalytic steam reforming of natural gas or other light hydrocarbons (e.g. liquefied petroleum gas, naphtha). Nitric acid (HNO_3) is produced from ammonia (NH_3), where in a first step NH_3 reacts with air to NO and NO_2 and then reacts with water to form HNO_3. Both processes are minor sources of NH_3 and NO_x emissions. During ammonia production, small amounts of CO, NMVOC and SO_2 are emitted.

In Austria there is only one producer of ammonia and nitric acid.

The following chart (Figure 48) depicts the process of ammonia synthesis, the main production lines (ammonia, urea, melamine, nitric acid, fertilizer etc.) with their main raw material as well as their internal subsequent processing of related products (Umweltbundesamt, 2004c). For a detailed process description of ammonia production and downstream processes please refer to Austria`s National Inventory Report (Umweltbundesamt, 2023a).

Figure 48: Scheme of ammonia synthesis and related production processes.



4.4.1.2 Methodological Issues

Activity data from 1990 onwards and emission data from 1994 onwards were reported directly to Umweltbundesamt by the only producer in Austria and thus represent plant specific data. From emission and activity data, an implied emission factor (IEF) was calculated (see Table 230 and Table 231). The calculated implied emission factor (IEF) for 1994 was applied to calculate emissions for the years 1990 to 1993, as no emission data were available for these years.

The IEF for NO_x from ammonia production fluctuate somewhat due to process intrinsic fluctuations. The lower vales result from a change of combustion temperature in the plant.

NH_3 emission factors vary depending on plant utilization, catalyst activity as well as on the frequency of production process interruptions (start-ups result in higher emissions), e.g. because of technical problems or catalyst change.

Table 230: Emissions and implied emission factors for NO_x, NH_3, CO, SO_2 and NMVOC from ammonia production (NFR Category 2.B.1).

Year	NO_x emission [t]	NO_x IEF [g/t]	NH_3 emission [t]	NH_3 IEF [g/t]	CO emission [t]	CO IEF [g/t]	SO_2 emission [t]	SO_2 IEF [g/t]	NMVOC emission [t]	NMVOC IEF [g/t]
1990	462.8	1003.8	7.4	16.0	123.1	267.1	0.03	0.06	7.0	15.13
1995	285.9	604.4	10.7	22.6	95.1	201.1	0.03	0.06	7.2	15.13
2000	206.5	428.1	7.0	14.5	43.0	89.2	0.03	0.06	6.1	12.57
2005	244.0	509.9	9.9	20.7	52.6	109.9	0.03	0.06	7.3	15.16
2010	197.7	399.1	10.7	21.6	56.9	114.9	0.19	0.38	8.6	17.32
2015	198.4	381.6	9.5	18.3	61.2	117.7	0.03	0.05	8.0	15.34
2020	206.2	399.7	22.6	43.8	40.7	78.9	0.03	0.06	7.0	13.57
2022	179.0	390.9	11.5	25.1	27.3	59.6	0.02	0.04	7.2	15.72

Table 231: Emissions and implied emission factors for NO_x and NH_3 from nitric acid production (NFR Category 2.B.2).

Year	NO_x emission [t]	NO_x IEF [g/t]	NH_3 emission [t]	NH_3 IEF [g/t]
1990	713.4	1345.9	1.4	2.6
1995	346.3	715.5	0.1	0.2
2000	406.5	761.6	0.4	0.7
2005	239.2	428.8	0.1	0.1
2010	144.0	262.9	7.8	14.2
2015	74.9	133.2	4.3	7.6
2020	63.0	113.1	4.8	8.6
2022	49.0	106.4	3.2	7.0

4.4.2 NFR 2.B.10 Other Chemical Industry

4.4.2.1 Source Category Description

In this category the following sources are reported:

- Ammonia nitrate production (NH_3 and PM)
- Fertilizer production (NO_x, NH_3, PM, HM)
- Urea production (NH_3, CO and PM)
- Sulfuric acid production (SO_2)
- Inorganic chemical processes (CO)
- Organic chemical proceses (NMVOC)
- Clorine production (Hg)

- Per-Trichloroethylene production (HCB)

4.4.2.2 Methodological Issues

Ammonium nitrate and urea production

For ammonium nitrate and urea production, activity data from 1990 onwards and emission data from 1994 onwards were reported directly to Umweltbundesamt by the only producer in Austria and thus represent plant specific data.

NH_3 emissions were reported separately for each of the two production processes; CO emissions occur during urea production only. The implied emission factors for NH_3 and CO that were calculated from activity and emission data of 1994 were applied to calculate emissions of the years 1990 to 1993 as no emission data were available for these years.

TSP emissions from ammonium nitrate production were also reported directly to Umweltbundesamt by the only producer in Austria and represent plant specific data. For urea production TSP emissions are reported for 1994 and from 2012 onwards, the value of 1994 was also used for 1990 and 1995, and emissions for 2000 to 2011 were calculated using the mean IEF from the years 2012–2022. The shares of PM_{10} and $PM_{2.5}$ are 90% and 80%, respectively, until 1996 (conventional plant) and 95% and 90% from 1997 onwards (modern plant), according to Umweltbundesamt (2001c).

Table 232: NH_3, TSP, PM_{10} and $PM_{2.5}$ emissions and implied emission factors for NH_3 emissions from Ammonium nitrate production.

Year	NH_3 emission [t]	NH_3 IEF [g/t]	TSP emission [t]	PM_{10} emission [t]	$PM_{2.5}$ emission [t]
1990	0.7	72.4	12.8	11.5	10.2
1995	0.9	72.4	14.9	13.4	11.9
2000	0.2	12.9	0.2	0.2	0.2
2005	0.3	17.2	0.3	0.2	0.2
2010	0.3	23.1	0.2	0.2	0.2
2015	0.3	23.1	0.1	0.1	0.1
2020	0.4	34.1	0.1	0.1	0.1
2022	0.4	27.3	0.1	0.1	0.1

Table 233: Emissions and implied emission factors for NH_3, CO and PM emissions from urea production.

Year	NH_3 emission [t]	NH_3 IEF [g/t]	CO emission [t]	CO IEF [g/t]	TSP emission [t]	TSP IEF [g/t]	PM_{10} emission [t]	PM_{10} IEF [g/t]	$PM_{2.5}$ emission [t]	$PM_{2.5}$ IEF [g/t]
1990	38.6	137.0	7.1	25.0	54.80	194.3	49.32	174.9	43.84	155.5
1995	47.7	121.4	9.7	24.7	54.80	139.4	52.06	132.5	49.32	125.5
2000	17.4	44.6	3.6	9.2	38.53	98.7	36.60	93.8	34.68	88.9
2005	30.1	72.3	3.8	9.1	41.12	98.7	39.06	93.8	37.01	88.9
2010	33.8	80.5	3.7	8.8	41.47	98.7	39.40	93.8	37.33	88.9
2015	42.8	98.5	3.7	8.5	27.70	63.7	26.32	60.6	24.93	57.4
2020	44.1	100.7	3.9	8.9	51.30	117.1	48.74	111.2	46.17	105.4
2022	36.0	94.9	3.6	9.5	61.20	161.3	58.14	153.3	55.08	145.2

Fertilizer production

For fertilizer production activity data from 1990 to 1994 were taken from national production statistics[103] (Statistik Austria); NO_x and NH_3 emissions and activity data from 1995 onwards were reported by the main producer in Austria. For the years 1990 to 1993, NH_3 emissions were estimated using information on emissions from the main producer and extrapolation to total production. The emission estimate for 1994 was obtained by applying the average emission factor of the years 1995 to 1999.

Cd, Hg and Pb emissions were calculated by multiplying the above mentioned activity data by national emission factors (Hübner, 2001a) that derive from PM emissions and analysis of the product as described in Magistrat der Landeshauptstadt Linz (1995).

Direct TSP emissions from fertilizer production at the production site were reported directly by the main producer. The shares of PM_{10} and $PM_{2.5}$ applied were 90% and 80% for the years 1990-1994 and 95% and 90% from 1995 onwards (modern plant), according to Umweltbundesamt (2001c).

Emissions from fertilizer handling were estimated at 320 t for the whole fertilizer production in Austria (Winiwarter et al., 2007), which was added to reported direct emissions for the whole time series. The shares of PM_{10} and $PM_{2.5}$ applied are 58.6% and 30.9%, respectively.

Table 234: NO_x and NH_3 emissions from fertilizer production.

Year	NO_x emission [t]	NO_x IEF [g/t]	NH_3 emission [t]	NH_3 IEF [g/t]
1990	154.1	111	218.7	157.5
1995	60.0	65.5	37.2	40.6
2000	71.4	69.8	73.2	71.6
2005	89.4	85.6	25.4	24.3
2010	81.4	77.4	36.0	34.3
2015	115.9	111.0	22.8	21.8
2020	89.1	87.2	32.5	31.8
2022	44.4	52.6	25.9	30.7

Table 235: Heavy metal and particulate matter emissions in fertilizer production.

Year	Cd [kg]	Hg [kg]	Pb [kg]	TSP [t]	PM_{10} [t]	$PM_{2.5}$ [t]
1990	0.93	0.12	1.17	762	356	222
1995	0.62	0.08	0.77	410	246	129
2000	0.64	0.09	0.80	412	246	129
2005	0.65	0.09	0.81	367	267	141
2010	0.65	0.09	0.82	362	222	107
2015	0.65	0.09	0.81	387	244	128
2020	0.64	0.09	0.80	389	200	85
2022	0.53	0.07	0.66	363	2001	87

[103] This results in an inconsistency of the time series, as activity data taken from national statistics represent total production in Austria, whereas the data obtained from the largest Austrian producer covers only the production of this producer. It is planned to prepare a consistent time series.

Sulfuric acid production (SO_2 emissions)

SO_2 emissions for 1990 to 2015 are based on emissions data (directly reported for some years and interpolated for missing years) from all relevant installations in Austria. The 2015 value was taken as proxy for subsequent years also.

Other processes in inorganic chemical industries (CO emissions)

The reported activity data is a sum of chemical production data taken from national statisics. CO emission data for inorganic chemical industries for 1990-1992 were taken from (Windsperger & Turi, 1997), they were obtained from inquiries of relevant emitting industries and extrapolated to a national total. The 1992 value was taken as proxy for the subsequent years.

Other processes in organic chemical industries (NMVOC emissions)

This category includes NMVOC emissions from one plant (polyolefine production). PS data was available for 1996 (also used for 1990-1998; in 1998 an abatement system was installed), 2000 (also reported for 1999) and 2003, with linear interpolation between 2000 and 2003 and 2003 to 2007. From 2007 onwards PRTR data is used. The plant has a polyolefin production capacity of 1 mio t.

Table 236: SO_2, NMVOC and CO emissions from 2.B.10 Other.

	NMVOC emissions [t]	CO emissions [t]	Sufuric acid production capacity [t]	IEF sulphuric acid production [g/t]	SO_2 emissions [t]
1990	1 611	12 537	270 700	5 780,64	1 565
1995	1 611	11 064	270 700	2 631,10	712
2000	518	11 064	277 700	2 142,25	595
2005	436	11 064	330 550	1 729,24	572
2010	560	11 064	323 550	1 536,88	497
2015	316	11 064	323 550	1 129,37	365
2020	263	11 064	323 550	1 129,37	365
2022	335	11 064	323 550	1 129,37	365

Chlorine, graphite and per- and trichloroethylene production

Hg emissions from chlorine production are calculated by multiplying production figures from industry by national emission factors (Windsperger et al., 1999) that are based on Winiwarter & Schneider (1995). In 1999 the chlorine producing company changed its production process from mercury cell to membrane cell. Therefore, for 1999 the EF was assumed to be half the value of the years before and since 2000 no Hg emissions result from chlorine production.

HCB emissions and production figures from per- and trichloroethylene production were evaluated in a national study (Hübner, 2001b). The emission factor used is 60 mg/t product and is based on the study (Umweltbundesamt Berlin, 1998). From 1993 onwards there is no production of Per- and Trichloroethylene in Austria.

The production of graphite electrodes constitutes the only graphite production process in Austria. As no emission factor is available for this specific process, PAH emissions from graphite production are not estimated.

Table 237: Hg and HCB emission factors and emissions from other processes in organic and inorganic chemical industries.

Year	Chlorine production		Per- Trichloroethylene production	
	Hg EF [mg/t]	Hg emissions [kg]	HCB EF [mg/t]	HCB emissions [kg]
1990	3000	270	60	1.26
1995	2000	180	NO	NO
2000	NA	NA	NO	NO
2005	NA	NA	NO	NO
2010	NA	NA	NO	NO
2015	NA	NA	NO	NO
2020	NA	NA	NO	NO
2022	NA	NA	NO	NO

4.4.2.3 Category specific recalculations

NFR 2.B.1 Ammonia production

NMVOC emissions from ammonia production were previously reported together with emissions from another production site under *2.B.10.a other*. They are now allocated according to the EMEP/EEA GB 2023 (no effect on overall emissions level).

NFR 2.B.10.a Chemical industry other – 2.B.1 Ammonia production – 2.B.2 Nitric acid production

A time series inconsistency was eliminated: In previous submissions for the years 1990-1993 NO_x emissions were taken from a study that upscaled emissions from some installations to total chemical production using business volumes. In this submissionemissions from these years are estimated in accordance with the methodology applied also for subsequent years considering relevant production processes (- 2.74 kt NO_x in 1990).

PM emissions from fertilizer and urea production were reassessed and recent measurement data incorporated; furthermore some inconsistencies of the time series were corrected (+0.02 kt TSP in 2021).

4.5 NFR 2.C Metal Production

In this category, emissions from iron and steel production and casting as well as process emissions from non-ferrous metal production and casting are considered.

4.5.1 NFR 2.C.1 Iron and Steel Production

4.5.1.1 Source Category Description

This sub category comprises emissions from blast furnace charging, basic oxygen furnace steel plants, electric furnace steel plants, rolling mills and iron casting operations.

4.5.1.2 Methodological issues

Blast Furnace Charging and Basic Oxygen Furnace Steel Plant

In Austria, there are two conventional integrated iron & steel production sites.

In this category, PM, POP and heavy metal emissions are considered. SO2, NOx, NMVOC and CO emissions are reported in category 1.A.2.a.

For recent years, all emission data except for PCB and HCB is reported directly by industry. The data for the 1990ies were taken from studies, mostly also based on PS data. For some years an IEF has been applied to reported AD from industry. Drops in IEFs show the effect of implemented abatement measures[104]. Details on the source of reported emissions data for each pollutant is given below:

- Cd: Emissions for 1990-1993 were taken from (Hübner, 2001a[105]), which also partly represent plant specific data; Emissions are reported since 2008; data from one site is available for 2005, and was extrapolated to total production using plant capacities. The resulting IEF for 2005 was used to calculate emissions for the years 1994–2004 and for 2006. For the years 2007–2018 and 2022 the average IEF of 2008–2018 calculated from reported emissions data is used, instead of directly reported data. This methodology is applied because reported emissions data are based on single measurements every three years, and this data resulted in significant dips and jumps which do not reflect the current status of the plant.
- Hg: Emissions are reported for both sites since 2015, an average IEF 2015–2020 was applied for years back to 2006; Emissions for 2005 were available from one plant, for the second plant an average emission value of 2015–2020 was used, resulting IEF used for years back to 1990.
- Pb: Emissions for 1990-1994 were taken from (Hübner, 2001a[106]), which also partly represent plant specific data. The reported emissions from one site for 2005 was extrapolated to total production using production capacities, the resulting IEF was applied for 1995–2006; Emissions are reported since 2008 for both sites; for 2007–2018 the average IEF of 2008–2018 was applied instead of using reported data, because these show significant variations which do not reflect the status of the plant but reflect the discountinous measurement results.
- PAH: Emissions are reported since 2012, an average IEF 2012–2021 was applied for years 2001–2011; emissions for the years 1990–2000 were taken from an unpublished national study (Hübner, 2001b[107]); Emissions reported correspond to PAH7, for 2018ff also measurement data of B(a)P and Indeno is available. For reporting PAH4 and the four relevant components the assumption was made that the share of B(a)P of PAH7 is the same as that of B(b)P and that B(k)P has the same share in PAH7 than Indeno.
- Dioxine: Emissions from one site are reported from 2002 onwards; for the second site data was available for 2002 and 2003, the average of these two years was used until 2021. For 2022 emissions data for both sites were reported. Emissions for the years 1990–2000 were

[104] voestalpine AG Corporate Responsibility Report 2013 - Clean air management

[105] according to European Commission IPPC Bureau (2000); Magistrat der Landeshauptstadt Linz (1995)

[106] according to European Commission IPPC Bureau (2000); Magistrat der Landeshauptstadt Linz (1995)

[107] according to Hübner (2000); European Commission IPPC Bureau (2000); Umweltbundesamt Berlin (1998)

taken from an unpublished national study (Hübner, 2001b[108]), the IEF from 2000 was applied for 2001;

- HCB: emission value for 1990 was taken from an unpublished national study (Hübner, 2001b[109]), for the other years a correlation with Dioxine emissions, where measurement data is available, was made (as measures for dioxin are also effective for HCB);
- PCB: emissions for 2021 were calculated from measurement data reported, a time series was constructed linking PCB IEF with dioxine IEF (as measures for dioxin are also effective for PCB).
- TSP: emissions since 2002 reported; emissions for the years 1990 to 2000 were taken from a national study (Winiwarter et al., 2001), the IEF from 2000 was applied for 2001These emissions were taken from environmental declarations from the companies.
- PM_{10}: emissions since 2005 reported; emissions for the years before calculated as 70% of TSP.
- $PM_{2.5}$: emissions calculated as 30% of TSP.

Activity data, POP, HM and PM emissions are presented in Table 238.

Table 238: Activity data (Pig Iron) and emissions from blast furnace charging.

	1990	1995	2000	2005	2010	2015	2020	2022
Activity [t]	3 444 000	3 888 000	4 320 000	5 457 755	5 643 855	5 794 527	5 285 850	5 803 214
				Emissions [kg]				
Cd	416	204	226	286	42	43	19	43
Hg	572	646	718	907	363	386	376	336
Pb	30 165	9 917	11 019	13 922	1 224	1 257	231	437
PAH	163	68	66	64	63	52	66	70
BAP	52	22	22	21	20	17	21	22
BBF	52	22	21	21	20	17	21	22
BKF	29	12	12	11	11	9	12	13
IND	29	12	12	11	11	9	12	13
				Emissions [g]				
DIOX	33	10	12	2	2	1	1	0.5
HCB	7 783	2 406	2 827	621	454	361	293	108
PCB	7 591	2 346	2 758	606	443	352	285	105
				Emissions [t]				
TSP	6 209	4 113	4 174	2 268	849	718	539	493
PM_{10}	4 346	2 879	2 922	1 314	496	455	324	366
$PM_{2.5}$	1 863	1 234	1 252	680	255	215	162	148

Table 239 presents coke input in the sinter plant, coke oven output and blast furnace chowpers.

[108] according to Hübner (2000); European Commission IPPC Bureau (2000); Umweltbundesamt Berlin (1998)

[109] according to Hübner (2000); European Commission IPPC Bureau (2000); Umweltbundesamt Berlin (1998)

Table 239: Activity data for the sub processes from 1990, 1995 and 2000.

Year	Activity [GJ]		
	sinter	**coke oven**	**blast furnace cowpers**
	coke oven input	**coke oven output**	**blast furnace gas**
1990	6 544 261	49 157 826	9 370 000
1995	4 740 138	41 264 751	9 621 911
2000	5 561 462	39 472 500	14 403 000

Electric Furnace Steel Plant

Estimation of emissions from electric furnace steel plants was carried out by multiplying production data by an emission factor. Activity data was provided by the Association for Mining and Steel Industry from 2005 onwards. The emission factors used and their sources are summarized in Table 240 together with electric steel production figures.

Table 240: Activity data and emission factors for emissions from Electric Steel Production 1990–2022.

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2022**
Activity [t]	370 107	453 645	540 539	622 485	637 383	667 000	675 000
			Emission factor [g/t Electric steel production]				
SO_2	590[1]	511[3]	119[3]	40[2]	→	→	40[2]
NO_x	330[1]	295[3]	119[3]	84[2]	→	→	84[2]
NMVOC	70[1]	→	→	→	→	→	70[1]
CO	52 000[1]	44 594[3]	7 565[3]	159[2]	→	→	159[2]
			Emission factor [mg/t Electric steel production]				
Cd	80.0[4]	13.0[5]	13.0[5]	0.4[2]	→	→	0.4[2]
Hg	75.0[4]	1.0[5]	→	→	→	→	1.0[5]
Pb	4 125.0[4]	470.0[5]	470.0[5]	19.3[2]	→	→	19.3[2]
PAH	13.8[6]	4.6[6]	→	→	→	→	4.6[6]
BAP	2.1[11]	0.7[11]	→	→	→	→	0.7[11]
BBF	7.2[11]	2.4[11]	→	→	→	→	2.4[11]
BKF	2.5[11]	0.8[11]	→	→	→	→	0.8[11]
IND	1.9[11]	0.6[11]	→	→	→	→	0.6[11]
			Emission factor [µg/t Electric steel production]				
DIOX	4.2[6]	1.4[6]	1.4[6]	0.1[2]	→	→	0.1[2]
HCB	840.0[6]	280.0[6]	280.0[6]	20.0[2]	→	→	20.0[2]
PCB	2500[10]	→	→	→	→	→	2500[10]
			Emission factor [g/t Electric steel production]				
TSP	610.0[7]	610.0[7]	30.0[10]	→	→	→	30.0[10]
PM_{10}	579.5[8]	579.5[8]	28.5[8]	→	→	→	28.5[8]
$PM_{2.5}$	549.0[9]	549.0[9]	27.0[9]	→	→	→	27.0[9]

Emission factor sources:

(1) (Windsperger & Turi, 1997), study published by the Austrian chamber of commerce, section industry. This study reported total VOC and did not distinguish between methane and NMVOC. According to the 2006 IPCC Guidelines (IPCC, 2006), chapter 4.2.2.2, VOC emissions in electric steel production consist of NMVOC only. Hence, it was assumed that the VOC emission factor according to this study equals the NMVOC emission factor.

(2) Mean values as reported from industry (Association of Mining and Steel Industries).

(3) Interpolated values (expert judgement Umweltbundesamt).

(4) (Windsperger et. al., 1999)

(5) (Hübner, 2001a)

(6) (Hübner, 2001b)

(7) (EMEP/CORINAIR Emission Inventory Guidebook 2006, EEA, 2007)

(8) Expert judgement: 95% TSP

(9) Expert judgement: 90% TSP

(10) EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, Chapter 2.C.1 Iron and Steel Production, Page 39, EEA, 2016)

(11) Share of the PAH fractions according to the plant specific data of Luxembourg, which were used as no default shares are incluced in guidebook and no PS data from the Austrian plant are available

Rolling Mills

The emission factor for VOC emissions from rolling mills was reported directly by industry and thus represents plant specific data. Similarly to electric steel production, emissions are restricted to NMVOC (i.e. no methane emissions). Hence, it was assumed that VOC emissions equal NMVOC emissions, resulting in an emission factor of 1 g NMVOC/t steel produced.

Steel production data were taken from national production statistics, the amount of electric steel was subtracted.

Iron cast

SO_2, NO_x, NMVOC and CO emissions were calculated by multiplying iron cast (sum of grey cast iron, cast iron and cast steel) by national emission factors. Activity data were obtained from „Fachverband der Gießereiindustrie Österreichs" (association of the Austrian foundry industry) and one production site, which is since 2015 no longer a member of the association. The emission factors were taken from data published by the Association of the Austrian foundry industry (Fachverband der Gießereiindustrie).

Table 241: Activity data and emission factors for cast iron 1990–2022.

	1990	1995	2000	2005	2010	2015	2022
Activity [t]	196 844	176 486	191 420	196 017	167 854	165 193	154 305
Emission factor [g/t Iron cast]							
SO_2	170	140	140	130	→	→	130
NO_x	170	160	160	151	→	→	151
NMVOC	1 450	1 260	1 260	1 180	→	→	1 180
CO	20 020	11 590	11 590	10 843	→	→	10 843

Steel Cast

Emission factors for POP emissions were taken from a national study (Hübner, 2001b). The emission factors used are 4.6 mg PAH per t cast iron, 0.03 µg Dioxine per t cast iron and 6.4 µg HCB per t cast iron. Heavy metal emissions were calculated by multiplying national emission factors (1990–1994: Windsperger et. al., 1999; 1995 onwards: Hübner, 2001a) by the same activity data used for POP emissions. The emission factors used are 1 mg Hg per t cast iron, 80 mg Cd (1990: 110 mg) per t cast iron and 2 g Pb (1990: 4.6 g) per t cast iron. Activity data until 1995 is taken from a national study (Hübner, 2001b). From 1996 onwards, data published by the Association of the Austrian foundry industry (Fachverband der Gießereiindustrie) has been used.

Ferroalloys

An emission factor for TSP (1 kg/t Alloy) was taken from the EMEP/EEA Emission Inventory Guidebook 2019 (EEA, 2019), emission factors for PM_{10} and $PM_{2.5}$ are based on expert judgement (PM_{10} 95% TSP, $PM_{2.5}$ 90%; same as for electric steel production).

4.5.1.3 Category-specific Recalculations

NFR 2.C.1 Iron and steel production

Emissions of POPs were reassessed:

- For all POPs a double counting of emissions was eliminated (emissions from steel production were accounted for twice)
- For dioxins the time series was corrected as emissions from one site had not been included for some years. This also affected PCB and HCB emissions as emissions of these species are correlated with dioxins.
- PAH emissions were corrected as previously PAH7 was reported instead of PAH4. In addition, the split into the different components was recalculated based on actual measurement data for two compounds and assumptions for the other two.

Effect on recalculations in 2021: -1.38 g for Dioxine, -0.07 t PAHs, -3.8 kg HCB. For PCB, emissions of the years before 2021 were revised (except for 2018 and 2019).

Activity data for 2007, 2010 and 2014 were updated for pig iron production and PM emissions for 2016 and 2020 were updated resulting in minor recalculations of heavy metals, PM and POPs (previously rounded values were used; recalculation effect e.g. -0.00008 t Pb in 2014, and 0.0003 kt TSP in 2020).

4.5.2 NFR 2.C.2 – 2.C.6 Non-ferrous Metals

4.5.2.1 Source Category Description

In this category, process emissions from non-ferrous metal production as well as from non-ferrous metal cast (light metal cast and heavy metal cast) are considered.

4.5.2.2 Methodological issues

Non-ferrous Metals Production

POP emissions from **aluminium production** were estimated in a national study (Hübner, 2001b) and were 6 090 kg PAH and 0.002 g Dioxine in 1990. Primary Aluminium production in Austria was terminated in 1992. Total PAH was split into the four components using the share of the EMEP/EEA Emission Inventory Guidebook 2019 (EEA, 2019).

For **secondary aluminium production** only emission data are reported. They are calculated from confidential production data using emission factors from national and international sources.

For **secondary copper production** the emission factors were taken from the EMEP/EEA GB 2019 for PM, PCB and SOx. EFs for HM, HCB, Dioxin and PAH were taken from national studies (Hübner 2001a) and (Hübner 2021).

Secondary lead is produced by two companies which use lead accumulators and plumbiferous metal ash as secondary raw materials. Lead recuperation is processed in rotary furnaces. Emissions from secondary lead production (2.C.5) were calculated from national data (BMWFW, 2016) using national emission factors (Hübner, 2001a) and emission factors from the EMEP/EEA Emission Inventory Guidebook 2016 (EEA, 2016) for PCB and PM. In order to avoid any double counting all SO_2 emissions are allocated to NFR category 1.A.2.b.

Non-ferrous Metals Casting

Activity data were obtained from „Fachverband der Gießereiindustrie Österreichs" (association of the Austrian foundry industry). The applied emission factors as presented below were taken from a study commissioned by the same association (Fachverband der Gießereiindustrie) and from direct information from this association.

Table 242: Activity data and emission factors for non-ferrous (light metal) cast 1990–2022.

	1990	1995	2000	2005	2010	2015	2022
Activity [t]	46 316	59 834	92 695	109 927	121 426	140 749	131 859
				Emission factor [g/t light metal cast]			
SO_2	120	10	→				10
NO_x	330	230	230	170	→		170
NMVOC	4 040	1 740	1 740	1 289	→		1 289
CO	2 340	880	880	660	→		660

Table 243: Emission factors and activity data for heavy metal cast 1990–2022.

	1990	1995	2000	2005	2010	2015	2022
Activity [t]	8 525	10 384	13 214	18 456	16 577	12 814	10 038
				Emission factor [g/t heavy metal cast]			
SO_2	100	80	→				80
NO_x	100	80	→				80
NMVOC	1 390	1 180	→				1 180
CO	3 290	2 770	→				2 770

4.5.3 Category-specific Recalculations

Activity data for copper production (2.C.7.a) for 2020 and 2021 were updated (e.g. + 0.00001 kt $PM_{2.5}$ and + 0.01 kt SO_2 in 2021).

4.6 NFR 2.D Solvent use

This chapter describes the methodology used for calculating air emissions from *Solvent use* in Austria. Solvents are chemical compounds which are used to dissolve substances as paint, glues, ink, rubber, plastic, pesticides or for cleaning purposes (degreasing). After application of these substances or other procedures of solvent use most of the solvents are released into air. Because solvents consist mainly of NMVOC, solvent use is a major source for anthropogenic NMVOC emissions in Austria. Once released into the atmosphere NMVOCs react with reactive molecules (mainly HO-radicals) or high energetic light to finally form CO_2.

Besides NMVOC further air pollutants from solvent use are relevant:

- Cd and Pb from NFR Sector 2.D.3.g Chemical products, as well as
- PAH, dioxins and HCB from NFR Sector 2.D.3.i Preservation of wood.

The following activities are covered by NFR sector 2.D.3-G:

NFR category	**Description**
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 application
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

4.6.1 Emission Trends

In the year 2022, 31% of total NMVOC emissions in Austria (31.38 kt) originated from *Solvent Use*. Table 244 presents the trend in NMVOC emissions by subcategories.

Table 244: Total NMVOC emissions and trend from 1990–2022 by subcategories of category 2.D.3 Solvent and Other Product Use.

NFR codes	2.D.3	2.D.3.a	2.D.3.b	2.D.3.c	2.D.3.d	2.D.3.e	2.D.3.f	2.D.3.g	2.D.3.h	2.D.3.i
year					**kt NMVOC**					
1990	114.52	16.30	0.09	0.00	45.79	13.26	0.44	12.79	12.65	13.20
1995	81.36	20.36	0.09	0.00	26.72	8.18	0.37	7.42	9.26	8.95
2000	58.89	18.91	0.09	0.00	16.67	6.51	0.29	4.78	5.42	6.22
2005	53.56	17.72	0.15	0.00	13.81	5.33	0.22	6.15	5.22	4.96
2010	44.91	16.93	0.12	0.00	11.40	3.99	0.12	5.90	3.39	3.05
2015	32.77	14.07	0.11	0.00	9.82	3.37	0.01	2.55	1.35	1.32
2020	36.95	20.52	0.11	0.00	9.26	3.03	0.01	2.19	0.71	1.11
2022	31.38	17.11	0.11	0.00	7.77	2.70	0.01	2.00	0.69	0.98
1990–2022	**-73%**	**5%**	**24%**	**17%**	**-83%**	**-80%**	**-98%**	**-84%**	**-95%**	**-93%**
Share in National Total										
1990	**35%**	**5%**	**0.03%**	**0.001%**	**14%**	**4%**	**0.1%**	**3.9%**	**3.9%**	**4.0%**
2022	**31%**	**17%**	**0%**	**0%**	**8%**	**3%**	**0%**	**2%**	**1%**	**1%**

NMVOC emissions in this sector decreased by 73% between 1990 and 2022, due to technological improvement also resulting from the enforced laws and regulations in Austria.

In the early 1990ies the VOC content of products such as paints, varnishes, preservatives and glues was limited in Austria, the use of CKWs and Benzol was largely prohibited, the content of aromatic compounds limited and measures for installations applying VOC containing products were set:

- Solvent Ordinance (1991)[110] (repealed by Solvent Ordinance 1995)
- Solvent Ordinance 1995[111] (repealed by Solvent Ordinance 2005)
- Paint finishing systems Ordinance (1995)[112] (repealed by VOC Installations Ordinance)

In the subsequent years the legislation was adapted to be in line with European legislation:

- VOC Installations Ordinance (2002)[113], implementation of "Solvent Emission Directive"[114]

[110] Verordnung des Bundesministers für Umwelt, Jugend und Familie über Verbote und Beschränkungen von organischen Lösungsmitteln (**Lösungsmittelverordnung**), BGBl. Nr. 492/1991

[111] Verordnung des Bundesministers für Umwelt über Verbote und Beschränkungen von organischen Lösungsmitteln (**Lösungsmittelverordnung 1995 – LMVO 1995**), BGBl 872/1995

[112] Verordnung des Bundesministers für wirtschaftliche Angelegenheiten über die Begrenzung der Emission von luftverunreinigenden Stoffen aus Lackieranlagen in gewerblichen Betriebsanlagen (**Lackieranlagen-Verordnung**), BGBl. Nr. 873/1995

[113] Verordnung des Bundesministers für Wirtschaft und Arbeit zur Umsetzung der Richtlinie 1999/13/EG über die Begrenzung der Emissionen bei der Verwendung organischer Lösungsmittel in gewerblichen Betriebsanlagen (VOC-Anlagen-Verordnung – VAV) BGBL II Nr. 301/2002

[114] Council Directive 1999/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations

- VOC Ordinance 2005[115] – implementation of "Paints Directive"[116]
- Amendment of VOC Ordinance (2005)[117] – implementation of "Industrial Emissions Directive" 2010/75/EC[118]

Measures implemented in emission intensive activity areas such as coating, painting and printing as well as in the pharmaceutical industry range from primary measures such as substitution of solvents, reduction of solvent contents and shift to lower or non-solvent emitting processes to secondary measures which basically is waste gas treatment.

4.6.2 NMVOC Emissions from Solvent use (Category 2.D.3.a-i)

4.6.2.1 Methodological Issues

Emissions are estimated using a combination of

- Top-down data from national statistics which provide information on the overall solvent use in Austria, updated annually;
- with bottom-up information from company solvent balances in solvent consuming sectors, updated every 3-5 years.

For the 2024 submission, another bottom up approach was launched. Data from companies were collected, and also information from previous years were updated.

Top down data

From national import/export and production statistics the national consumption of solvents is obtained:

National consumption of Substancei = (Substancei Import – Substancei Export + Substancei Production)

The non-solvent use of substances (i.e. where the substance is used as a reagent) is subtracted from national consumption:

$\textit{Solvent Use per Substance}_i = \textit{Solvent Balance per Substance}_i - \textit{Non Solvent Use of Substance}_i$

For products containing solvents, such as paints and glues, a balance of imports and exports is made, and the solvent content is estimated. The production of solvent containing products is not

[115] Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über die Begrenzung der Emissionen flüchtiger organischer Verbindungen durch Beschränkung des Inverkehrsetzens und der Verwendung organischer Lösungsmittel in bestimmten Farben und Lacken (**Lösungsmittelverordnung 2005 – LMV 2005**), BGBl. II Nr. 398/2005

[116] Directive 2004/42/EC of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in decorative paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC

[117] Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, mit der die Lösungsmittelverordnung 2005 geändert wird (**Änderung der Lösungsmittelverordnung 2005**), BGBl. II Nr. 25/2013

[118] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

accounted for in this equation, as the amount of solvents used for their production are already accounted for in the above mentioned consumption of solvents:

Solvents in Product$_p$ = (Solvent-containing Product$_p$ Import – Solvent-containing Product$_p$ Export) Solvent content of Product$_p$*

The overall solvent use in Austria is then calculated as the sum of the balances per substance and the amounts of solvents contained in products imported and exported:

Overall solvent use in Austria = $\sum_i$ Solvent Consumption of Substance$_i$ + $\sum p$ Solvents in Product$_p$

For the year 2020 an adaption of the top down data was made:
The increase in the overall solvent use in Austria 2019–2020 was verified with industry and is in the range of expected increased disinfectant use due the pandemic. Therefore, and because no information on the development in other categories was available, this increase was soley attributed to the domestic use sucategory. To avoid underestimation of emissions, another 1kt of desinfectant was added to the total sum, as due to emergency law, also pharmacies and small companies were allowed to produce disinfectants and denaturate ethanol themselves without customs officials being present.

Bottom up data

Domestic solvent use

Data on domestic solvent use in 2000 was obtained by a survey of 1 800 households (Windsperger et al., 2002a). Therein this survey, the application of solvent containing products of 37 categories in 5 main groups was collected: cosmetic, do-it-yourself, household cleaning, car, pesticides and insecticides). In addition, solvent use in the context of moonlighting besides commercial work and do-it-yourself (DIY) was estimated.

For 2015ff data from import/export statistics were used to index the annual changes of consumption.

Regarding emission factors an expert judgment was available for households (Windsperger et al., 2002a) which was updated in 2015 based on information from the German inventory.

Data for the years in between was intrapolated.

Paints used in construction and domestic paint use

Statistical data was combined with information on the average solvent content of paints derived from studies of the effects of the Ecopaint directive. As activity data reflects the solvent content of paints and not the amount of paints used, an emission factor of 95% is applied.

Industrial and commercial solvent use

The time series is mainly based on surveys of the years 2000, 2015, 2019 and 2022.

For 2000 and 2002 an extensive survey on the use of solvents was carried out in 1 300 Austrian companies (Windsperger et al., 2002b). In this survey data on the solvent content of paints, cleaning agents etc. and on solvents used (both substances and substance categories) like acetone or alcohols were collected. Furthermore information was gathered about:

- type of application of the solvents

  - final application,
  - cleaner,
  - product preparation;
- type of waste gas treatment
  - open application,
  - waste gas collection,
  - waste gas treatment.

For every category of application and waste gas treatment an emission factor was estimated to calculate solvent emissions in the year 2000 (see Table 245).

Table 245: Emission factors for NMVOC emissions from Solvent Use.

Category	Factor
final application	1.00
cleaner	0.85
product preparation	0.05
open application	1.00
waste gas collection	0.50
waste gas treatment	0.20

The above mentioned survey was carried out in all industrial branches with solvent applications; results for solvent use per substance category were collected at NACE-level-4. The total amounts of solvents collected were extrapolated using the number of employees to upscale to the total industrial branch (Statistik Austria, 2000 & 1998 and using information from KSV1870 INFORMATION 2000). Furthermore, the data set was extrapolated to historical years using the same (1980, 1990, 1995) factor "solvent use per employee", where the number of employees of the respective year were again taken from national statistics (Statistik Austria, 2001) (Windsperger et al., 2004). For the pillar year 2005 the structural business statistics (number of employees (NACE Rev.1.1)) were taken from (EUROSTAT, 2008).

To finally estimate emissions from AD, development of the economic and technical situation in relation to the year 2000 was also considered. The information were collected for three pillar years (1980, 1990, 1995) and were taken from several studies (SCHMIDT et al., 1998, BARNERT, 1998) and expert judgements from associations of industries (chemical industry, printing industry, paper industry) and other stakeholders.

For the year 2015 an extensive research (Windsperger et al., 2019) was done, based on solvent balances of those companies that were obliged to report their use of solvents as well as emissions under directive 1999/13/EC (VOC Solvents Directive). For the years 2019 and 2022 again solvent balances from companies were collected, the data was complemented by employment data. The data base now includes data sets from about 1 000 installations (as data is not complete for all installations, gap filling using data from other years had to be done). The companies are allocated to the different NACE categories, and, based on the ratio of employers of the collected installations to total employers of this NACE category, a judgement regarding completeness is made. For some categories the survey can be considered as complete (such as for car manufacturer, where companies generally are large and covered by the reporting obligations of the solvent directive). For other sectors, especially the small structured buisnesses as carpenters and car repairing, the collected emissions and activity data is upscaled using employment data. For some processes, such as oil extraction, it had been considered that the emission/employee ratio for the installations where data was available might be different than for the remaining NACE sector (e.g. by assuming a emission/employee ratio 10 times lower).

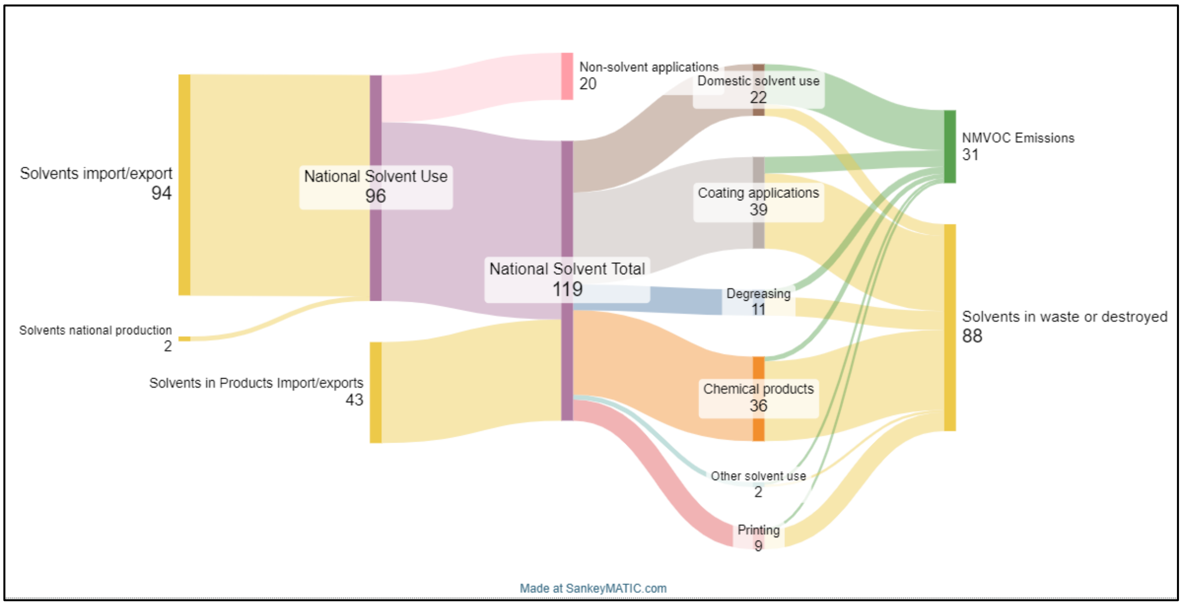
Activity Data (i.e. total amount of solvents used) was linearly interpolated between all years where no data was available (1991-1994, 1996-1999, 2001, 2003–2015 and 2015–2019). For 2020 the AD of 2019 was used and for 2021 the average value of 2022 and 2020 was used. Also the Emission factors were interpolated in years between surveys, except for 2020 and 2021 where for most catgories the value of 2019 was used (for those where there was only little difference between 2019 and 2022).

Top down / bottom up combination

Data from the top down approach (for the reference year 2000, up to 2002 as well as 2015, 2019 and 2022) were compared with data from the bottom up approach. In the first survey for 2000–2002 large discrepancies were detected, further investigations were necessary. Additional solvent uses were identified (such as windscreens wiper fluids, antifreeze, hospitals, de-icing agents of aeroplanes, tourism, cement- respectively pulp industry as well as additionally identified non-solvent uses) and data added to the model (Windsperger et al., 2002a und b).

The remaining gap is 4–20%. Finally, the bottom up data was adjusted to finally fit the top down sum. For the years 2000–2003 all sub sectors were adjusted equally, from 2015 onwards the upscaling was done only for those sub sectors where no full survey had been achieved.

Figure 49: Sankey model of the Austrian solvents emission inventory for the inventory year 2022, Submission 2024, values in kt solvent/kt NMVOC.



4.6.2.2 Activity data

Activity data for *2.D.3 Solvent Use* consists of the amount of solvents placed on the market in Austria, minus the amount of "non-solvent use" (see chapter on methodological issues for a description of data used).

Table 246: Activity data for solvent and other product use [t] 1990–2022.

	2.D.3	2.D.3.a	2.D.3.d	2.D.3.e	2.D.3.f	2.D.3.g	2.D.3.h	2.D.3.i
Year					**t Solvent**			
1990	137 924	23 361	50 131	15 467	459	18 585	14 729	15 192
1995	130 088	25 296	50 371	13 564	426	12 465	13 474	14 492
2000	112 872	21 896	35 517	11 940	340	23 798	8 242	11 140
2005	115 848	21 202	36 186	11 889	281	25 961	10 957	9 222
2010	117 464	20 980	38 203	10 900	180	29 637	11 449	5 993
2015	118 279	18 075	38 132	11 367	18	34 328	13 411	2 840
2020	123 946	25 249	39 536	11 763	19	32 613	12 507	2 148
2022	119 459	21 658	39 469	11 349	12	35 778	9 097	1 986

4.6.2.3 Emission factors

Implied emission factors are calculated from the reported or extrapolated emissions and activity data taken from the company reports as explained above or, for domestic solvent use, estimated from consumption applying emission factors.

According to an encouragement from the CLRTAP review in 2017, IEFs are also presented on a g/person per year basis for 2.D.3.a, Domestic Solvent use for 2022 and are as follows:

Domestic solvent use (other)	1 331 g NMVOC/person per year
Domestic use of pharmaceutical prod.	575 g NMVOC/person per year

Table 247: Implied NMVOC Emission factors for Category 3 Solvent and Other Product Use 1990–2022.

	2.D.3.a	2.D.3.d	2.D.3.e	2.D.3.f	2.D.3.g	2.D.3.h	2.D.3.i
				EF			
1990	0.91	0.90	0.81	0.95	0.81	0.86	0.76
1995	0.91	0.70	0.58	0.88	0.78	0.69	0.67
2000	0.86	0.47	0.55	0.85	0.20	0.66	0.56
2005	0.84	0.38	0.45	0.77	0.24	0.48	0.54
2010	0.81	0.30	0.37	0.68	0.20	0.30	0.51
2015	0.78	0.26	0.30	0.60	0.08	0.09	0.46
2020	0.81	0.23	0.25	0.62	0.07	0.06	0.52
2022	0.79	0.20	0.24	0.62	0.06	0.08	0.49

4.6.2.4 Category-specific recalculations

Data on installation basis that is prepared by the operators according to the VOC directive were collected and incorporated. During intensive QC, which included comparison with the data of 2015 and 2019, some corrections of the data for 2015 and 2019 were made, leading to a recalculation for most sub-categories from 2015 onwards.

Also, corrections on the top down data were made: besides correction of minor transcription errors for the years from 2016 onwards, non-solvent use of a new company became available which was considered for 2021 leading to a decrease of total solvent use in Austria. As bottom up data is extrapolated to this value, this resulted in lower activity data and thus lower emissions for 2021.

Overall, the recalculation difference for 2021 of this subcategory is – 1.34 kt NMVOC.

4.6.3 NFR 2.D.3.b Road paving with asphalt

For NMVOC and PM the default values of the EMEP EEA GB 2019 (abated technology) have been applied. The operation conditions were proven via personal conversation with Gestrada (Austrian Association for Asphalt). No unabated technologies are allowed in Austria.

Activity data were obtained from the European Asphalt Pavement Association (EAPA) that provides a consistent time series in its annual publication "Asphalt in Figures".

Table 248: Activity data and NMVOC and PM_{10} emissions from road paving with asphalt.

	Activity	NMVOC emissions	PM_{10} emissions
Year	**[t]**	**[t]**	**[t]**
1990	5 900 000	89	236
1995	5 900 000	89	236
2000	5 900 000	89	236
2005	10 000 000	150	400
2010	8 200 000	123	328
2015	7 200 000	108	288
2020	7 400 000	111	296
2022	7 300 000	110	292

4.6.4 NFR 2.D.3.c Asphalt roofing

In this category CO, NMVOC and PM emissions from production of bituminous roofing felts are considered. As one of the production site is also engaged in asphalt blowing, emissions resulting from this process at this plant are also included. Emissions from the second asphalt blowing plant in Austria which is part of the only refinery are reported together with other emissions from the refinery in NFR category 1.A.1.b.

The contribution to Austria's national total emissions is very low: 0.003% of NMVOC and 0.001% of PM_{10} emissions arise from asphalt roofing plants in Austria.

The CO EF was taken from the EMEP 2019 GB. NMVOC and TSP emissions were estimated based on information on abatement technologies and measurement data from all but one small production sites. For the shares of PM_{10} and $PM_{2.5}$ the default share values of the EMEP 2019 GL were used. The information was obtained for 2020 and extrapolated to total production in Austria (taken from official production statistics Statistik Austria, 2020). The implied EF of 2020 was used for the whole time series as according to plant operators no major changes in technology took place since then.

It has to be noted that in Austria no natural asphalt is used for the production of bituminous roofing felts.This would require adding solvents to the raw material, which would result in a high NMVOC EF.

4.6.5 Emissions other than NMVOC from NFR 2.D.3.g Chemical products and 2.D.3.i Preservation of wood

Cd and Pb from NFR sector 2.D.3.g Chemical products arise from paints manufacturing. Emissions were taken from (Windsperger et al., 1999).

PAH, dioxins and HCB arise from preservation of of railway ties and telephone poles with products containing tar oil. This was relevant in the early 90ies only. Emissions were taken from (Hübner, 2001b).

4.7 NFR 2.G Other Product Manufacture and Use

The category 2.G covers emissions, which originate from the use of fireworks and tobacco.

	2.G other use (Use of fireworks)	2.G other use (Use of tobacco)
Key category	Cd (for 2.G total)	
Pollutant	SO_2, CO, NO_x, TSP, PM_{10}, $PM_{2.5}$, Cd, Hg, Pb	CO, NO_x,NMVOC, NH_3, TSP, PM_{10}, $PM_{2.5}$, Cd, Dioxin, PAH (incl. 4 species)
Activity	Amount of fireworks placed on market	Sales of tabacco products
Method	EMEP/EEA 2019 default emission factors except for PM emissions from fireworks where EF from literature based on measurements were applied.	

4.7.1 Methodological Issues

For emissions from fireworks, the amount of fireworks placed on the market was used (import + production – export) as activity data.

For tobacco use, the amount of cigarettes, loose tobacco and cigars sold in Austria was used. According to the EMEP/EEA Guidebook, 1g of tobacco per cigarette and 5g of tobacco per cigar was assumed. Due to bans of fireworks in 2020 (due to the pandemic), unsold fireworks were sold in 2021, where import/export showed very low values. Therefore, for 2020 and 2021 half of the sum of both years was assigned to each year.

EMEP/EEA 2019 default emission factors except for PM emissions from fireworks where EF from literature based on measurements were applied (Keller & Schragen, 2021), taking into account Austrian sales data on different types of fireworks for 2019. The resulting EFs that were applied for all years are:

- 51,8 kg PM_{10} = TSP / t fireworks
- 42,4 kg $PM_{2.5}$ / t fireworks

Table 249: Emissions from fireworks from 1990–2022.

NFR	2.G Use of Fireworks								
	SO_2	NO_x	CO	Cd	Hg	Pb	TSP	PM_{10}	$PM_{2.5}$
Unit	t	t	t	kg	kg	kg	t	t	t
1990	4.73	0.41	11.19	2.32	0.09	1 227.07	81.16	81.16	66.39
1995	4.19	0.36	9.93	2.05	0.08	1 088.34	71.98	71.98	58.88
2000	6.45	0.56	15.26	3.16	0.12	1 673.76	110.70	110.70	90.55
2005	6.03	0.52	14.28	2.96	0.11	1 565.81	103.56	103.56	84.71
2010	5.75	0.49	13.60	2.82	0.11	1 491.42	98.64	98.64	80.69
2015	2.89	0.25	6.85	1.42	0.05	750.80	49.66	49.66	40.62
2020	1.47	0.13	3.49	0.72	0.03	382.38	25.29	25.29	20.69
2022	3.30	0.30	8.14	1.69	0.06	892.96	59.06	59.06	48.31

Table 250: Emissions from Tobacco Use from 1990–2022.

NFR	2.G Tobacco Use									
	NO_x	CO	NMVOC	NH_3	TSP	PM_{10}	$PM_{2.5}$	Cd	Diox	PAH
Year	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[kg]	[g]	[kg]
1990	30.32	928.27	81.54	69.91	454.87	454.87	454.87	90.97	1.68	4.14
1995	29.00	887.76	77.98	66.86	435.02	435.02	435.02	87.00	1.61	3.96
2000	29.08	890.30	78.20	67.06	436.26	436.26	436.26	87.25	1.62	3.97
2005	25.53	781.41	68.64	58.85	382.91	382.91	382.91	76.58	1.42	3.49
2010	26.94	824.56	72.43	62.10	404.05	404.05	404.05	80.81	1.50	3.68
2015	25.10	768.48	67.50	57.88	376.57	376.57	376.57	75.31	1.39	3.43
2020	24.53	750.97	65.97	56.56	367.99	367.99	367.99	73.60	1.36	3.35
2022	24.28	743.33	65.29	55.99	364.24	364.24	364.24	72.85	1.35	3.32

Table 251: Emissions from Tobacco Use from 1990–2022.

Year	Benzo_a	Benzo_b	Benzo_k	Indeno
	g	g	g	g
1990	1870	758	758	758
1995	1788	725	725	725
2000	1794	727	727	727
2005	1574	638	638	638
2010	1661	673	673	673
2015	1548	628	628	628
2020	1513	613	613	613
2022	1446	586	586	586

4.7.2 Category specific recalculations

No recalculations have been carried out since the last submission.

4.8 NFR 2.H Other processes

This category covers emissions in the food and beverages industry. Emissions from 2.H.1 are included 1.A.2.d.

4.8.1 NFR 2.H.2 Food and Beverages Industry

4.8.1.1 Source Category Description

This category includes NMVOC emissions from the production of bread, wine, spirits and beer and PM emissions from the production of beer. Furthermore this category includes POP emissions from smokehouses.

4.8.1.2 Methodological Issues

NMVOC emissions were calculated by multiplying the annual production by an emission factor. The following emission factors were applied:

- Bread...................... 4 200 g_{NMVOC}/t_{bread}
- Wine .... 65 g_{NMVOC}/hl_{wine}
- Beer .... 20 g_{NMVOC}/hl_{beer}
- Spirits .... 2 000 g_{NMVOC}/hl_{spirit}
- Animal feed .... 898 g_{NMVOC}/t_{feed}
- Sugar .... 100 g_{NMVOC}/t_{sugar}

All emission factors were taken from Swizerland [BUWAL, 1995] or Germany[119] because of the very similar structures and standards of industry. Activity data were taken from national statistics (Statistik Austria). For the year 2008 no activity data are available, therefore the values of 2007 were also used for 2008.

PM emissions from beer production correspond to fugitive emissions from barley used for the production of malt. Emissions were estimated in a national study (Winiwarter et al., 2001) and amounted to:

- TSP 1990: ....2.2 t, 1995: 2.1 t, 1999–2005: 1.9 t
- PM_{10}................1990: 1.1 t, 1995: 1.0 t, 1999–2005: 0.9 t

[119] [German Informative Inventory Report] (umweltbundesamt.de) https://iir.umweltbundesamt.de/2021/sector/ippu/pulp_paper_food/food_and_beverages/start

- $PM_{2.5}$ .... 1990: 0.5 t, 1995: 0.3 t, 1999–2005: 0.3 t

POP emissions from smokehouses were estimated in an unpublished study (Hübner, 2001b[120]) that evaluates POP emissions in Austria from 1985 to 1999. The authors of this study calculated POP emissions using technical information on smokehouses and the number of smokehouses from literature (Wurst & Hübner, 1997), (Meisterhofer, 1986). The amount of smoked meat was also investigated by the authors of this study. From 2000 onwards the emission values of 1999 have been used as no updated emissions are available. Activity data and emissions are presented in Table 252.

Table 252: POP emissions and activity data from smokehouses 1990–2022.

Year	Activity [t]	Emissions						
	Smoked meat	PAH [kg]	BAP [kg]	BBF [kg]	BKF [kg]	IND [kg]	Diox [g]	HCB [g]
1990	15 318	545	191	175	66	112	1.8	358
1995	19 533	107	38	34	13	22	0.4	72
2000	19 533	37	13	12	5	8	0.1	26
⇣	⇣	⇣	⇣	⇣	⇣	⇣	⇣	⇣
2022	19 533	37	13	12	5	8	0.1	26

4.8.1.3 Category-specific recalculations

No recalculations have been carried out since the last submission.

4.9 NFR 2.I Wood Processing

4.9.1 Source Category Description

This category includes particulate matter emissions from

1. Wood processing: emissions from saw mills and further processing of sawn wood

2. Wood chips (by-products): supply and handling of wood chips and sawmill by-products for the use in chipboard and paper industry:

- unloading from truck
- transport from storage and drop in into silo

3. Wood chips-boilers: supply and handling of woodchips and sawmill by-products for use in combustion plants:

- chipping in mobile chippers and dropping to heaps
- loading onto truck with wheel loader
- unloading from truck into boxes

[120] according to Meisterhofer (1986)

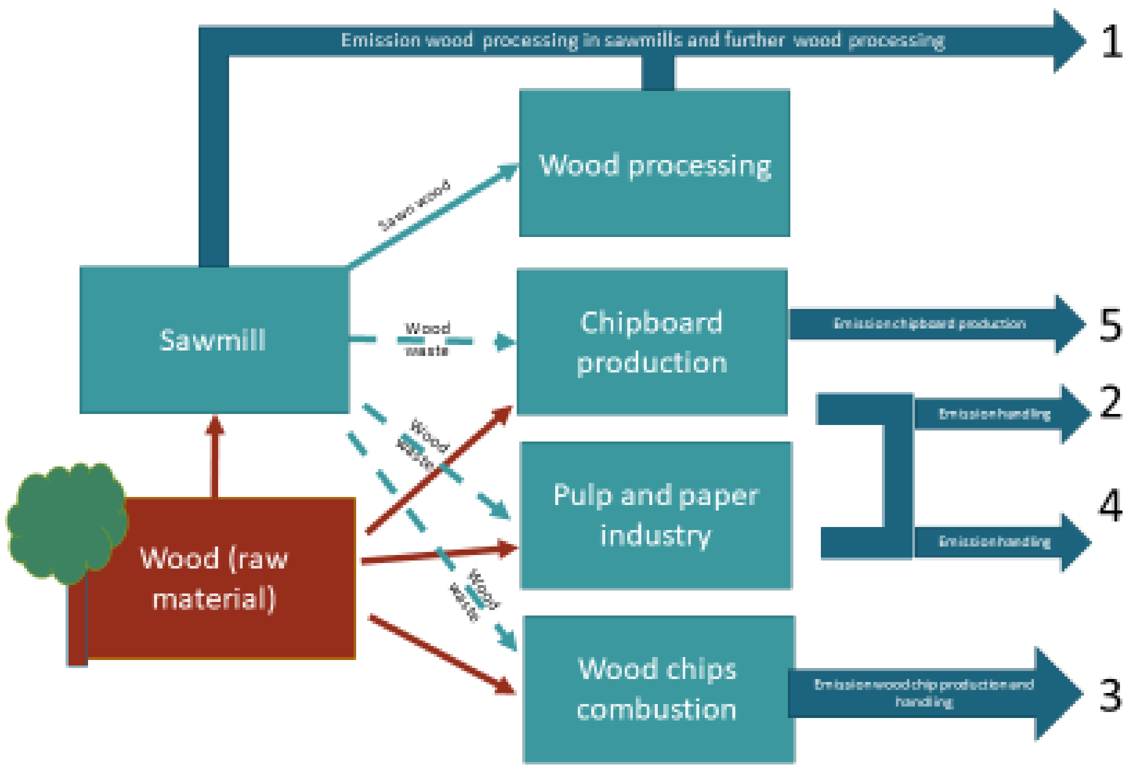
- conveyor from boxes and drop in into silo

4. Wood chips onsite: production and handling of wood chips produced on-site in chip-board and paper industry:

- conveyor band from wood chipper to heap
- transport from storage and drop in into silo

5. Chipboard production: emissions from chipboard production (additional to fugitive emissions from handling of wood chips considered in (1), (2) and (4)).

Figure 50: Sources of particulate matter emissions from wood products. The numbers refer to the different sources that are described above.



Source: Umweltbundesamt

4.9.2 Methodological Issues

The methodology for emission calculation was developed in a national study (Winiwarter et al., 2007) and emissions were calculated for 2001 applying emission factors of a Swiss study (EMPA, 2004) to Austrian activities.

Table 253: Activity data (used for all years) and emission factors 2.I subcategories.

Sub category	EF	AD	EMI TSP 2001 [t]
1 wood processing	146.5 g TSP/t	4 Mio t	586 t
2 wood chips (by-product)	20 g TSP/t	4.8 Mio t	96 t
3 wood chips-boilers	35 g TSP/t (2 190 g /TJ)	see Table below	70 t
4 wood chips onsite production	30 g TSP/t	5.6 Mio t	168 t
5 chipboard production	18 171 314 g/ mio m³	see Table below	43.375 t

The presented AD is used for all years, exept for wood chips – boilers were annual data are available from the national energy balance ("wood waste – gross consumption") and for chipboard production where an annual value is available from production statistics. For these two categories an IEF was calculated from the 2001 values and applied for the rest of the time series.

For all sub-categories the following shares were used: PM_{10}=40% TSP, $PM_{2.5}$=16% TSP.

Table 254: Activity data and emissions for supply (production) and handling of wood-chips and sawmill by-products for the use in combustion plants.

Year	Wood waste – gross consumption [TJ]	TSP Emissions [t]	Chipboard Production [mio m³]	TSP Emissions [t]
1990	11 788	25.81	1.603	29.12
1995	12 595	27.58	1.706	31.00
2000	29 982	65.65	2.157	39.19
2005	55 204	120.87	3.118	56.65
2010	102 161	223.68	3.738	67.92
2015	108 175	236.85	3.551	64.53
2020	104 474	228.75	2.462	44.74
2022	114 833	251.43	2.463	44.75

4.9.2.1 Category-specific recalculations

During extensive QA/QC a transcription error was corrected, resulting in minor recalculations of the whole time series (e.g. – 0.0004 kt TSP in 2021).

5 AGRICULTURE (NFR SECTOR 3)

5.1 Sector Overview

This chapter includes information on the estimation of NH_3, NO_x, NMVOC, SO_2, CO, particulate matter (PM), heavy metals (HM) and persistent organic pollutant (POP) of the sector *Agriculture* in Austria corresponding to the data reported in category 3 of the NFR format. It describes the calculations of source categories *3.B Manure Management, 3.D Agricultural Soils* and *3.F Field Burning of Agricultural Residues.*

For some pollutants the agricultural sector is only a minor source: emissions of SO_2, CO, heavy metals and POPs arise only from the categories *3.D.f Use of pesticides* and *3.F Field burning of agricultural wastes*. The contribution to the national total is low for category *3.D.f* (0.2% of total HCB in 2022); in category *3.F* no emissions occurred in 2022 ("NO").

To give an overview of Austria's agricultural sector some information is provided below (according to the 2020 Farm Structure Survey – full survey) (BML, 2000–2023): Agriculture in Austria is rather small-scaled: 154 593 farms are managed, 54.9% of these farms manage less than 20 ha, whereas only 5.7% of the Austrian farms manage more than 100 ha cultivated area. 118 432 holdings are classified as situated in less favoured areas. Related to the federal territory Austria has the highest share of mountainous areas in the EU (70%). The structural change of Austria´s Agriculture is continued: the number of agricultural holdings decreased between 2010 and 2020 by 11% whereas the size of holdings increased in this period. In 2010, an average total area of 42.6 ha was managed on a holding, in 2020 it increased to 44.9 ha.

The agricultural area comprises 2.60 million hectares that is a share of ~ 31% of the total territory (forestry ~ 41%, other area ~ 11%). The shares of the different agricultural activities are as follows:

- 51% arable land,
- 22% grassland (meadows mown several times and seeded grassland),
- 24% extensive grassland (meadows mown once, litter meadows, rough pastures, alpine pastures and mountain meadows),
- 3% other types of agricultural land-use (vineyards, orchards, house gardens, vine and tree nurseries).

5.2 General description

5.2.1 Completeness

Table 255 gives an overview of the NFR categories included in this chapter and presents the transformation matrix from SNAP categories. It also provides information on the status of emission estimates of all subcategories. A „✓" indicates that emissions from this sub-category have been estimated.

Table 255: Overview of sub-categories of agriculture and status of estimation.

NFR Category		NEC gas				CO	PM			Heavy metals			POPs			
		NO_x	NMVOC	SO_2	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$	Cd	Hg	Pb	Dioxin	PAH	HCB	PCB
3.B.	MANURE MANAGEMENT	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
3.B.1	Cattle	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
3.B.1.a	Dairy Cattle	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
3.B.1.b	Non-Dairy Cattle	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
3.B.2	Sheep	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
3.B.3	Swine	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
3.B.4	Other Livestock	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
	Buffalo	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Goats	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
	Horses	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
	Mules and asses[1)]	IE	IE	NA	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Laying hens	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
	Broilers	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
	Turkeys	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
	Other poultry	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
	Other Animals	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
3.D	AGRICULTURAL SOILS	✓	✓	NA	✓	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
3.D.a.1	Inorganic N fertilizers	✓	NA	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2	Organic N fertilizers	✓	✓	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.a	Animal manure applied to soils	✓	✓	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.b	Sewage sludge applied to soils	✓	NA	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.c	Other organic fertilizers applied to soils (including compost)	✓	NA	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.3	Urine and dung deposited by grazing animals	✓	✓	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.4	Crop residues	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.b	Indirect emissions from managed soils	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D.c	Farm-level agricultural operations including storage, handling and transport of agricultural products	NA	NA	NA	NA	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
3.D.d	Off-farm storage, handling and transport of bulk agricultural products	NA	NA	NA	NA	NA	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA
3.D.e	Cultivated crops	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.f	Use of pesticides	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	✓	NA
3.F	FIELD BURNING OF AGRICULTURAL RESIDUES[2)]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	NA
3.I	Agriculture other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

1) included in 3.B.4 Horses

2) emissions reported 1990–2020, NO in 2021 and 2022

5.2.2 Key Categories

Austria's key category analysis is presented in Chapter 1.5. This chapter includes information on the agriculture sector. Key sources within this category are presented in Table 256.

Table 256: Key sources of sector Agriculture.

NFR Category	Source Categories	Key Categories	
		Pollutant	**KS-Assessment**
3.B.1	Manure Management (Cattle)	NH_3	LA, TA
3.B.1	Manure Management (Cattle)	NMVOC	LA
3.B.3	Manure Management (Swine)	NH_3	LA, TA
3.D.a.1	Inorganic N-fertilizers	NH_3	LA, TA
3.D.a.1	Inorganic N-fertilizers	NO_x	LA
3.D.a.2	Organic fertilizers	NH_3	LA, TA
3.D.a.2	Organic fertilizers	NO_x	LA
3.D.a.2	Organic fertilizers	NMVOC	LA
3.D.c	On-farm storage, handling and transport of agricultural products	TSP	LA
3.D.c	On-farm storage, handling and transport of agricultural products	PM_{10}	LA
3.D.f	Use of pesticides	HCB	TA

LA = Level Assessment 2022

TA = Trend Assessment 1990–2022

5.2.3 Methodology

The Austrian agriculture inventory model follows the N-flow concept. NH_3 emissions are calculated based on the amount of total ammoniacal nitrogen (TAN). TAN is present in the urine of animals and considered being equivalent to the N content of urine. This calculation method is more precise than the calculation based on total N excretion because emissions of NH_3 arise from TAN. The calculation addresses both N pools (N excretion and TAN) for the different stages of manure management (housing → storage → spreading) in terms of NH_3, NO_x, N_2O and N_2 (storage) emissions and includes information of the total N amount within each relevant stage (N excretion), and the fraction of that amount that is present as TAN.

Table 257 includes a summary of the methodologies used in Austria's agriculture sector as recommended in the CLRTAP Review report for Austria 2010 (United Nations, 2010).

Table 257: Summary of methodologies used in Austria's agriculture inventory.

NFR category		Methodology used
3.B Manure Management	3.B.1 Cattle	T3 (NH_3), T2 (NO_x, NMVOC), T1 PM)
	3.B.2 Sheep	T2 (NH_3, NO_x, NMVOC), T1 (PM)
	3.B.3 Swine	T3 (NH_3), T2 (NO_x, NMVOC), T1 PM)
	3.B.4 Other Livestock	T2 (NH_3, NO_x, NMVOC), T1 (PM)
3.D Agricultural Soils	3.D.a.1 Inorganic N fertilizers	T3 (NH_3), T1 (NO_x)
	3.D.a.2.a Animal manure applied to soils	T3 (NH_3), T2 (NMVOC), T1 (NO_x)

NFR category		Methodology used
	3.D.a.2.b Sewage sludge applied to soils	T1
	3.D.a.2.c Other organic fertilizers applied to soils (including compost)	T1
	3.D.a.3 Urine and dung deposited by grazing animals	T3 (NH_3), T2 (NMVOC), T1 (NO_x)
	3.D.c Farm-level agricultural operations including storage, handling and transport of agricultural products	T1
	3.D.d Off-farm storage, handling and transport of bulk agricultural products	T1 (country-specific)
	3.D.e Cultivated crops	T2
	3.D.f Use of pesticides	T1
3.F Field Burning of agricultural Residues		T1

The following table presents an overview of the country specific data used in the agriculture inventory including a short indication on the sources for this data.

Table 258: Information on country specific data used in sector agriculture.

NFR category	Parameter	Source
3.B Manure Management		
3.B (all livestock)	MMS distribution	Amon & Hörtenhuber (2010), Amon & Hörtenhuber (2019)
3.B (cattle, swine, chicken, horses)	Anaerobic digestion	Amon (2002), E-CONTROL (2006–2021, 2022, 2023), Hörtenhuber (2022), Kompost- und Biogasverband (2023)
3.B (cattle, swine)	N excretion	Hörtenhuber et al. (2022b), Hörtenhuber et al. (2023)
3.B (other livestock than cattle and swine)	N excretion	Unterarbeitsgruppe N-adhoc (2004), BML (2022)
3.D. Agricultural Soils		
Austria's N-flow model	Country-specific consideration of N-losses	(Amon et al., 2002, 2008, 2010, 2014 & 2019)
Sewage sludge spreading	N content data	Umweltbundesamt (1997)
Compost application	N content data	Expert judgement by Umweltbundesamt (2015)

5.2.4 Uncertainty Assessment

The following chapter gives an estimate of uncertainties with respect to NO_x, NH_3, NMVOC, SO_2 and $PM_{2.5}$ emissions from animal manures, agricultural soils as well as field burning of agricultural soils. Overall uncertainties result from uncertainties in the activity data and from uncertainties in the emission factors.

Activity data

Uncertainties of cattle and swine numbers were re-evaluated in submission 2016. Uncertainties were derived by analysing official Austrian livestock numbers published in June and December each year. Comparing these two data sets the standard deviation was calculated. As a conservative approach the doubled standard deviation was taken, leading to an uncertainty for dairy cattle of 2%, for non-dairy cattle of 1% and for swine of 4%.

Emission factors

Emission factors are rated based on the qualitative assessment (see Chapter 1.7, Table 25).

Table 259 presents uncertainties for emissions (for selected pollutants) as well as for activity data used in sector agriculture according to the error propagation method (Tier 1).

Table 259: Combined uncertainties of emissions in sector 3 Agriculture for selected pollutants.

NFR Categories		NO_x Emissions [%]	NH_3 Emissions [%]	NMVOC Emissions [%]	SO_2 Emissions [%]	$PM_{2.5}$ Emissions [%]
3.B.1	Manure Management (Cattle)	+/-125.0%	+/-20.0%	+/-125.0%	NA	+/-200.0%
3.B.2	Manure Management (Sheep)	+/-125.4%	+/-41.2%	+/-125.4%	NA	+/-200.2%
3.B.3	Manure Management (Swine)	+/-125.1%	+/-20.4%	+/-125.1%	NA	+/-200.0%
3.B.4	Manure Management (Other animals)	+/-125.4%	+/-41.2%	+/-125.4%	NA	+/-200.2%
3.D.a.	Agricultural Soils	+/-125.1%	+/-40.3%	+/-125.1%	NA	NA
3.D.c	On-farm storage	NA	NA	NA	NA	+/-200.1%
3.D.d	Off-farm storage	NA	NA	NA	NA	+/-200.1%
3.D.e	Cultivated Crops	NA	NA	+/-750.0%	NA	NA
3.F	Field Burning*)	+/-160.1%	+/-160.1%	+/-160.1%	+/-160.1%	+/-160.1%
Activity Data						
Animal Population - Cattle		+/-1%				
Animal Population - Swine		+/-4%				
Animal Population – Sheep and Other		+/-10%				
Area Data & Fertilizer Input (combined)		+/-5%				

*) *emissions reported 1990-2020, NO in 2021 and 2022*

5.2.5 Quality Assurance and Quality Control (QA/QC)

The following sector specific QA/QC procedures have been carried out:

1. Activity data check
   - ✓Check for transcription errors, comparison with published data (BML, 2000–2023),
   - ✓ Consistency checks of sub-categories with totals,
   - ✓ Plausibility checks of dips and jumps;

2. Emission factors
   - ✓ Comparison with EMEP/EEA default values and factors reported by other countries;
3. Calculation by spreadsheets
   - ✓ Consistent use of livestock characterization,
   - ✓ Cross-checks through all steps of calculation,
   - ✓ Documentation of sources and correct use of units;
4. Results (emissions)
   - ✓ Check of recalculation differences,
   - ✓ Plausibility checks of dips and jumps;
5. Documentation
   - ✓ Findings and corrections marked in the spreadsheets,
   - ✓ Improvement list (internal and external findings).

In the Austrian QMS regularly extensive QA and verification activities are carried out (Tier 2 QA).

In 2012 Agriculture was validated. Some minor inconsistencies with respect to the MMS data have been found and corrected.

In 2014 an external review by Austrian Agricultural experts within the framework of a stakeholder meeting was held. Reason was the revision of the Austrian inventory model for sector agriculture according to the 2006 IPCC GL and the EMEP/EEA GB 2013. Applied values and parameters were discussed and validated by the national experts.

In 2018 the agricultural model was revised as new data on the agricultural practice in Austria became available with the TIHALO II study (Pöllinger et al., 2018) as well as due to improvements of the N-flow according to the EMEP/EEA GB 2016. Within the framework of this revision a stakeholder meeting (so-called "inventory talks") was held in order to discuss applied values, parameters, time series and study results with Austrian agricultural experts (Umweltbundesamt, 2010, 2014 & 2018).

In submission 2022, Austria included updated and representative values for nitrogen and energy intake, excretion of nitrogen (Nex) and volatile solids (VSex) as a result of the research project on country-specific animal feeding and nutrition ("MiNutE" study, Hörtenhuber et al., 2022b; Hörtenhuber et al., 2023). These values were discussed and verified by Austrian agricultural experts.

In 2023, Austria verified its NH_3 estimates by comparing them with the calculations and results of the 3*.B Manure Management N flow tool* from the European Environment Agency (EEA, 2023b).

Basically, the comparison showed a good correlation of trends and emission levels between the two calculations. The Austrian N-flow model for cattle and swine is much more complex and there was a need to simplify the calculations in order to be able to use the EEA N-flow tool. One of the conclusions therefore was that the national circumstances in terms of feeding and agricultural practices would not be represented adequately by standardized tools. Minor issues found in the national inventory during this verification exercise (mainly effecting air emissions) have already been implemented into the 2024 submission.

A general description of Austria's QMS (Quality Management System), activities and improvements 2023 is presented in Chapter 1.6.

5.2.6 Planned Improvements

A new survey on animal husbandry and manure management systems ("TIHALO III" study) is currently carried out. Work is in progress and the study results will be implemented in submission 2025. Additionally, in the GHG inventory (also affecting air emissions) the implementation of the 2019 Refinement to the 2006 IPCC GL for sectors 3.B Manure Management and 3.D Agricultural Soils is planned for the next submission.

The complete implementation of the EMEP EEA GB 2023, in particular the reporting of the new emission sources (NH_3 from crop residues, NH_3 from cats and dogs to be reported under NFR sector 6), will be finalised for next submission.

5.3 NFR 3.B Manure Management

The Austrian sectorial inventory model follows the N-flow concept (Amon & Hörtenhuber 2014, Amon & Hörtenhuber, 2019).

Data on animal husbandry and manure management systems all over Austria are based on the following surveys: (Konrad, 1995), TIHALO I (Amon et al., 2007) and TIHALO II (Pöllinger et al., 2018).

In response to questions raised during the comprehensive ESD Review 2020 (EEA, 2020) and the NEC Review 2021 (EC, 2021a) on Austria's feeding assumptions, the Umweltbundesamt initiated a new representative study. The feeding of cattle and swine has changed substantially in the last two decades and it was decided to update the national inventory based on latest available science. Thus, from 2020 to 2022 the University of Natural Ressources and Life Sciences Vienna carried out a specific research project on country-specific animal feeding and nutrition ("MiNutE" study, Hörtenhuber et al., 2022b; Hörtenhuber et al., 2023). In submission 2022, Austria included updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) into the inventory.

5.3.1 Methodological Issues

NH_3 emissions from Sector 3 Agriculture are estimated according to the EMEP/EEA Air Pollutant Emission Inventory Guidebook (EEA, 2019 and 2023a). Emissions from cattle and swine are estimated using a country specific methodology, which requires detailed information on animal characteristics and the manner in which manure is managed. NH_3 emissions from the non-key animal categories sheep, goats, poultry, horses and deer are calculated by using the detailed Tier 2 method following the EMEP/EEA Guidebook 2023. The Tier 2 method follows a mass flow analysis, which is more detailed and thus better reflects Austrian conditions.

Sector manure management is not a key category for NO_x emissions. However, the calculations are based on the Tier 2 methodology provided in the EMEP/EEA Guidebook 2023 (EEA, 2023a).

Following a recommendation under the NEC Review 2018 (EC, 2018), Austria applied the Tier 2 methodology for NMVOC emissions from manure management, which has been identified as a key source for category cattle (*3.B.1*). The enhanced methodology has been used for all livestock categories.

Animal numbers

The Austrian official statistics (Statistik Austria, 2023f) provides national data of annual livestock numbers on a very detailed level. These data are based on livestock counts held in December each year[121].

Table 260, Table 261 and Table 262 presents applied animal data. Background information listed below:

From 1990 onwards: The continuous decline of dairy cattle numbers is connected with the increasing milk yield per cow: For the production of milk according to Austria's milk quota every year a smaller number of cows is needed.

1991: A minimum counting threshold for poultry was introduced. Farms with less than 11 poultry were not considered any more. However, the contribution of these small farms is negligible, both with respect to the total poultry number and to the trend.
The increase of the soliped population between 1990 and 1991 is caused by a better data collection from riding clubs and horse breeding farms.

1993: New characteristics for swine and cattle categories were introduced in accordance with Austria's entry into the European Economic Area and the EU guidelines for farm animal population categories. In 1993 part of the "Young cattle < 1 yr" category was included in the "Young cattle 1–2 yr" category. This shift is considered to be insignificant: no inconsistency in the emission trend of "Non-Dairy Cattle" category was recorded.
In the same year "Young swine < 50 kg" were shifted to "Fattening pigs > 50 kg" (before 1993 the limits were 6 months and not 50 kg which led to the shift) causing distinct inconsistencies in time series. Following a recommendation of the Centralized Review 2003, the age class split for swine categories of the years 1990–1992 was adjusted using the split from 1993.

1993: For the first time other animals e.g. deer (but not wild living animals) were counted. Following the recommendations of the Centralized Review 2004, to ensure consistency and completeness animal number of 1993 was used for the years 1990 to 1992.

1995: The financial support of suckling cow husbandry increased significantly in 1995 when Austria became a Member State of the European Union. The husbandry of suckling cows is used for the production of veal and beef; the milk yield of the cow is only provided for the suckling calves. Especially in mountainous regions with unfavourable farming conditions, suckling cow husbandry allows an extensive and economic reasonable utilisation of the pastures. Suckling cow husbandry contributes to the conservation of the traditional Austrian alpine landscape.

1996–1998: The market situation affected a decrease in veal and beef production, resulting in a declining suckling cow husbandry. Farmers partly used their former suckling cows for milk production. Thus, dairy cow numbers slightly increased at this time. Reasons are manifold: Changing market prices, BSE epidemic in Europe and change of consumer behaviour, milk quota etc.

[121] For cattle livestock counts are also held in June, but seasonal changes are very small (between 0% and 2%). Livestock counts of sheep are only held in December (sheep is only a minor source for Austria and seasonal changes of the population are not considered relevant).

1998–2000; 2006–2008: increasing/ decreasing swine numbers: The production of swine has a high elasticity to prices: Swine numbers are changing due to changing market prices very rapidly. Market prices change due to changes in costumer behaviour, saturation of swine production, epidemics etc.

Table 260: Domestic livestock population and its trend 1990–2022 (I).

Year	Livestock category – Population size [heads] *						
	Dairy	Non-Dairy	Suckling Cows	Young Cattle < 1 yr	Breeding Heifers 1–2 yr	Fattening Heifers, Bulls, Oxen 1–2 yr	Other Cattle > 2 yr
1990	904 617	1 679 297	47 020	925 162	254 883	305 920	146 312
1995	706 494	1 619 331	210 479	691 454	266 108	298 244	153 046
2000	621 002	1 534 445	252 792	655 368	246 382	220 102	159 801
2005	534 417	1 476 263	270 465	628 426	229 874	206 429	141 069
2010	532 735	1 480 546	260 883	634 052	187 386	256 266	141 959
2011	527 393	1 449 134	256 831	623 364	184 160	245 770	139 009
2012	523 369	1 432 249	248 438	628 715	184 932	238 968	131 196
2013	529 560	1 428 722	236 655	626 970	191 002	243 546	130 549
2014	537 744	1 423 457	229 986	629 401	191 049	241 408	131 613
2015	534 098	1 423 512	224 348	624 483	194 493	244 588	135 600
2016	539 867	1 414 524	216 678	632 150	192 455	239 588	133 653
2017	543 421	1 400 055	207 007	623 517	190 364	248 227	130 940
2018	532 873	1 379 935	200 475	618 218	188 698	239 685	132 859
2019	524 068	1 355 452	195 480	605 322	183 402	243 023	128 225
2020	524 783	1 330 649	190 685	598 598	179 120	235 277	126 969
2021	526 461	1 343 639	185 692	611 007	180 083	240 992	125 865
2022	550 554	1 310 517	157 811	596 990	199 330	230 800	125 586
Trend 90–22	**-39.1%**	**-22.0%**	**235.6%**	**-35.5%**	**-21.8%**	**-24.6%**	**-14.2%**

The FAO agricultural data base (FAOSTAT) provides worldwide harmonized data (FAO Agr. Statistical System, 2001). In the case of Austria, these data come from the national statistical system (Statistik Austria). However, there are inconsistencies between these two data sets. Analysis shows that there is often a time gap of one year between the two data sets. FAOSTAT data are seemingly based on the official Statistik Austria data but there is an annual attribution error. In the Austrian inventory Statistik Austria data are used, which are the best available.

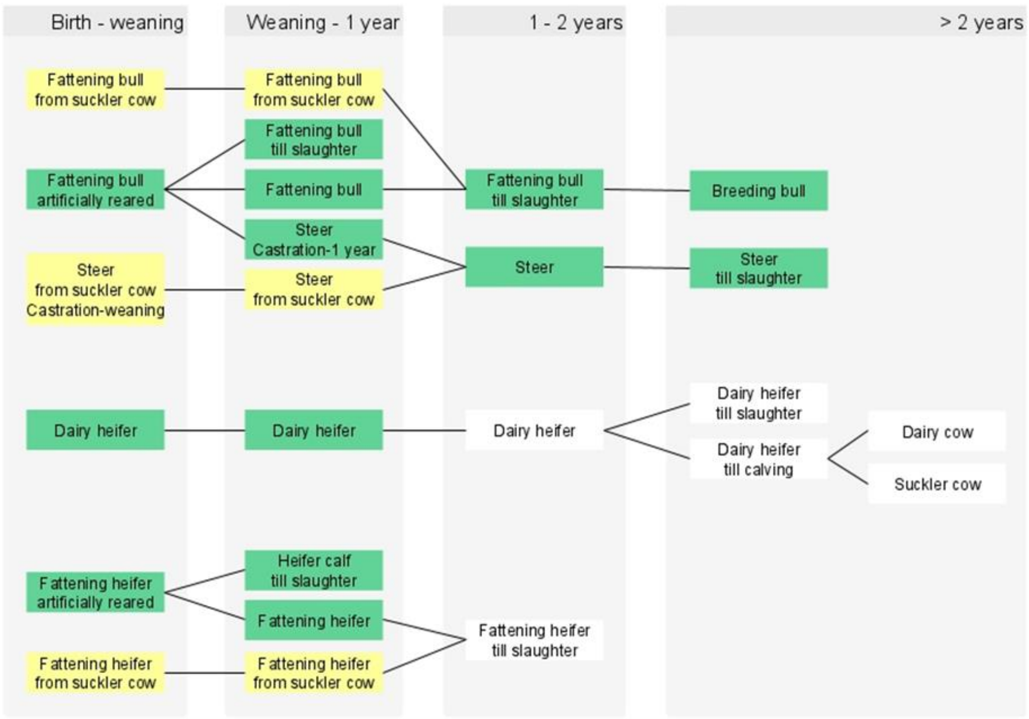
Cattle numbers decreased by 0.5 % in 2022 compared to the year before (dairy cows: + 4.6 %; other cattle: - 2.5 %). According to the Green Report 2023 (BML, 2023a) the reason for this decline is the ongoing structural change; the number of cattle farms also decreased by 2.1 % compared to 2021.

Splitting of cattle categories for background calculations

In order to be able to take more precise feeding assumptions and energy requirement calculations into account, the livestock categories "cattle <1 year", "cattle 1-2 years, breeding animals", "cattle 1-2 years, fattening animals", "dairy cows", "suckling cows" and “other cattle > 2 years” were further subdivided. For this subdivision additional data from AgrarMarkt Austria (AMA) were used. However, the numbers of animals per superordinate category (see Table 260) based on (Statistik Austria, 2023f) were not changed.

Figure 51: Allocation of the cattle numbers for determining energy requirements.

Allocation of the cattle numbers for determining energy requirements



Source: Umweltbundesamt

Reallocation of swine categories

The number of pigs was reclassified to allow a more accurate calculation of energy requirements by dividing them into three categories: "breeding sows (including suckling piglets up to 8 kg live weight) and boars", "piglets 8 to 32 kg live weight" and "fattening pigs" (see Table 261).

Breeding sows and boars

The livestock numbers of category "breeding pigs over 50 kg", taken from livestock census data of Statistics Austria, also include gilts above 50 kg until first insemination, which make up approximately 19% of this category. In terms of feed intake and nutrient excretion they correspond more to category "fattening pigs" and have therefore been assigned to that category. Breeding boars, which comprise just about 2% of "breeding pigs (over 50 kg)," were calculated similarly as sows in terms of feed intake and excretions.

Piglets 8 to 32 kg

In the official Austrian livestock census, piglets between 8 and 32 kg live weight are divided into the categories "up to 20 kg" and "young pigs 20-50 kg". The number of piglets 8 to 32 kg used for emission calculations was determined based on rearing days and body weight.

Fattening pigs

As the category "fattening pigs above 32 kg to the end of fattening" is not provided in the livestock census, it had to be derived from the categories "piglets 20-50 kg" and "pigs 50 kg to end of fattening". In addition, the category "gilts above 50 kg before first insemination" was added, since these were subtracted from the breeding sows category.

The total number of pigs according to Statistics Austria (Statistik Austria, 2023f) exceeds the total number of pigs used in the inventory calculations as they do not consider litters <8 kg. This can be explained by the emission factors of breeding sows, which already take into account the emissions of suckling piglets up to 8 kg live weight. The Austrian swine numbers are presented in the following table.

Table 261: Domestic livestock population and its trend 1990–2022 (II).

Year	**Livestock category – Population size [heads]***									
	Total Swine (including litter <8kg)**	**Total Swine (excluding litter <8kg)**	**Young & Fattening Pigs incl. gilts**	**Breeding Sows without replacement gilts**	**Young Swine 8-32 kg**	**litter <8kg[3)]**	**Sheep**	**Goats**	**Horses[1)]**	**Deer[2)]**
1990	3 687 981	3 470 006	2 002 846	374 956	1 092 204	217 975	309 912	37 343	49 200	37 100
1995	3 706 185	3 262 871	1 878 195	368 616	1 016 060	443 314	365 250	54 228	72 491	40 323
2000	3 347 931	2 948 771	1 723 098	307 020	918 653	399 160	339 238	56 105	82 943	39 612
2005	3 169 541	2 812 822	1 694 649	287 570	830 604	356 719	325 728	55 100	92 560	43 014
2006	3 139 438	2 774 835	1 659 535	288 522	826 778	364 603	312 375	53 108	95 304	43 926
2007	3 286 292	2 913 744	1 761 475	288 248	864 022	372 548	351 329	60 487	98 048	44 839
2008	3 064 231	2 716 737	1 629 226	270 714	816 797	347 494	333 181	62 490	100 792	45 751
2009	3 136 967	2 781 641	1 699 735	266 571	815 336	355 326	344 709	68 188	103 536	46 663
2010	3 134 156	2 776 522	1 696 999	261 410	818 113	357 634	358 415	71 768	106 280	47 575
2011	3 004 907	2 669 093	1 643 448	249 725	775 920	335 814	361 183	72 358	109 024	45 654
2012	2 983 158	2 646 917	1 635 956	239 999	770 962	336 241	364 645	73 212	111 768	43 733
2013	2 895 841	2 575 599	1 594 771	231 750	749 078	320 242	357 440	72 068	114 512	41 812
2014	2 868 191	2 544 151	1 577 174	224 983	741 994	324 040	349 087	70 705	117 256	41 600
2015	2 845 451	2 525 795	1 572 529	225 158	728 108	319 656	353 710	76 620	120 000	41 388
2016	2 792 803	2 483 812	1 549 287	218 773	715 751	308 991	378 381	82 735	120 000	41 176
2017	2 820 082	2 507 701	1 570 251	221 197	716 252	312 381	401 480	91 134	130 000	40 457
2018	2 776 574	2 471 234	1 562 976	210 675	697 584	305 340	406 336	91 536	130 000	39 738
2019	2 773 225	2 468 737	1 557 498	211 058	700 181	304 488	402 658	92 504	130 000	39 018
2020	2 806 461	2 495 809	1 571 571	208 364	715 874	310 652	393 764	92 758	130 000	38 299
2021	2 785 587	2 479 172	1 568 407	205 556	705 209	306 415	402 345	100 601	130 000	38 299
2022	2 650 151	2 352 717	1 489 800	191 188	671 729	297 434	400 664	99 019	130 000	38 299
Trend 90–22	***-28.1%***	***-32.2%***	***-25.6%***	***-49.0%***	***-38.5%***	***36.5%***	***29.3%***	***165.2%***	***164.2%***	***3.2%***

** from 1990 to 1992 adjusted age class split for swine as recommended in the centralized review (October 2003)*

*** total number of Swine according to (Statistik Austria, 2023f) and published in (BML, 2023a)*

[1)] for the years 2000–2002 and 2004–2014: interpolated values

[2)] for the years 1991–1993, 2000–2002, 2004–2009, 2011–2012, 2014–2015 and 2017–2019: interpolated values

[3)] not applied because already considered in the emission factors of breeding sows

Sheep and goat numbers decreased slightly in 2022 compared to 2021. Swine population stagnated the last years and this trend can be observed for 2022 too, where livestock numbers decreased slightly compared to 2020.

Horse numbers for 2015, 2016, 2017, 2018, 2019, 2020, 2021 and 2022 are annually published in the Ministry of Agriculture's Green Reports in (BML 2023b, p. 53) and based on an estimate by the Austrian Horse Breeding Association which includes both agricultural and leisure horses. Horse numbers used for the years before 2004 are based on livestock accountings and are assessed to be representative for Austria. Data for the years 2004 to 2014 were derived by interpolation.

Table 262: Domestic livestock population and its trend 1990–2022 (III).

Year	**Livestock category – Population size [heads] ***					
	Total Poultry	**Chicken***	**Laying hens***	**Broilers***	**Turkeys****	**Other Poultry****
1990	13 820 961	13 139 151	8 392 369	4 746 782	524 616	157 194
1995	13 959 316	13 157 078	7 899 011	5 258 067	679 477	122 761
2000	11 786 670	11 077 343	6 555 815	4 521 528	588 522	120 805
2005	13 489 222	12 801 345	6 678 696	6 122 650	568 854	119 022
2010	14 644 413	13 918 813	7 061 377	6 857 436	615 813	109 787
2011	15 020 126	14 305 565	7 373 407	6 932 158	610 708	103 853
2012	15 395 838	14 692 317	7 685 438	7 006 879	605 602	97 919
2013	15 771 551	15 079 069	7 997 468	7 081 601	600 497	91 985
2014	16 334 620	15 634 432	8 356 808	7 277 624	597 071	103 117
2015	16 897 690	16 189 796	8 716 148	7 473 648	593 645	114 249
2016	17 460 759	16 745 159	9 075 488	7 669 671	590 219	125 381
2017	18 033 026	17 309 548	9 190 513	8 119 035	584 503	138 975
2018	18 605 292	17 873 937	9 305 538	8 568 399	578 787	152 569
2019	19 177 559	18 438 326	9 420 563	9 017 763	573 070	166 162
2020	19 749 825	19 002 715	9 535 588	9 467 127	567 354	179 756
2021	19 749 825	19 002 715	9 535 588	9 467 127	567 354	179 756
2022	19 749 825	19 002 715	9 535 588	9 467 127	567 354	179 756
Trend 90–22	***42.9%***	***44.6%***	***13.6%***	***99.4%***	***8.1%***	***14.4%***

* *interpolated values for the years 2004–2009, 2011–2012, 2014–2015 and 2017–2019*

***value for 1999 is not available – value derived from the average share of previous and following 5 years of total other poultry; interpolated values for the years 2004–2009, 2011–2012, 2014–2015 and 2017–2019*

Animal numbers of Poultry and Other (deer) are not included in the livestock counts held in December each year but gathered within Austria's farm structure surveys carried out as complete surveys every 10 years. The latest farm structure survey was carried out in 2020. Livestock data for poultry (layers, broilers, turkeys and other poultry) as well as for deer was included based on the final results of the 2020 survey (Statistik Austria, 2022). The 2020 figures were taken as proxy for the years 2021 and 2022.

5.3.2 NH_3 emissions from cattle (3.B.1) and swine (3.B.3)

Key Category: NH_3

5.3.2.1 Agricultural practice – cattle and swine

Manure Management System Distribution (MMS)

MMS data used in the national inventory is based on the following national surveys on agricultural practices (Konrad, 1995, Amon et al., 2007 and Pöllinger et al., 2018). The research project 'Animal husbandry and manure management systems in Austria (TIHALO I)' (Amon et al., 2007) has been carried out as a comprehensive survey on the agricultural practices in Austria. Within this project, the Division of Agricultural Engineering (DAE) of the Department for Sustainable Agricultural Systems of the University of Natural Resources and Applied Life Sciences (BOKU) closely co-operated with the Swiss College of Agriculture, the Austrian Chamber of Agriculture, the Umweltbundesamt, the Agricultural Research and Education Centre Raumberg-Gumpenstein and the Statistics Austria. The statistical sampling plan (5 000 Austrian farms, return rate of 39%) was set up with the assistance of the Statistics Austria to guarantee the selection of a representative sample.

As a result of TIHALO I, for the year 2005 updated representative data on animal husbandry and manure management systems all over Austria was available. For the year 1990 MMS data based on (Konrad, 1995) was used. In this study data on existing Austrian conditions were derived from a research survey carried out on 720 randomly-chosen agricultural enterprises in the years 1989–1992.

In 2017, the TIHALO I study has been followed-up by a new research project (TIHALO II) (Pöllinger et al., 2018). For this project, as for the previous one, a comprehensive survey on the agricultural practices in Austria has been carried out. 5 000 questionnaires were sent to the farmers and a return rate of 37% could be achieved. Compared to the first TIHALO study, the questionnaire for the farmers was additionally available as an online version, which was used by more than 50% of the participants. The new study was conducted by the Agricultural Research and Education Centre Raumberg-Gumpenstein as lead, but in close cooperation with the Austrian Chamber of Agriculture, the Federal Institute of Agricultural Economics, the Federal Ministry for Sustainability and Tourism[122] and the Umweltbundesamt. So, for 2017 updated information on livestock feeding, management systems and practices as well as application techniques in Austria became available.

For the creation of a plausible time series the MMS distribution of 1990 (based on Konrad 1995) partly had to be adapted. Changes to the year 1990 were derived from the TIHALO I and TIHALO II study results and expert opinion (DI Alfred Pöllinger, Agricultural Research and Education Centre Raumberg-Gumpenstein) carried out in (Amon & Hörtenhuber, 2019). Thus, MMS data are available for 1990 (Konrad), 2005 (TIHALO I) and 2017 (TIHALO II). The years in between were derived by interpolation. Taking into account the existing provisions of animal welfare, adjustments were necessary in the area of cattle husbandry for the years after 2017. For the years from 2018 onwards the trend 2005–2017 was extrapolated resulting in increased shares of loose housing systems and decreased shares of tied systems for cattle. However, the overall shares of liquid and solid systems based on (Pöllinger et al. 2018) remained unchanged.

[122] From 2022 onwards „The Federal Ministry for Agriculture, Forestry, Regions and Water Management" (BML)

Information on anaerobic digestion is based on data published by the Austrian Energy Regulator (E-CONTROL, 2006–2022) and (Kompost- und Biogasverband, 2023). 1990 data are based on (Amon, 2002).

For the livestock categories sheep, poultry, horses, goats and deer country specific MMS data has been applied. Data are based on the TIHALO II results (Pöllinger et al., 2018) and expert judgement (Pöllinger, 2018), carried out in (Amon & Hörtenhuber, 2019). Except for chicken, the MMS distribution of these animal categories has been kept constant over the entire time series.

Table 263: Share of N in manure management systems 1990 (cattle and swine).

Animal category	**Manure Management Systems 1990**					
	Buildings – tied systems		**Buildings – loose housing systems**		**Excreted outside the buildings**	
	liquid slurry [%]	**solid manure [%]**	**liquid slurry [%]**	**solid manure [%]**	**yards [%]**	**pasture [%]**
Dairy cows	23.6	50.4	11.0	3.4	0.9	10.7
Suckling cows	12.3	58.7	6.0	11.3	1.1	10.7
Cattle < 1 year	11.3	53.3	6.8	23.0	0.8	4.8
Breeding heifers 1–2 years	17.5	39.5	9.4	6.7	0.8	26.2
Fattening heifers, bulls & oxen, 1–2 years	30.4	37.3	18.2	12.8	0.8	0.6
(other) cattle > 2 years	20.6	44.9	9.2	6.6	1.0	17.8
Breeding sows plus litter	--	--	69.2	29.7	1.2	--
Fattening pigs	--	--	71.3	28.2	0.6	--

For yards the values for the year 1990 were estimated to be the half of the values from 2005 (Pöllinger, 2008).

Table 264: Share of N in manure management systems 2005 (cattle and swine).

Animal category	**Manure Management Systems 2005**					
	Buildings – tied systems		**Buildings – loose housing systems**		**Excreted outside the buildings**	
	liquid slurry [%]	**solid manure [%]**	**liquid slurry [%]**	**solid manure [%]**	**yards [%]**	**pasture [%]**
Dairy cows	13.4	49.9	23.4	7.3	1.8	4.2
Suckling cows	6.1	45.1	11.4	21.6	2.1	13.7
Cattle < 1 year	4.6	30.8	13.8	46.8	1.6	2.4
Breeding heifers 1–2 years	9.9	40.1	22.9	16.4	1.5	9.2
Fattening heifers, bulls & oxen, 1–2 years	12.2	24.4	36.1	25.5	1.5	0.3

Animal category	Manure Management Systems 2005					
	Buildings – tied systems		Buildings – loose housing systems		Excreted outside the buildings	
	liquid slurry [%]	solid manure [%]	liquid slurry [%]	solid manure [%]	yards [%]	pasture [%]
(other) cattle > 2 years	12.5	42.0	20.2	14.5	1.9	8.9
Breeding sows plus litter	--	--	60.0	37.7	2.3	--
Fattening pigs	--	--	88.2	10.7	1.1	--

Table 265: Share of N in manure management systems 2017 (cattle and swine).

Animal category	Manure Management Systems 2017					
	Buildings – tied systems		Buildings – loose housing systems		Excreted outside the buildings	
	liquid slurry [%]	solid manure [%]	liquid slurry [%]	solid manure [%]	yards [%]	pasture [%]
Dairy cows	7.3	26.5	48.4	9.1	5.0	3.7
Suckling cows	3.0	15.9	25.7	31.0	6.5	17.8
Cattle < 1 year	0.0	0.0	21.6	70.4	1.8	6.2
Breeding heifers 1–2 years	3.6	19.9	38.0	28.9	5.6	4.0
Fattening heifers, bulls & oxen, 1–2 years	3.7	14.0	49.4	28.8	0.7	3.4
(other) cattle > 2 years	4.5	24.7	36.9	23.9	2.6	7.4
Breeding sows plus litter	--	--	82.3	16.7	1.0	--
Fattening pigs	--	--	91.2	8.0	0.8	--

Table 266: Share of N in manure management systems 2022 (cattle and swine).

Animal category	Manure Management Systems 2022					
	Buildings – tied systems		Buildings – loose housing systems		Excreted outside the buildings	
	liquid slurry [%]	solid manure [%]	liquid slurry [%]	solid manure [%]	yards [%]	pasture [%]
Dairy cows	4.8	16.7	50.9	18.9	5.0	3.7
Suckling cows	1.8	3.7	27.0	43.2	6.5	17.8
Cattle < 1 year	0.0	0.0	21.6	70.4	1.8	6.2
Breeding heifers 1–2 years	1.0	11.5	40.6	37.3	5.6	4.0
Fattening heifers, bulls & oxen, 1–2 years	0.2	9.6	53.0	33.1	0.7	3.4

Animal category	Manure Management Systems 2022					
	Buildings – tied systems		Buildings – loose housing systems		Excreted outside the buildings	
	liquid slurry [%]	solid manure [%]	liquid slurry [%]	solid manure [%]	yards [%]	pasture [%]
(other) cattle > 2 years	1.2	17.4	40.2	31.2	2.6	7.4
Breeding sows plus litter	--	--	82.3	16.7	1.0	--
Fattening pigs	--	--	91.2	8.0	0.8	--

Trends in manure management of cattle

The time series shows that tied systems and systems with straw-litter decrease, whereas loose housing systems and slurry-based systems increase. In 2017, slurry-based loose housing systems are predominantly used in Austria's cattle husbandry.

While the share of pasture increased for suckling cows (and to a lesser extent also for fattening heifers and cattle < 1 year), it decreased for the other cattle categories.

Trends in manure management of swine

The time series shows that housings with straw-litter for young and fattening pigs decreased and those with slatted floors increased. According to the TIHALO II study (Pöllinger et al., 2018), straw-litter systems decreased in 2017 compared to 2005.

In general, small farms more frequently use systems with solid manure; large farms make more use of slurry systems.

Free range systems for pigs are uncommon in Austria. Data collected within (Amon et al., 2007) and (Pöllinger et al., 2018) showed that hardly any pig had free access to a pasture.

N-input from straw as bedding material – cattle and swine

There is hardly any straw production in Austrian alpine grassland regions, which contribute to the production of a major proportion of Austrian milk. The import of straw from arable land regions is connected with remarkable costs (for collecting, pressing and transport) and that results in significantly reduced straw inputs into alpine litter-based systems compared to farms in the lowlands producing their own straw. As a consequence, overall N input from straw to manure management systems is comparatively low. Austrian assumptions for cattle are based on expert judgement of (Dieter Kreuzhuber, 2013), who is ÖKL's[123] person responsible for agricultural buildings, including ÖKL recommendations for the adding of straw in manure management systems.

Information on N inputs from straw for breeding sows, fattening pigs, goats, sheep, soliped and other animals (deer) is taken from EMEP/EEA-Guidebook 2023, Table 3-7, as for these animal categories in Austria hardly any information is available from expert estimates or national literature. For poultry, straw inputs are calculated according to Germany's National Inventory Report 2013 (Federal Environment Agency Germany, 2013). The following tables include the straw use per animal, day and year.

[123] Österreichisches Kuratorium für Landtechnik und Landentwicklung

Table 267: Straw supply for cattle (per head).

	kg straw per animal and day and year							
	tied system with solid storage		tied system with liquid slurry		loose house systems with solid manure		loose house systems with liquid slurry	
	kg straw per day	**kg straw per year**	**kg straw**	**kg straw per year**	**kg straw**	**kg straw per year**	**kg straw**	**kg straw per year**
Dairy cattle and suckling cows	1.5	547.5	0.2	73	4.0* / 2.5*	1 460 / 912.5	0.5	182.5
Young cattle	1.2	438					0.3	109.5

** 4 kg straw for deep litter systems and 2.5 kg straw for the bedding in solid manure systems*

Table 268: Straw supply for swine, sheep, goats, horses and poultry (per head).

	kg straw per animal and year	
	Solid storage	**Liquid slurry (grazing)**
	kg straw	**kg straw**
Fattening pigs	200	0
Breeding sows plus litter	600	0
Sheep, goats and 'other animals'	20	0
Horses etc.	500	0
Layers	0.5	0
Broilers	1.4	0
Turkeys	10.3	0
Other poultry (e.g. ducks)	19.5	0

In pastures and yards no straw is used. For the calculation of the N amounts the EMEP/EEA default N content of straw (0.004 kg N per kg straw) was used for all animal categories (EMEP/EEA Guidebook 2023, Table 3-7).

Manure storage – cattle and swine

Table 269 describes the share of composted and not composted solid manure for the years 1990, 2005 and 2017. The values for 2005 are taken from the TIHALO I survey (Amon et al., 2007), those for 2017 from the TIHALO II survey (Pöllinger et al., 2018). The Austrian expert Alfred Pöllinger estimated data for 1990 on the basis of TIHALO I results (Amon & Hörtenhuber, 2008). The values from 2006–2016 were derived by linear extrapolation. For the years from 2018 onwards the values of 2017 were taken.

Table 269: Share of composted and untreated solid manure for cattle and swine in Austria in 1990, 2005 and 2017.

	1990		2005		2017	
	Composted solid manure [%]	**Untreated solid manure [%]**	**Composted solid manure [%]**	**Untreated solid manure [%]**	**Composted solid manure [%]**	**Untreated solid manure [%]**
Dairy cows	6.0	94.1	11.9	88.1	6.0	94.0
Suckling cows	5.9	94.2	11.7	88.3	7.0	93.0
Cattle < 1 year	5.9	94.1	11.8	88.2	6.6	93.4
Breeding heifers 1–2 years	5.9	94.1	11.8	88.2	6.0	94.0
Fattening heifers, bulls & oxen, 1–2 years	4.4	95.6	8.8	91.2	6.1	93.9
Cattle > 2 years	5.7	94.3	11.4	88.6	5.4	94.6
Breeding sows plus litter	6.4	93.7	12.7	87.3	5.2	94.8
Fattening pigs	4.2	95.8	8.4	91.6	7.4	92.6

For 2018, 2019, 2020, 2021 and 2022 the same shares as for 2017 have been used.

Table 270: Slurry storage and treatment for cattle and swine in 1990, 2005 and 2017.

	Dairy cows	**Suckling cows**	**Cattle < 1 year**	**Breeding heifers 1–2 years**	**Fattening heifers, bulls & oxen, 1–2 years**	**(Other) cattle > 2 years**	**Breeding Sows plus litter**	**(Young &) Fattening Pigs**
1990								
Solid cover	73.4	76.8	78.2	74.9	79.5	78.2	83.9	74.5
Uncovered and not aerated	14.1	12.2	10.3	15.9	11.3	9.4	10.8	16.3
Uncovered and aerated	5.7	5.8	6.8	4.2	4.1	8.2	2.6	1.9
Straw cover	0	0	0	0.1	0	0.1	0.3	0.4
Plastic foil	0	0	0	0	0	0	0.1	0.4
Natural crust	6.9	5.2	4.8	5.0	5.1	4.2	2.4	6.5
2005								
Solid cover	70.5	73.9	74.8	72.8	77.5	74.1	82.6	73.6
Uncovered and not aerated	11.2	9.3	6.9	13.8	9.3	5.3	9.5	15.4
Uncovered and aerated	11.4	11.5	13.5	8.3	8.2	16.3	5.1	3.7
Straw cover	0	0	0	0.1	0	0.1	0.3	0.4
Plastic foil	0	0	0	0	0	0	0.1	0.4
Natural crust	6.9	5.2	4.8	5.0	5.1	4.2	2.4	6.5
2017								
Solid cover	71.0	83.0	73.0	72.0	73.0	72.0	75.0	70.0

	Dairy cows	Suckling cows	Cattle < 1 year	Breeding heifers 1–2 years	Fattening heifers, bulls & oxen, 1–2 years	(Other) cattle > 2 years	Breeding Sows plus litter	(Young &) Fattening Pigs
Uncovered and not aerated	9.9	5.5	9.4	9.6	10.2	6.7	9.9	14.1
Uncovered and aerated	1.2	0.7	1.2	1.2	1.3	0.8	0.9	1.2
Straw cover	1.0	0	0.5	1.0	0	1.0	1.0	1.0
Plastic foil	0	0	0	0	0.1	0	2.0	2.0
Natural crust	16.9	10.8	15.9	16.2	15.4	19.5	11.2	11.7

Note: 2017 data are based on the TIHALO II survey results (Pöllinger et al., 2018). Data for 2005 are based on the outcomes of the TIHALO I study (Amon et al. 2007). 1990 data are based on (Konrad 1995), TIHALO I & II study results and expert judgement (Pöllinger, 2008), carried out in (Amon & Hörtenhuber, 2019).

For 2018, 2019, 2020, 2021 and 2022 the same shares as for 2017 have been used.

5.3.2.2 Animal excretion – cattle and swine

N excretion

In previous years country specific N excretion values were based on (Gruber & Pötsch, 2006, Pötsch et al., 2005, Steinwidder & Guggenberger, 2003, Unterarbeitsgruppe N-adhoc, 2004 and Zar, 2004) and Richtlinien Sachgerechter Düngung (BML, 2022). However, the feeding of cattle and swine has changed in the last two decades. Therefore, a new research project on country-specific animal feeding and nutrition (“MiNutE” study, Hörtenhuber et al., 2022b; Hörtenhuber et al., 2023) has been carried out. As a result, updated and representative values for energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) have been included into the inventory since submission 2022.

Within the framework of this country specific study, the necessary information was compiled and derived from official statistical data, international and national technical literature, representative data from producer associations (e.g. ZAR, project "Efficient Cow" Egger-Danner et al., 2018), feed analyses and feed calculations of the project partner and the feed company Fixkraft (fixkraft.at, based on the feeding strategies of their customers). The results were supplemented and revised with information from experts, e.g. feeding advisors from the chambers of agriculture, working group advisors and additional data surveys on farms.

The extensive results of the “MiNutE” Study made it possible to calculate national excretion values at a much more detailed level based on the latest available scientific literature (IPCC, 2019).

Cattle

The annual N excretion rates were calculated with Equation 10.31A (IPCC, 2019), which can be estimated as the difference between the total nitrogen taken in by the animal and the total nitrogen retained for growth and milk production.

$$Nex_{(T)} = (N_{intake(T)} - N_{retention(T)}) * 365$$

$Nex_{(T)}$ = annual N excretion rates, kg N animal-1 yr-1
$N_{intake(T)}$ = the daily N intake per head of animal of species/category T, kg N animal-1 day-1
$N_{retention(T)}$ = amount of daily N intake by head of animal of species / category T, that is retained by animal of species/category T, kg N animal-1 day-1,
365 = Number of days in a year

The same dietary assumptions have been used as for modelling methane emissions from CRF sector *3.A Enteric Fermentation*. Detailed information can be found in Austria´s National Inventory Report 2024 (Umweltbundesamt, 2024a).

N intake rates are determined by applying equation 10.32 (IPCC, 2019) based on the gross energy intake and crude protein in dry matter. The energy demand of cattle has also been calculated by applying the 2019 Refinement to the 2006 IPCC GL, taking into account body mass and weight gain performance, husbandry, milk yield, gestation and feeding parameters. Crude protein in dry matter was calculated using data from different national studies (Egger-Danner et al., 2016; Steinwidder & Häusler, 2004; Steinwidder & Guggenberger, 2003; Steinwender, 1992) and is detailed documented in (Hörtenhuber et al., 2022a).

N retention rates are calculated by applying equation 10.33 of the 2019 Refinement to the 2006 IPCC GL. For dairy and suckling cows the respective milk yields and protein in milk is taken into account. Milk yields are presented in Table 271. For dairy cows the milk yield is provided annually by Statistics Austria, published in (BML, 2000–2023). For suckler cows an annual milk yield of 3 000 kg for 1990 and of 3 500 kg for the years from 2004 onwards was determinded (Häusler, 2009). Data on the average fat content and protein content of milk from dairy cows for the years 1991–2022 were derived from information provided by AgrarMarkt Austria (AMA). Due to missing data for the year 1990, the value of 1991 was adopted. Similar to dairy cows, the AMA data on the average fat and protein content of delivered has been used as the measured milk fat content of cows of beef breeds does not differ significantly to those of dairy cows according to (Scholz et al., 2001). For the other cattle categories the average daily weight gain and net energy for growth are the parameters needed. The average daily weight gain was determined based on national studies, detailed described in (Hörtenhuber et al., 2022a). Net energy for growth has been calculated by applying equation 10.15 (IPCC, 2019).

Table 271: Austria specific N excretion values of dairy and suckling cows for the period 1990–2022.

Year	Dairy cows		Suckling cows	
	Milk yield [kg yr^{-1}]	Nitrogen excretion [kg/animal*yr]	Milk yield [kg yr^{-1}]	Nitrogen excretion [kg/animal*yr]
1990	3 791	91.05	3 000	72.18
1995	4 619	92.44	3 179	72.85
2000	5 210	93.92	3 357	74.14
2005	5 783	97.00	3 500	75.46
2010	6 100	99.88	3 500	76.37
2011	6 227	100.57	3 500	76.44
2012	6 418	102.15	3 500	76.71
2013	6 460	102.38	3 500	76.76
2014	6 542	103.08	3 500	76.95
2015	6 579	103.65	3 500	77.20
2016	6 759	104.88	3 500	77.30
2017	6 865	105.13	3 500	77.25
2018	7 104	106.04	3 500	77.20
2019	7 179	106.27	3 500	77.15
2020	7 286	106.78	3 500	77.16

Year	Dairy cows		Suckling cows	
	Milk yield [kg yr^{-1}]	Nitrogen excretion [kg/animal*yr]	Milk yield [kg yr^{-1}]	Nitrogen excretion [kg/animal*yr]
2021	7 249	106.69	3 500	77.18
2022	7 250	106.85	3 500	77.27

[1)] *From 1995 onwards data have been revised by Statistik Austria, which led to significant higher milk yield data of Austrian dairy cows.*

Table 272: Austria specific N excretion values of other cattle.

Year	Nitrogen excretion [kg/animal*yr]			
	breeding heifers 1-2 years	fattening heifers & bulls & oxen 1-2 years	cattle <1 year	cattle >2 year
1990	60.67	58.53	30.53	63.75
1995	60.14	58.46	33.18	63.40
2000	59.61	58.14	33.74	63.10
2005	59.08	57.51	34.60	62.75
2010	59.24	57.93	36.35	62.46
2011	59.38	58.00	36.45	62.66
2012	59.52	58.17	36.41	62.90
2013	59.66	58.37	36.25	63.12
2014	59.79	58.48	36.20	63.34
2015	59.93	58.57	36.30	63.54
2016	60.07	58.62	36.37	63.75
2017	60.21	58.66	36.43	63.90
2018	60.39	58.63	36.48	64.02
2019	60.57	58.68	36.65	64.16
2020	60.75	58.83	36.74	64.33
2021	60.75	58.82	36.67	64.32
2022	60.75	58.70	35.80	64.55

Swine

Annual N excretion rates of the categories breeding pigs (sows and boars), piglets 8-32 kg, and fattening pigs were calculated using equation 10.31A provided in the 2019 Refinement to the IPCC 2006 GL.

N intake rates for swine are estimated with equation 10.32A taking into account dry matter intake per day during a specific growth stage and the crude protein in dry matter for growth stage.

Following the 2019 Refinement to the IPCC 2006 Guidelines, the N retention rates vary among different swine categories. So, for breeding sows equation 10.33A, for piglets equation 10.33B and for fattening pigs equation 10.33C have been applied.

Information on performance indicators (daily gain of weight, average slaughter weights, etc.), feed quantities and components of feed rations is summarized in (Hörtenhuber et al., 2022a).

Table 273: Austria specific N excretion values of swine.

Year	Nitrogen excretion [kg/animal*yr]		
	breeding sows plus litter	**fattening pigs**	**piglets 8-32 kg**
1990	23.2	14.8	3.7
1995	22.9	14.6	3.7
2000	22.6	14.5	3.8
2005	22.3	14.3	3.8
2010	22.3	13.8	3.6
2011	22.3	13.7	3.6
2012	22.3	13.6	3.6
2013	22.3	13.5	3.5
2014	22.3	13.4	3.5
2015	22.2	13.3	3.5
2016	22.2	13.2	3.5
2017	22.2	13.1	3.4
2018	22.2	13.0	3.4
2019	22.1	12.9	3.4
2020	22.1	12.9	3.4
2021	22.1	12.9	3.4
2022	22.1	12.9	3.4

TAN content in excreta – cattle and swine

The mass-flow approach makes use of the total ammoniacal nitrogen (TAN) when calculating emissions. The initial share of TAN must be known as well as any transformation rates between organic N and TAN. TAN content for Austrian cattle and pig manure is given in Schechtner (1991) and BML (2022).

Table 274: TAN content for Austrian cattle and pig manure after Schechtner (1991) and BML (2022).

	TAN content [kg NH_4-N per kg Nex]
Cattle – farmyard manure	0.15
Cattle – liquid manure	0.50
Swine – farmyard manure	0.15
Swine – liquid manure	0.65

5.3.2.3 Calculation of NH_3 emissions – cattle and swine

NH_3 emissions from cattle and swine were calculated using a country specific methodology following the N-flow model.

Emissions of Ammonia (NH_3) occur during animal housing, the storage of manure and the application of organic fertilizers on agricultural soils. Emissions of nitric oxide (NO_x) were calculated for manure management and field spreading of manure.

Following the latest version of the CLRTAP Reporting Guidelines, NH_3 and NO_x-Emissions from the application of livestock manures to land have to be reported under *3.D Agricultural soils (3.D.a.2.a*

Animal manure applied to soils). In line with the NFR reporting, the methodological description is provided in chapter 3.D of this report.

NH_3 emissions from category *3.B.1 Cattle and* *3.B.3 Swine* are calculated as follows:

$$NH_{3\ (3.B)} = NH_{3\ (housing)} + NH_{3\ (storage)}$$

Where no national emission factors are available, emission factors are taken from the Swiss ammonia inventory, which is calculated with the computer-based programme "DYNAMO" (Menzi et al., 2003, Reidy et al., 2007, Reidy & Menzi, 2005). Due to similar management strategies and geographic structures, Swiss animal husbandry is closest to Austrian animal husbandry.

NH_3 emissions from housing – cattle and swine

Table 275 provides NH_3 emission factors for the housings of cattle and swine (Eidgenössische Forschungsanstalt, 1997 and Döhler et al., 2002).

Table 275: Emission factors for NH_3 emissions from animal housing.

Manure management system	**Emission factor [kg NH_3-N (kg N excreted)$^{-1}$]**
Pasture/range/paddock – cattle	0.050
Cattle, tied systems, liquid slurry system	0.040
Cattle, tied systems, solid storage system	0.039
Cattle, loose houses, liquid slurry system	0.118
Cattle, loose houses, solid storage system	0.118
Fattening pigs, liquid slurry system	0.150
Fattening pigs, solid storage system	15% of total N + 30% of the remaining TAN
Sows plus litter, liquid slurry system	0.167
Sows plus litter, solid storage system	0.167

For yards the default Tier 2 EFs from the EMEP/EEA GB 2023 have been applied (Table 3-9).

Table 276: NH_3 emission factors for yards.

Manure management system	**Emission factor [kg NH_3-N (kg TAN)$_{-1}$]**
Dairy cattle	0.30
Non-dairy cattle	0.53

Note: EFs are given as a proportion of TAN

N excretion per manure management system

Country-specific N excretion per animal waste management system for Austrian cattle and swine has been calculated using the following formula:

$$Nex_{(MMS)} = \sum_{(T)} [N_{(T)} \times Nex_{(T)} \times MMS_{(T)}]$$

$Nex_{(MMS)}$	=	*N excretion per manure management system [kg yr^{-1}]*
$N_{(T)}$	=	*number of animals of type T in the country (see Table 260, Table 261 and Table 262)*
$Nex_{(T)}$	=	*N excretion of animals of type T in the country [kg N $animal^{-1}$ yr^{-1}] (see Table 271, Table 272 and Table 273)*
$MMS_{(T)}$	=	*fraction of $Nex_{(T)}$ that is managed in one of the different distinguished manure management systems for animals of type T in the country*
(T)	=	*type of animal category*

Abatement factors for housing systems of cattle and swine

In submission 2019 the grooved floor system for cattle and the partly slatted floor systems for swine was implemented to the Austrian ammonia inventory (Amon & Hörtenhuber, 2019).

Specific abatement factors from the *UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions* (UNECE, 2015) were used. The AF is multiplied with the EF.

Table 277: Abatement factors (AF) for NH_3 emissions from housing systems (liquid systems cattle and swine).

Livestock category		**Housing system**	**Share in liquid systems* 2017**	**AF**
Cattle	Dairy cattle	Grooved floor	8.1%	0.75
	Suckling cows		3.4%	
	Cattle < 1 year		2.0%	
	Breeding heifers 1–2 years		2.2%	
	Fattening heifers, bulls & oxen, 1–2 years		2.8%	
	Cattle > 2 years		1.1%	
Swine	Breeding sows plus litter	Partly slatted floor	47.0%	0.85
	Fattening pigs		9.0%	

** for cattle: share in liquid loose housing systems*

For 2018, 2019, 2020, 2021 and 2022 the same shares as for 2017 have been used.

NH_3 emissions from manure storage – cattle and swine

NH_3 emissions from storage are estimated from the amount of N left in the manure when the manure enters the storage. This amount of N is calculated as following:

From total N excretion the N excreted during grazing and the NH_3-N losses from housing (see above) are subtracted. The remaining N enters the store.

Solid manure

According to the EMEP/EEA GB 2023 account must also be taken of the fraction (f_{imm}) of TAN that is immobilized in organic matter when manure is managed as solid. The default value of 0.0067 kg N kg^{-1} straw for f_{imm} has been applied (EEA, 2023a).

Liquid manure

For slurries, a fraction (f_{min}) of the organic N is mineralized to TAN before the gaseous emissions are calculated according to the EMEP/EEA GB 2023. The default value of 0.1 for f_{min} has been applied (EEA, 2023a).

NH_3 emission factors – cattle and swine

Table 278 provides NH_3 emission factors for the storage of cattle and swine manures (Eidgenössische Forschungsanstalt, 1997).

Table 278: NH_3 emission factors for manure storage.

Manure storage system	**Emission factor [kg NH_3-N (kg TAN)$^{-1}$]**
Cattle, liquid slurry system	0.15
Cattle, solid storage system	0.30

Manure storage system	Emission factor [kg NH_3-N (kg TAN)$^{-1}$]
Pigs, liquid slurry system	0.12
Pigs, solid storage system	0.30

Abatement factors for storage systems of cattle and swine manures

Table 279 shows abatement factors (AF) to emission factors (EF) for a range of manure treatment options. Untreated variants systems, for example uncomposted solid manure, give the reference value '1'. EF for other treatment options, managements and systems get an associated AF, e.g. +20% for the composting of solid manure (AF = 1.2). The AF is multiplied with the EF. Factors were taken from the Swiss ammonia inventory, which is calculated with the computer-based programme 'DYNAMO' (Menzi et al., 2003, Reidy et al., 2007, Reidy & Menzi, 2005). Due to similar management strategies and geographic structures, Swiss animal husbandry is closest to Austrian animal husbandry.

DYNAMO is based on the N flow model and estimates ammonia emissions for each stage of the manure management continuum. Animal categories, manure management systems and a range of additional parameters are considered within DYNAMO. DYNAMO parameters were adapted to Austrian specific conditions. The DYNAMO model is peer reviewed by the EAGER[124] group and published in (Reidy et al., 2008, 2009).

Table 279: Abatement factors (AF) for NH_3 emissions from manure storage.

Manure storage	[AF]
Uncomposted solid manure	1
Composted solid manure	1.2
Uncovered tank	1
Solid cover – liquid system	0.2
Aerated open tank – liquid system	1.1
Straw cover – liquid system	0.6
Plastic foil cover – liquid system	0.4
Natural crust – liquid system	0.6

Abatement factors are fully consistent with those provided in the UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions (UNECE, 2015).

5.3.3 NH_3 emissions from sheep (3.B.2), goats (3.B.4.d), horses (3.B.4.e), poultry (3.B.4.g) and other animals (3.B.4.h)

Key Category: Horses (3.B.4.e) (NH_3)

For the livestock categories sheep (3.B.2), goats (3.B.4.d), horses (3.B.4.e), poultry (3.B.4.g) and other animals (3.B.4.h) the EMEP/EEA Tier 2 methodology has been applied. Tier 2 uses a mass flow approach based on the concept of TAN (EEA, 2023a).

[124] European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

5.3.3.1 Agricultural practice – non-key livestock categories

Solid systems and pasture are the relevant MMS for these animal categories in Austria.

Table 280: Share of N in animal waste management systems (non-key livestock).

Livestock category	Liquid/Slurry	Solid Storage	Anaerobic Digestion	Pasture/Range/ Paddock
	[%]	[%]	[%]	[%]
Sheep	0.0	65.0	0.0	35.0
Goats	0.0	94.4	0.0	5.6
Horses	0.0	80.0	0.0	20.0
Laying hens	0.0	95.5	0.5	4.0
Broilers	0.0	99.2	0.5	0.3
Turkeys	0.0	99.8	0.0	0.2
Other poultry	0.0	99.8	0.0	0.2
Other animals	0.0	20.0	0.0	80.0

Shares are kept constant for all years, except for laying hens and broilers.

N-input from straw as bedding material – non-key livestock categories

Information on N inputs from straw for sheep, goats, soliped and other animals (deer) is taken from the EMEP/EEA-Guidebook 2023, Table 3-7, as for these animal categories in Austria hardly any information is available from expert estimates or national literature. For poultry, straw inputs are calculated according to Germany's National Inventory Report 2013 (Federal Environment Agency Germany, 2013). The straw use per animal and year is presented in Table 268.

5.3.3.2 Animal excretion – non-key livestock categories

Country specific N excretion values are presented in the following table:

Table 281: Austria specific N excretion values of non-key livestock categories.

Livestock category	Nitrogen excretion [kg/animal*yr]
Sheep	13.1
Goats	12.3
Horses	47.9
Layers	0.73
Broilers	0.28
Turkeys	1.18
Other poultry	0.48
Other animals/furred game[1)]	13.1

[1)] N-ex value of sheep applied

5.3.3.3 Calculation of NH_3 emissions – non-key livestock categories

Table 282 presents the default EMEP/EEA Tier 2 NH_3-N emission factors and associated parameters used in the calculations for Austria's non-key livestock categories (EEA, 2023a, Table 3-9).

Table 282: Default Tier 2 NH_3-N EF and associated parameters for the Tier 2 methodology.

NFR	Livestock category	proportion of TAN	EF housing	EF storage	EF spreading
3.B.2	Sheep	0.50	0.22	0.32	0.90
3.B.4.d	Goats	0.50	0.22	0.28	0.90
3.B.4.e	Horses (mules, asses)	0.60	0.22	0.35	0.90
3.B.4.g.i	Laying hens	0.70	0.20	0.08	0.45
3.B.4.g.ii	Broilers	0.70	0.21	0.30	0.38
3.B.4.g.iii	Turkeys	0.70	0.35	0.24	0.54
3.B.4.g.iv	Other poultry	0.70	0.38(*)	0.21(*)	0.50(*)
3.B.4.h	Other animals(**)	0.50	0.22	0.32	0.90

*) *EF = weighted mean of ducks & geese for 2022*

**) *In Austria the livestock category 'other animals' corresponds to deer (red deer, sika deer and fallow deer) according to the national farmstructure survey (STATISTIK AUSTRIA 2022). As sheep is the most similar livestock category to deer, for 'other animals' the NH_3 emission factors of sheep have been used.*

NH_3 emissions from housing – non-key livestock categories

NH_3-N emissions from the housing of non-key animals are calculated by using the following formula:

$$Nex_{(MMS)} * \text{TAN proportion} * EF_{housing}$$

$Nex_{(MMS)}$= N excretion per manure management system [kg yr^{-1}]

As indicated in Table 280, all of the non-key livestock categories are managed on solid systems.

NH_3 emissions from storage – non-key livestock categories

NH_3-N emissions from storage are estimated from the amount of N left in the manure when it enters the storage (N left for storage).

In the calculations of emissions from the storage of animal manure the NH_3-N losses from housing and the fraction of TAN that is immobilized in organic matter (f_{imm}) when manure is managed as solid are taken into account. For f_{imm} the EMEP/EEA default value of 0.0067 has been applied (EEA, 2023a).

Abatement factors for storage systems of layers and broilers

In submission 2019 for layers and broilers the management system "manure belt with covered storage" was implemented in Austria´s ammonia inventory (Amon & Hörtenhuber, 2019) using specific abatement factors (AF) from the *UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions* (UNECE, 2015). These abatement factors, adjusted to Austria's agriculture practice, were multiplied with the EF.

Table 283: Abatement factors (AF) for NH_3 emissions from storage systems (layers and broilers).

Livestock category	Housing system	Share in solid systems 2021	AF (UNECE, 2015)	AF applied in Austria
Layers	systems with manure belt and covered storage	27.7%	0.3	0.58*
Broilers	systems with manure belt and covered storage	28.5%	0.3	0.65**

** reduced abatement potential compared to (UNECE, 2015)*

*** half of the abatement potential provided in (UNECE, 2015)*

Layers: 20% of the systems with manure belts and covered storage are drying the manure on the belts through forced ventilation (Pöllinger et al., 2018). For these 20% the abatement potential of -70% (AF = 0.3) from (UNECE, 2015) has been taken. For the remaining 80% of manure collected on manure belts only the half of the potential outlined in (UNECE, 2015) has been applied.

Broilers: Even though drying can be expected, no explicit information for broilers is available in the case of the use of manure belts for frequent collection and removal of manure to closed storage areas. Consequently, a conservative approach has been chosen by applying half of the abatement potential as provided in the UNECE Ammonia Abatement Guidance Document (UNECE, 2015) (-35% instead of -70%) for the proportion of broilers with manure belts.

In 1990, the manure drying through forced ventilation on manure on belts was not common in Austria (Pöllinger, 2018, carried out in Amon & Hörtenhuber, 2019).

5.3.4 NH_3 emissions from biogas plants

From submission 2019 onwards NH_3 emissions from anaerobic digestion at biogas facilities (reported under NFR 5.B.2, sector *5 Waste*) have been included in the Austrian inventory. Emissions are calculated in sector 3 Agriculture but reported under sector 5 Waste, in line with the CLRTAP reporting Guidelines.

Activity data

Basis for emission calculation is the N from vegetable inputs (energy crops) as well as the N in the manure inputs when entering the biogas facilities (see Table 284). For manure, all N-losses during animal housing before, are taken into account. The remaining N from manure (after subtraction of NH_3-N losses during the digestion process) is included in the N amount applied to soils (N left for spreading, reported in agriculture sub-sector 3.D).

Table 284: N amounts digested in biogas facilities 1990–2022.

Year	N (manure-inputs)	N (vegetable-inputs)	Total N inputs
		[kg year^{-1}]	
1990	20 558	55 953	76 511
1995	153 683	425 239	578 922
2000	487 077	1 342 861	1 829 938
2005	949 530	2 585 007	3 534 536

Year	N (manure-inputs)	N (vegetable-inputs)	Total N inputs
		[kg year^{-1}]	
2010	2 211 091	3 542 337	5 753 427
2011	1 470 949	3 967 113	5 438 062
2012	1 525 495	3 982 333	5 507 828
2013	1 576 406	3 997 529	5 573 935
2014	1 629 721	4 012 634	5 642 355
2015	1 657 614	4 124 919	5 782 533
2016	1 703 685	4 291 965	5 995 650
2017	1 620 786	4 330 692	5 951 478
2018	1 662 670	4 071 751	5 734 421
2019	1 289 240	3 747 936	5 037 176
2020	1 638 023	3 704 492	5 342 516
2021	1 815 825	3 464 602	5 280 427
2022	1 484 070	3 410 620	4 894 690

Methodology

The calculations were done according to the Tier 1 methodology of the EMEP/EEA Guidebook 2023 (EEA, 2023a, Chapter 5.B.2, Table 3-1).

5.3.5 NO_x emissions from Manure Management (3.B)

Key Category: No

NO_x emissions from manure management were calculated according to the Tier 2 methodology as outlined in the EMEP/EEA Guidebook 2023 (EEA, 2023a). The calculations make use of the mass-flow approach based on the concept of a flow of TAN through the manure management system.

Activity data and methodology

According to the EMEP/EEA GB 2023, NO_x emissions occur from slurry stores based on the amount of TAN. These N amounts per type of manure system have been already estimated within NH_3 calculations (please refer to chapter 5.3.2.3 for cattle and swine and to chapter 5.3.3 for the other livestock categories) and are multiplied with an emission factor (slurry or solid).

For cattle and swine national TAN contents are available from (Schechtner, 1991) and BML (2022) (see Table 274). Default TAN values according to the EMEP/EEA GB 2023, Table 3-9, have been applied for sheep, goats, horses, poultry and deer.

Emission factors

Emission factors are taken from the EMEP/EEA GB 2023, Table 3-10. The NO emission factors for slurry and solid (storage) are expressed as proportion of TAN (0.0001 for slurry and 0.01 for solid).

5.3.6 N_2 emissions from manure management

Since submission 2019 N_2 losses have been included in the Austrian N flow model (Amon & Hörtenhuber, 2019).

Activity data and methodology

N_2 emissions result from storage of manure and need to be taken into account in the mass-flow calculation according to the EMEP/EEA GB 2023. N_2 emission calculations are based on the amounts of TAN left for storage per type of manure system (see also NO_x calculations, chapter 5.3.5). These amounts of N are multiplied with the respective EF (slurry or solid).

National TAN contents for cattle and swine are taken from (Schechtner, 1991 and BML, 2022, presented in Table 274). For the other livestock categories the default values according to the EMEP/EEA GB 2023, Table 3-9, are used.

Emission factors

For both slurry and litter-based manures, the default N_2 emission factors from Table 3-10 (EEA, 2023a) have been applied.

5.3.7 NMVOC from Manure Management (3.B)

Key Category: Cattle (3.B.1)

Austria uses the Tier 2 methodology as recommended in the NEC Review 2018 (EC, 2018).

Activity data

Livestock data

Livestock numbers were taken from the Austrian official statistics (Statistik Austria, 2023f) (please refer to Table 260, Table 261 and Table 262). New study results of a research project on country-specific animal feeding and nutrition ("MiNutE" study, Hörtenhuber et al., 2022b; Hörtenhuber et al., 2023) leading to updated and representative values for energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) were implemented into the inventory in submission 2022. As a result, animal numbers had to be reallocated. Detailed information is provided in chapter 5.3.1.

Manure management system data (MMS)

Information on MMS distributions used in sector manure management were taken from (Konrad, 1995), (Amon et al., 2007) and (Pöllinger et al., 2018).

Silage feeding

Silage plays an important role in the feeding of cattle. In the "MiNutE" project various studies, statistical data and literature sources were used to estimate the proportions of silage within the roughage or in the total diets. For dairy cows, the comprehensive data from the project "Efficient cow" on feeding (Egger-Danner et al., 2018) for the year 2016 was used, which included grass and corn silages. This data was taken for all years. The evaluation resulted in a share of 55% silage as Austrian average. For suckling cows the data on silage feeding is stemming from (Steinwidder, 2003). For all other cattle categories the average proportions were calculated on the basis of (Gruber et al., 2021, Neumayr, 2012, Steinwidder, 2003, LFL, 2020 and Resch et al., 2006).

Sheep, goats and horses are not fed with silage in Austria.

Methodology

The Tier 2 methodology according to the EMEP/EEA GB 2023 (EEA, 2023a) has been applied for all livestock categories. As a consequence of the Tier 2 calculations, NMVOC emissions are split into emissions from buildings (feeding, housing and storage), application (reported under NFR category 3.D.a.2.a) and grazing (reported under NFR 3.D.a.3).

Cattle

The Tier 2 approach based on the feed intake in MJ was used. For detailed information on national feed intake data for cattle please refer to chapter 5 of "Austria's National Inventory Report 2024 – Submission under the United Nations Framework Convention on Climate Change" (Umweltbundesamt, 2024a).

Calculations have been done based on feed intake and silage fraction according to the formulas as provided in the EMEP/EEA GB 2023, p. 26. Default Tier 2 emission factors for feeding, building and grazing are taken from Table 3.11 of the EMEP/EEA GB 2023. Table 285 provides the resulting country-specific emission factors for the different cattle categories for 2022.

Table 285: Country-specific NMVOC emission factors of cattle for 2022.

Livestock category	**3.B**	**3.B**	**3.D.a.2.a**	**3.D.a.3**
	EF silage feeding [kg NMVOC head^{-1} yr^{-1}]	**EF housing incl. storage [kg NMVOC head^{-1} yr^{-1}]**	**EF application [kg NMVOC head^{-1} yr^{-1}]**	**EF grazing [kg NMVOC head^{-1} yr^{-1}]**
Dairy cows	15.23	5.22	6.11	0.03
Suckling cows	4.72	3.46	3.02	0.11
Cattle < 1 year	2.34	1.34	0.89	0.01
Breeding heifers 1–2 years	6.02	2.85	2.72	0.02
Fattening heifers, bulls & oxen, 1–2 years	12.01	2.82	2.78	0.02
Cattle > 2 years	8.75	2.63	2.58	0.03

All livestock categories other than cattle

NMVOC emissions from swine, sheep, goats, horses, poultry and deer were calculated using the EMEP/EEA 2023 Tier 2 methodology on the basis of VS excretion (EEA, 2023a, p. 31). For detailed information on the VS excretion, please refer to chapter 5 of "Austria's National Inventory Report 2024 – Submission under the United Nations Framework Convention on Climate Change" (Umweltbundesamt, 2024a).

For the calculation of NMVOC emissions from housing and grazing the default NMVOC Tier 2 emission factors have been applied (Table 3-12 of the EMEP/EEA GB, 2023). Table 286 provides an overview of NMVOC emission factors and parameters used in the calculations.

Table 286: NMVOC emission factors and fractions used for livestock categories other than cattle for 2022.

Livestock category	3.B Housing	3.B Manure store	3.D.a.2.a Application	3.D.a.3 Grazing
	kg NMVOC / kg VS ex	NH_3_storage / NH_3_building	NH_3 application / NH_3 building	kg NMVOC / kg VS ex
Breeding sows	0.007042	0.16	0.36	-
Young & fattening pigs	0.001703	0.18	0.37	-
Sheep	0.001614	1.11	1.91	0.00002349
Goats	0.001614	0.96	1.79	0.00002349
Horses	0.001614	1.16	1.53	0.00002349
Laying hens	0.005684	0.30	0.74	-
Broilers	0.009147	1.09	0.48	-
Turkeys	0.005684	0.52	0.38	-
Other poultry	0.005684	0.40	0.36	-
Other animals	0.001614	1.11	1.84	0.00002349

Livestock other than cattle is not fed with silage in Austria.

5.3.8 Category-specific Recalculations

Update of activity data

Livestock data – cattle < 1 year

The livestock category cattle < 1 year comprises slaughtering calves < 1 year, other male calves and cattle < 1 year, and other female calves and cattle <1 year according to the official statistics (Statistics Austria). The breakdown by type of use is determined by Statistics Austria using model calculations. Methodological improvements resulted in shifts between the cattle < 1 year sub-categories in the years 2003–2021 and thus led to revised average values for gross energy intake, $N_{excretion}$ and $VS_{excretion}$ for cattle < 1 year.

Background data for feeding and nutrition of dairy and suckling cows

New figures for the protein and fat content of milk for the year 2021 became available (AMA, 2023b). This update resulted in minor revisions of the values for gross energy intake, $N_{excretion}$ and $VS_{excretion}$ of dairy and suckling cows.

Biogas plants

New data on input materials for Austria's biogas plants became available from the compost and biogas association (Kompost- und Biogasverband, 2023) resulting in slightly revised NO_x and NH_3 emissions with an impact on the source categories 3.B Manure Management, 3.D.a.2.a Animal manure applied to soils and 3.D.a.2.c Other organic fertilizers applied to soils for 2020 and 2021.

Methodological changes

One reason for the revised estimates is the improved activity and nutrition data as already explained above. Additionally, a linkage error in the NMVOC agriculture sector model for other cattle was corrected.

Overall, NH_3 and NO_x emissions from manure management have increased, whereas NMVOC emissions have decreased compared to the previous submission (+0.2 kt NH_3, +0.002 kt NO_x and -2.2 kt NMVOC for 2021).

5.4 NFR 3.B Particle Emissions from Manure Management

Key Category: No

In NFR category *3.B Manure Management* particle emissions from Animal Husbandry are included.

5.4.1 Methodological Issues

Particle emissions from animal husbandry are primary connected with the manipulation of forage, a smaller part arises from dispersed excrements and litter. Wet vegetation and mineral particles of soils are assumed being negligible, thus particle emissions from free-range animals are not included.

The estimations of particle emissions from animal husbandry are related to the Austrian livestock number.

Activity data

The Austrian official statistics (Statistik Austria, 2023f) provides national data of annual livestock numbers on a very detailed level (please refer to Table 260, Table 261 and Table 262).

Emission Factors

Measurements and emission estimates of 'primary biological aerosol particles' based on measurements (Winiwarter et al., 2009) don't indicate high amounts of cellulosic materials existing in the atmosphere. According to Winiwarter et al. (2009), the default EMEP/EEA EFs seem to significantly overestimate emissions and should be better indicated as 'potential emissions' because resulting high emission values could not be validated by measurements. One reason is that underlying measurement data used for generation of default EFs (e.g. Takai et al., 1998) is based on indoor air measurements (with focus on 'inhalable dust' and 'respirable dust') neglecting the losses during transfer to the outdoor air. Following Winiwarter et al (2009) the origin of dust material, which is relevant for this source category is mainly fodder, bedding material and excrements and they tend to agglomerate under humid weather conditions.

Based on these results and due to lack of more reliable up-to-date data the emission factors of the RAINS model (Lükewille et al., 2001) have been assessed to be much more accurate for Austria. Calculations result in lower and much more realistic estimates compared to the results when using the EMEP/EEA GBs default Tier 1 emission factors.

In Table 287 the applied emission factors are listed.

Table 287: TSP emission factors animal housing.

Livestock	Emission Factor [kg TSP/animal]	Livestock	Emission Factor [kg TSP/animal]
Dairy cows	0.235	Laying hens	0.016
Other cattle	0.235	Broilers	0.016
Fattening pigs	0.108	Turkeys	0.016
Sows	0.108	Other poultry	0.016

Livestock	Emission Factor [kg TSP/animal]	Livestock	Emission Factor [kg TSP/animal]
Ovines	0.235	Goats	0.153
Horses	0.153	Other animals	0.016

Following (Klimont, et al. 2002) the share of PM_{10} in TSP is assumed being 45% and the share of $PM_{2.5}$ in TSP is assumed being 10%.

It is supposed, that there is no condensable component included in the PM_{10} and $PM_{2.5}$ emission factors (see also chapter 12.3) although it is not described explicitly in (Winiwarter et al., 2007 and 2009) and (Lükewille et al., 2001).

5.4.2 Category-specific Recalculations

No recalculations have been carried out.

5.5 NFR 3.D Agricultural Soils

NFR sector *3.D Agricultural Soils* includes emissions of ammonia (NH_3), nitric oxide (NO_x), NMVOC and particulate matter (TSP, PM) as well as HCB emissions from the usage of pesticides. The methodology for estimating PM emissions is presented in a separate chapter (Chapter 5.6).

5.5.1 Methodological Issues

In the Austrian inventory source category *3.D Agricultural Soils* comprises NH_3 and NO_x emissions from:

- Application of inorganic N fertilizers (3.D.a.1);
- Application of organic N fertilizers (3.D.a.2) including:
  - Animal manure applied to soils (3.D.a.2.a). This emission source is reported under NFR category 3*.D Agricultural Soils* in compliance with the CLRTAP Reporting Guidelines 2023. Up to submission 2015 NH_3 emissions from this source were reported under source category *4.B Manure management.*
  - Sewage sludge applied to soils (3.D.a.2.b) and
  - Other organic fertilizers applied to soils (3.D.a.2.c), which comprises N inputs from digested energy crops in biogas slurry and compost.
- Urine and dung deposited by grazing animals (3.D.a.3)

NMVOC emissions from:

- Animal manure applied to soils (3.D.a.2.a), reported for the first time in submission 2019 as a consequence of improved calculations in sector 3.B Manure Management (Tier 2 methodology).

- Urine and dung deposited by grazing animals (3.D.a.3), reported for the first time in submission 2019 as a consequence of improved calculations in sector 3.B Manure Management (Tier 2 methodology).
- Cultivated crops (3.D.e)

HCB emissions from:

- Use of Pesticides (3.D.f)

5.5.2 Inorganic N-fertilizers (3.D.a.1)

Key Category: NH_3

Activity Data

Austria estimates emissions from different types of mineral fertilizers according to the EMEP/EEA GB 2023. Activity data are based on Austria's official national mineral fertilizer statistics, annually compiled by Agrarmarkt Austria (AMA). National fertilizer statistics are annually published in the so-called "Green Reports" (BML, 2000–2023).

Detailed historical data for different mineral fertilizer types are available from 1990 to 1994 (due to the fertilizer tax collected at that time). National data of urea use is available for the entire time series (Raiffeisen Ware Austria (RWA), Austria's leading fertilizer trading firm provided data 1995–2012, Austrian Federal Ministry of Sustainability and Tourism, provided data 2013–2014). From 2015 onwards, detailed data for different types of fertilizers are available. A consistent time series of fertilizer types other than urea has been generated by linear interpolation and adjustment to annual total mineral fertilizer amounts in consistency with Austria's annual national statistics.

Sales data are changing very rapidly due to changing market prices, high inter-annual variations are caused by the effect of storage: Not the whole amount purchased is applied in the year of purchase. The fertilizer tax intensified this effect at the beginning of the 1990ies. Considering this effect, the arithmetic average of each two years is used as fertilizer application data. Table 288 provides national N fertilizer data from 1990 to 2022.

Table 288: N usage of different types of mineral fertilizers (arithmetic average of two years) in Austria 1990–2022.

Year	Calcium ammonium nitrate (CAN)	N solutions (Urea AN)	Ammonium sulphate (AS)	N-stabilised fertilizers*	Calcium nitrate (CN)	NPK mixtures	Other	Urea
				[t N/year]				
1990	79 024	-	3 814	3 300	15	50 945	76	2 807
1995	74 114	20	400	7 535	16	40 019	208	5 058
2000	70 547	216	1 597	6 992	25	35 649	196	5 328
2005	51 614	413	2 794	6 449	34	31 279	184	7 483
2010	38 384	610	3 991	5 907	43	26 909	172	12 450
2011	55 080	649	4 230	5 798	44	26 035	170	11 683
2012	57 214	688	4 469	5 689	46	25 161	168	13 800
2013	55 660	728	4 709	5 581	48	24 287	165	13 685
2014	60 808	767	4 948	5 472	50	23 413	163	16 189
2015	69 977	806	5 188	5 364	51	22 539	161	16 848

Year	Calcium ammonium nitrate (CAN)	N solutions (Urea AN)	Ammonium sulphate (AS)	N-stabilised fertilizers*	Calcium nitrate (CN)	NPK mixtures	Other	Urea
				[t N/year]				
2016	73 583	764	5 462	5 066	67	21 276	303	19 917
2017	67 977	764	5 671	5 272	60	21 010	306	19 103
2018	67 774	910	5 792	5 177	44	20 186	334	15 203
2019	63 431	984	5 079	4 796	48	18 510	598	12 238
2020	65 632	1 034	4 757	4 795	43	19 076	797	10 821
2021	69 745	941	4 957	4 730	54	19 551	1 120	9 983
2022	62 955	941	3 845	4 663	64	16 127	1 180	11 592

Data sources: Annual fertilizer statistics compiled by AMA (Agrarmarkt Austria, http://www.ama.at) and annually published in the "Green Reports" (BML, www.gruenerbericht.at)

Urea data 1995 to 2014: Raiffeisen Ware Austria, sales company (http://www.rwa.at) & BMNT (2013 & 2014)

Fertilizer types other than urea for years 1995 to 2014: derived by linear interpolation and adjusted to total annual N amounts in consistency to annual national statistics

From 2015 onwards: annual amounts per fertilizer type published by Agrarmarkt Austria (AMA, 2023a): www.ama.at

Emissions of ammonia (NH_3)

NH_3 emissions from synthetic fertilizers are estimated using a country specific methodology, which requires detailed information on urea fertilizer application. The EMEP/EEA GB 2023 provides specific NH_3 emission factors for different types of synthetic fertilizers and for normal and high pH soils (EEA 2023a, table 3-2). A 'normal' pH is a pH of 7.0 or below, a 'high' pH is a pH of more than 7.0 (usually calcareous soils) as defined in (EEA, 2023a). 65% of Austria´s soils are classified as normal and 35% as high based on Austrian Soil Information System – BORIS – (http://www.borisdaten.at). The EMEP/EEA Guidebook 2023 does not include default emission factors for N-stabilised urea fertilizers. However, for the relevant fertilizer types used in Austria study results of extensive field trials are available and published in (VDLUFA 2017, p.166 ff.). According to these, they show average reductions in NH_3 emissions from urea of 40 to 90 % through the combination of new and highly efficient urease and nitrification inhibitors. This corresponds well to the reduction potential of 70% for solid urea listed in the UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions, p. 27. Consequently, for N-stabilised fertilizers the urea EF of 0.199 kg NH_3/kg N was adjusted by 70% resulting in an EF of 0.060 kg NH_3/kg N applied.

In Austria, full time-series data for the different mineral fertilizer types is shown in Table 288. For all these types of mineral fertilizer the weighted average of the respective default emission factors for normal pH soils and high pH soils (EEA, 2023a, table 3-2) have been calculated. The resulting emission factors, adjusted to Austrian conditions, are indicated in the following table.

Table 289: NH_3 emission factors for the different types of mineral fertilizers in Austria.

Mineral fertilizer	Emission factors (EMEP/EEA GB 2023)	Emission factors (EMEP/EEA GB 2023)	Weighted emission factors
	normal (ph <=7)	high (ph >7)	65% normal, 35% high
		[g NH_3 (kg N applied)$^{-1}$]	
Calcium ammonium nitrate (CAN)	24	52	34

Mineral fertilizer	**Emission factors (EMEP/EEA GB 2023)**	**Emission factors (EMEP/EEA GB 2023)**	**Weighted emission factors**
	normal (ph <=7)	**high (ph >7)**	**65% normal, 35% high**
		[g NH_3 (kg N applied)$^{-1}$]	
N solutions (Urea AN)	87	161	113
Ammonium sulphate (AS)	84	187	120
Calcium nitrate (CN)	84	187	120
NPK mixtures	84	187	120
Urea	195	206	199
N-stabilised fertilizers*			60(*)
Other**	-	-	85(**)

(*) default EF of urea reduced by 70% according to (UNECE, 2015).

(**) For other fertilizers the 2023 EMEP/EEA default Tier 1 EF is used.

Abatement factor for rapid incorporation of urea

In 2019 a representative survey ('Application of urea fertilizer in the Austrian agriculture') investigating the amount, the type (stabilized, non-stabilized) and the incorporation practice of urea was carried out (Baumgarten et. al., 2019). Study results show that in Austria 41% of the non-stabilized urea is incorporated at least on the same day of application.

Following the UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions (UNECE, 2015) quickly mixing urea into the soils reduces emissions by around 50%-80%. For emission calculation in the Austrian inventory the lower boundary of 50% has been chosen.

Emissions of nitric oxide (NO_X)

The Tier 1 methodology according to the EMEP/EEA GB 2023 is applied. Emissions of NO_x are calculated as a fixed percentage of total fertilizer nitrogen applied to soil. For all mineral fertilizer types the default emission factor of 4% is used (0.04 kg NO per kg applied fertilizer-N).

5.5.3 Organic N-fertilizers applied to soils (3.D.a.2)

Key source: NH_3, NO_x

NFR source category *3.D.a.2 Organic fertilizers* comprise emissions from Animal manure applied to soils (3.D.a.2.a), Sewage sludge applied to soils (3.D.a.2.b) and Other organic fertilizers applied to soils (3.D.a.2.c) including N inputs from digested energy crops (biogas plants) and compost.

5.5.3.1 Animal manure applied to soils (3.D.a.2.a)

Emissions of ammonia (NH_3), nitric oxide (NO_x) and non-methane volatile organic compounds (NMVOC) occur during the application of animal manure on agricultural soils. Following the current CLRTAP Reporting Guidelines, emissions have to be reported under Agricultural Soils (NFR *3.D.a.2.a Animal manure applied to soils)*.

Activity Data

Livestock numbers and information on MMS are described in chapter 5.3.

Nitrogen left for spreading

After housing and storage, manure is applied to agricultural soils. Manure application is connected with NH_3-N, NO_x-N and N_2O-N losses that depend on the amount of manure N. With regard to a comprehensive treatment of the nitrogen budged, Austria established a link between the ammonia and nitrous oxide emissions inventory. A detailed description of the methods applied for the calculation of N_2O emissions is given in the report "Austria's National Inventory Report 2024 – Submission under the United Nations Framework Convention on Climate Change" (Umweltbundesamt, 2024a).

From total N excretion the following losses were subtracted:

- N excreted during grazing
- NH_3-N losses from the housings and yards
- NH_3-N losses from manure storage
- NH_3-N losses from biogas plants
- NO_x-N losses from manure management
- N_2O-N losses from manure management
- N_2-losses during manure storage

The remaining N is applied to agricultural soils.

NH_3 emissions from animal manure applied to soils – cattle and swine

A country specific methodology has been applied.

This method distinguishes between the types of waste produced by each animal sub category: solid manure and liquid slurry. This is relevant, because TAN contents and therefore NH_3 emissions are highly dependent on the quality of waste and organic matter content in slurry. According to the EMEP/EEA Emission Inventory Guidebook 2023 the N input from straw use in manure management systems is taken into account.

NH_3 emissions from manure nitrogen applied to soils have been calculated using the following formula:

$$\mathbf{NH_3\text{-}N_{spread} = N_{exLFS} * (Frac_{SS} * F_{TAN\ SS} * EF\text{-}NH_3\text{-}N_{spread\ SS} + Frac_{LS\text{-}bc} * F_{TAN\ LS} * EF\text{-}NH_3\text{-}N_{spread\ LS} + Frac_{LS\text{-}bs} * F_{TAN\ LS} * EF\text{-}NH_3\text{-}N_{spread\ LS} * CF_{bs})}$$

NH_3-N_{spread}	=	*NH_3-N emissions driven by intentional spreading of animal waste from Manure Management systems on agricultural soils (droppings of grazing animals are not included!)*
N_{exLFS}	=	*Annual amount of nitrogen in animal excreta left for spreading on agricultural soils, corrected for losses during manure management; it does not include nitrogen from grazing animals*
$Frac_{SS}$	=	*Fraction of nitrogen left for spreading produced as farmyard manure in a solid waste management system*
$Frac_{LS\text{-}bc}$	=	*Fraction of nitrogen left for spreading produced as liquid slurry in a liquid waste management system (broadcast spreading)*
$Frac_{LS\text{-}bs}$	=	*Fraction of nitrogen left for spreading produced as liquid slurry in a liquid waste management system (band spreading)*
CF_{bs}	=	*Correction factor band spreading*

$F_{TAN\ SS}$	=	*Fraction of total ammoniacal nitrogen (TAN) in animal waste produced in a solid waste management system including N input from straw*
$F_{TAN\ LS}$	=	*Fraction of total ammoniacal nitrogen (TAN) in animal waste produced as slurry in a liquid waste management system including N input from straw*
$EF\text{-}NH_3\text{-}N_{spread\ SS}$	=	*NH_3-N Emission factor of animal waste from a solid manure system (farmyard manure) spread on agricultural soils (broadcast spreading)*
$EF\text{-}NH_3\text{-}N_{spread\ LS}$	=	*NH_3-N Emission factor of animal waste from a liquid slurry waste management system spread on agricultural soils (broadcast spreading)*

Application technologies – cattle and swine

Since inventory revision 2008 the agriculture inventory considers band spreading application of liquid manure. Table 290 gives information on slurry application for the years 1990, 2005, 2017 and 2022. The values for the year 1990 are expected to be the half of the ones in 2005, taken from the TIHALO I survey (expert estimation by Alfred Pöllinger, June 2008).

In submission 2022, information on low-emission manure spreading techniques was updated from 2017 onwards. The update is based on subsidy data from the ÖPUL promotion database[125] of the Federal Ministry of Agriculture, Forestry, Regions and Water Management (BML) covering the years until 2027.

Table 290: Cattle and pig slurry application in Austria 1990, 2005, 2017and 2022.

	1990		2005		2017		2022	
	Broadcast application	**Low-emission spreading**	**Broadcast application**	**Low-emission spreading**	**Broadcast application**	**Low-emission spreading**	**Broadcast application**	**Low-emission spreading**
	(%)	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
Cattle	96.6	3.4	93.1	6.9	91.4	8.6	83.7	16.3
Swine	97.2	2.8	94.3	5.7	67.5	32.5	43.1	56.9

Following the TIHALO II study (Pöllinger et al., 2018) and the current ÖPUL promotion data the use of low-emission manure spreading techniques for the application of cattle slurry has been quite stable between 2005 and 2017, but is significantly increasing since then. For pig slurries the share of low-emission spreading techniques has been risen significantly in 2022 compared to 2005. Slurry injection is still not a common technique for cattle farms in Austria in 2022 (< 1% of total low-emission manure spreading).

[125] The Agri-environmental Programme ÖPUL is intended to foster the environmentally sound management of the agricultural areas in Austria. One of the objectives is the reduction of greenhouse gas and ammonia emissions from agriculture.

Table 291: Share of band spreading techniques in Austria 1990, 2005, 2017 and 2022.

	1990			2005			2017			2022		
	Trailing hose	Trailing shoe	Injector	Trailing hose	Trailing shoe	Injector	Trailing hose	Trailing shoe	Injector	Trailing hose	Trailing shoe	Injector
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Cattle	3.4	-	-	6.9	-	-	5.8	2.9	-	8.3	7.8	0.1
Swine	2.8	-	-	5.7	-	-	29.0	2.0	1.5	26.7	17.8	12.4

NH_3 emission factors

NH_3 emission factors for spreading of slurry and farmyard manure (expressed as share of TAN) following (Reidy et al., 2007) have been applied:

Table 292: Emission factors for NH_3 emissions from animal waste application.

Application technique	Emission factor [kg NH_3-N (kg TAN)$^{-1}$]
spreading solid manure cattle	0.79
spreading solid manure pigs	0.81
broadcast spreading liquid manure cattle	0.50
broadcast spreading liquid manure pigs	0.25

Abatement factors for low-emission manure spreading technologies (slurry)

Table 293 presents weighted abatement factors (AF) derived from average usages of several reduced-emission techniques for slurry application in 1990, 2005, 2017, 2020, 2021 and 2022. The AF is multiplied with the EF of broadcast spreading (reference value: 1). Factors were taken from the Swiss computer based programme „DYNAMO" (Menzi et al., 2003, Reidy et al., 2007, Reidy & Menzi, 2005) and are fully consistent with the abatement factors provided in the UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions (UNECE, 2015).

Additionally to band spreaders in 2017 also trailing shoes and injectors were used (Pöllinger et al., 2018). Thus, the AF had to be adjusted accordingly based on the respective shares and abatement potentials provided in (UNECE, 2015). For the years 2006–2016, the AF has been determined by linear interpolation. As already described, in submission 2022 new up-to-date data derived from manure amounts reported in the ÖPUL promotion database have been implemented. Based on this information, the split of techniques has been improved for the years since 2018.

Table 293: Abatement factors (AF) for NH_3 emissions from slurry application.

Application technique	Average weighted AF						AF (Unece 2015)
	1990	2005	2017	2020	2021	2022	
Broadcast spreading	1	1	1	1	1	1	1
Low-emission manure spreading - cattle	0.70	0.70	0.63*	0.60*	0.60*	0.60*	
Low-emission manure spreading - swine	0.70	0.70	0.66*	0.51*	0.51*	0.53*	

Application technique	Average weighted AF						AF (Unece 2015)
	1990	2005	2017	2020	2021	2022	
Band spreading							0.70
Trailing shoe							0.50
Shallow injection							0.20

**weighted average of band spreaders, trailing shoe and shallow injection*

NH_3 emissions from animal manure applied to soils – non-key livestock categories

For sheep, goats, horses, poultry and other animals the default EMEP/EEA Tier 2 NH_3-N emission factors and the default TAN values have been used (EEA, 2023a, Table 3-9) as also indicated in Table 282. All N-losses (NH_3-N, NO_x-N, N_2O-N and N_2 losses) at the previous stages of manure (housing and storage) have been subtracted in line with the N-flow approach. As already described above, Austria established a link between the ammonia and nitrous oxide emissions inventory. In line with the EMEP/EEA Guidebook 2023 the N input from straw use in manure management systems has been taken into account.

Abatement factors for rapid incorporation

In submission 2019, rapid incorporation of animal manures (see Table 294) was included in Austria´s ammonia inventory (Amon & Hörtenhuber, 2019). 1990 values have been derived by expert judgement (Pöllinger, 2018), carried out in (Amon & Hörtenhuber, 2019). The years in between have been derived by linear interpolation. The abatement factors were taken from (UNECE, 2015); the abatement factor for humid conditions (timing) before application was taken from (Reidy & Menzi, 2007). For 2018, 2019, 2020, 2021 and 2022 the same values as for 2017 have been used.

Table 294: Rapid incorporation practised in Austria in 2017 based on (Pöllinger et al., 2018) and (Pöllinger, 2018).

Livestock category	Solid manure		Liquid manure			humid conditions (timing) before application
	incorporation < 4 hours	incorporation <12 hours	incorporation <4 hours	incorporation <12 hours	1:1 dilution of slurry	
	AF = 0.45	AF = 0.50	AF = 0.45	AF = 0.70	AF = 0.70	AF = 0.90
Cattle	22%	60%	22%	60%	3%	64-70%*
Swine	36%	59%	37%	59%	28%	67-68%**
Poultry	50%	50%	-	-	-	70%
Sheep	20%	60%	-	-	-	60%
Goats	20%	60%	-	-	-	60%
Horses	20%	60%	-	-	-	60%
Other animals	20%	60%	-	-	-	60%

Note: the values given in the table indicate the shares in total solid/liquid manure

**depending on cattle category*

***depending on swine category*

Only the part of the manure, which is applied on arable land, can potentially be incorporated into soils. There is no technical potential for manure amounts applied on grassland. For cattle it is assumed that only 20% of the manure is applied on arable land (the rest is applied on grassland), whereas for pigs, layers, broilers and turkeys the share of manure applied on arable land is 95%. 80% of duck manure, 30% of goat manure and 20% of the manure of sheep, horses and other animals is applied on arable land according to (Pöllinger, 2018).

NO_x Emissions from animal manure applied to soils

The Tier 1 methodology according to the EMEP/EEA GB 2023, chapter 3.D, is applied. The default emission factor of 0.04 kg NO per kg of organic fertilizer-N spread on agricultural soils is used, which has been taken from table 3-1 (EEA, 2023a).

NMVOC Emissions from animal manure applied to soils

NMVOC emissions from category 3.D.a.2.a animal manure applied to soils are calculated with the EMEP/EEA Tier 2 approach. The calculation method comprises EF for buildings (feeding, housing and storage), manure application and grazing. For further details on methodologies and parameters used please refer to sub-sector 3.B Manure management, chapter 5.3.7.

5.5.3.2 Sewage sludge applied to soils (NFR 3.D.a.2.b)

Ammonia emissions (NH_3)

The default emission factor of sewage sludge taken from (EEA, 2023a) has been applied (0.13 kg NH_3/kg fertilizer N).

Emissions of nitrogen oxide (NO_x)

NO_x emissions were estimated according to the EMEP/EEA GB 2023 (EEA, 2023a, Annex 2) using the default Tier 1 EF of NO for sewage sludge (0.04 kg NO_2/kg sewage sludge N).

Activity Data

In the frame of the reporting obligation under the Urban Wastewater Directive (91/271/EEC) the annual amount of sewage sludge as ton dry substance per year (t DS/a) is collected by the authorities of the Austrian Provincial Governments. After quality assessment and aggregation, the data are reported once a year to the national authorities.

Table 295: Amount of sewage sludge (dry matter) produced in Austria, 1990–2022.

Year	Total [t dm]	agriculturally applied [t dm]	agriculturally applied [%]
1990	161 936	31 507	19.5
1995	390 500	42 400	10.9
2000	392 909	43 220	11.0
2005	290 110	35 541	12.3
2010	262 805	44 354	16.9
2011	265 962	43 796	16.5
2012	266 949	41 487	15.5
2013	238 273	38 231	16.0
2014	239 044	39 626	16.6
2015	234 880	46 861	20.0
2016	237 938	48 313	20.3
2017	236 180	47 549	20.1
2018	234 481	48 170	20.5

Year	Total [t dm]	agriculturally applied [t dm]	agriculturally applied [%]
2019	233 499	49 676	21.3
2020	228 009	48 357	21.2
2021	193 623	47 909	24.7
2022	196 448	50 229	25.6

Amounts of agriculturally applied sewage sludge were obtained from: Water Quality Report 2000 (Philippitsch et al., 2001), Report on sewage sludge (Umweltbundesamt, 1997), Austrian report on water pollution control (BMLFUW, 2002a) and deliveries from Austria's federal provinces to Umweltbundesamt (Umweltbundesamt, 2011, 2013, 2014a, 2015, 2016a, 2017a, 2018, 2019, 2020, 2021a, 2022, 2023b).

Data on N content of sewage sludge was obtained from (Umweltbundesamt, 1997). The study contains sewage sludge analyses carried out by the Umweltbundesamt. Digested sludge samples from 17 municipal sewage sludge treatment plants taken in winter 1994/1995 were investigated with regard to more than one hundred inorganic, organic and biological parameters in order to get an idea of the quality of municipal sewage sludge. Following this study a mean value of 3.9% N in dry matter was taken.

In 2007 the N-content value of sewage sludge was re-examined. The comparison with national Studies (Zessner, M., 1999) and (ÖWAV-Regelblatt Nr. 17 – Landwirtschaftliche Verwertung von Klärschlamm 2004 – www.oewav.at approved the value of 3.9% N/dm.

The amount of nitrogen input from agriculturally applied sewage sludge was calculated according following formula:

$$F_{Sslu} = Sslu_N * Sslu_{agric}$$

F_{Sslu} = Annual nitrogen input to soils by agriculturally applied sewage sludge [t N]
$Sslu_N$ = Nitrogen content in dry matter [%] – 3.9%
$Sslu_{agric}$ = Annual amount of sewage sludge agriculturally applied [t/t] (see Table 295)

5.5.3.3 Other organic fertilizers applied to soils (3.D.a.2.c)

This source category includes

- the N inputs from energy crops applied to soils as fertilizer after the digestion process in biogas plants (digestates) and
- the N inputs from compost applied on agricultural soils.

Ammonia emissions (NH_3)

The Tier 1 approach according to the EMEP/EEA Emission Inventory Guidebook 2023 is applied. The default emission factor for other organic wastes of 0.08 kg NH_3 per kg N applied has been used (EEA, 2023a, Table 3-1).

Emissions of nitric oxide (NO_x)

The Tier 1 approach according to the EMEP/EEA Emission Inventory Guidebook 2023 is applied. The default NO emission factor for other organic wastes of 0.04 kg NO/kg waste N applied (EEA, 2023a, Table 3-1) has been used.

Activity Data

Energy crops

The calculation of N from anaerobically digested energy crops (digestates) was done on the basis of raw material and energy balances reported by E-Control (E-CONTROL, 2006–2022) for the years 2007, 2010, 2011, 2014–2019. For 2020–2022 information is obtained by (Kompost- und Biogasverband, 2023). N content of digested energy crops was derived from specific literature (Resch et al., 2006; Landesbetrieb Landwirtschaft Hessen, 2013; Süd-Treber GmbH, 2021). Amounts of digested manure N are calculated in sector manure management.

Table 296: N from biogas slurry and compost.

Year	Digestates (livestock manures) [kg N year^{-1}]	Digestates (veg. part) [kg N year^{-1}]	N from compost [kg N year^{-1}]
1990	20 558	55 953	60 236
1995	153 683	425 239	694 352
2000	487 077	1 342 861	875 945
2005	949 530	2 585 007	1 137 307
2010	2 211 091	3 542 337	1 303 964
2011	1 470 949	3 967 113	1 408 564
2012	1 525 495	3 982 333	1 560 827
2013	1 576 406	3 997 529	1 471 292
2014	1 629 721	4 012 634	1 530 673
2015	1 657 614	4 124 919	1 504 839
2016	1 703 685	4 291 965	1 637 533
2017	1 620 786	4 330 692	1 641 556
2018	1 662 670	4 071 751	1 631 028
2019	1 289 240	3 747 936	1 704 948
2020	1 638 023	3 704 492	1 731 477
2021	1 815 825	3 464 602	1 810 716
2022	1 484 070	3 410 620	1 768 664

Compost

Activity data for agricultural compost application was derived by expert judgement by Umweltbundesamt (2015) based on treated amounts and application pathways (Buchgraber et al., 2003) and (Egle et al., 2014). Based on (Landwehr, 2000, Kranert & Landwehr, 2010, Römpp, 1996–1999) and (Brunstermann, 2007) an organic mass loss of 50% during the composting process has been applied. For compost, a dry matter content of 40% (Römpp, 1996–1999) was used. The N-content of dry matter of 1.4% was derived from (Amlinger et al., 2005).

Total amounts of compost (composting plants and home composting) were taken from Table 313 (chapter waste). Based on (Buchgraber et al., 2003 and Egle et al., 2014) a share of 45% of the compost from composting plants is applied in sector agriculture. The dry matter content of 40% for compost is derived from (Römpp, 1996–1999).

Table 297: Amount of compost (dry matter) produced in Austria, 1990–2022.

Year	Total amount of compost [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied compost N [t N]
1990	83 561	4 303	5.1	60
1995	230 215	49 597	21.5	694
2000	293 394	62 568	21.3	876
2005	337 811	81 236	24.0	1 137
2010	366 861	93 140	25.4	1 304
2011	383 990	100 612	26.2	1 409
2012	408 881	111 488	27.3	1 561
2013	395 643	105 092	26.6	1 471
2014	406 344	109 334	26.9	1 531
2015	403 880	107 489	26.6	1 505
2016	427 051	116 967	27.4	1 638
2017	428 747	117 254	27.3	1 642
2018	426 617	116 502	27.3	1 631
2019	440 388	121 782	27.7	1 705
2020	445 348	123 677	27.8	1 731
2021	458 589	129 337	28.2	1 811
2022	453 852	126 333	27.8	1 769

5.5.4 Urine and dung deposited by grazing animals (3.D.a.3)

Key Category: No

Emissions of ammonia (NH_3)

Cattle and Swine

The emission factor of 0.05 kg NH_3-N/kg N excreted has been taken from (Eidgenössische Forschungsanstalt, 1997).

The share of N excreted on pastures is presented in Table 263 to Table 265. Free range systems for pigs are uncommon in Austria, there are no emissions occurring from that source.

Nitrogen excretion values of cattle and swine are presented in Table 271, Table 272 and Table 273.

Sheep, goats, horses, poultry and other animals

Tier 2 default NH_3-N EFs have been taken (EEA, 2023a, Table 3-9). For other animals (deer) the EF of sheep has been used. N-excretion values and TAN proportion are described in chapter 5.3.3.

Emissions of nitric oxide (NO_x)

The Tier 1 methodology does not distinguish between emissions from manure applied to land (3.D.a.2.a) or those from excreta deposited during grazing (3.D.a.3). During the NEC Review 2021, the TERT recommended Austria to report emissions in category 3.D.a.3 instead of the notation key

'IE' in the next annual submission. In Austria's inventory, specific excreted nitrogen amounts are available to report emissions where they occur.

Since then, in accordance to the recommendation of the review, Austria reports NO_x emission values from grazing by applying the simple approach of multiplying the specific N amounts with the default Tier 1 EF of 0.04 kg NO/kg fertilizer and manure N applied taken from (EEA, 2023a, Table 3-1).

Emissions of non-methane volatile organic compounds (NMVOC)

From submission 2019 onwards NMVOC emissions from category 3.D.a.3 Urine and dung deposited by grazing animals were reported. In contrast to the EMEP/EEA Tier 1 methodology, which includes only NMVOC emissions from feeding, the Tier 2 approach comprises EF for buildings (feeding, housing and storage), manure application and grazing. Thus, improved calculations resulted in emission estimates for grazing.

For further details on methodologies and parameters used please refer to sub-section 3.B Manure management, chapter 5.3.7.

5.5.5 Cultivated crops (3.D.e)

Key Category: No

5.5.5.1 NMVOC emissions from vegetation

The Tier 2 methodology according to the EMEP/EEA GB 2023 has been applied. Austria estimates emissions for all of the relevant crop types for which EFs are available in the 2023 EMEP/EEA Guidebook (wheat, rye and rape) (see Table 3-4). For the remaining cropland area an average of the highest and lowest EF (wheat and rape) was applied (0.83 kg NMVOC/ha), as recommended in the NEC Review 2017 (EC, 2017). Austria has cold climate conditions. In 2022, the average temperature varied in Austria's cities from 10.3°C in Klagenfurt to 13.4 °C in Vienna; the coldest regions in Austria's mountains recorded an average of -6°C (ZAMG, Jahrbuch 2022). The overall mean temperature in Austria was 8.6°C in 2022. Grassland is predominately located in mountainous (cold) regions. Therefore, the emission factor for grass (15 °C) of 0.41 kg NMVOC/ha/yr following the EMEP/EEA GB 2023, Table 3-4, has been taken. Emissions are calculated with the following formula.

$$E_{NMVOC\_cl\_gl} = \Sigma A_{cl,gl} * EF_{cl,gl}$$

$E_{NMVOC\_cl,gl}$	=	*annual NMVOC emission flux from cropland and grassland areas (kg NMVOC)*
$A_{cl,gl}$	=	*annual cropland area, annual grassland area (ha)*
$EF_{cl,gl}$	=	*EF of wheat, rye, rape and average EF (wheat and rape) for cropland and grass (15°C) for grassland (kg NMVOC/ha)*

Activity data

Data of agricultural land use are taken from (Statistik Austria, 1990–2022). Land use areas (cropland, grassland, alpine grassland) are harmonized with sector Land Use, Land Use Change and Forestry (LULUCF) of Austria's GHG inventory to be consistent within the Austrian Inventory and across all sectors. Cropland areas are based on data from the national Farm Structure Surveys (FSS) and the Integrated Administration and Control System (IACS).

In the years when the full FFS was conducted (1990, 1995, 1999, 2010 and 2020) these data were taken (ÖSTAT, 1991, 1998, STATISTIK AUSTRIA, 2001, 2013 and 2022b). In some intermediate years random sample Farm Structure Surveys were carried out (1993, 1997, 2003, 2005, 2007, 2013 and 2016 – sources: ÖSTAT, 1994, 1998, STATISTIK AUSTRIA, 2005, 2006, 2008, 2014, 2018f), and these data for cropland area were also taken. Since joining the EU in 1995, Austria operates the IACS[126] data base, which in contrast to FSS is up-dated yearly, but includes only cropland and grassland area of farms that receive support under the CAP.

Since submission 2022, the annual total cropland area is linearly interpolated for the non-FSS years and over certain intermediate random sample FSS years (e.g. 2003 and 2005), for which time series consistency issues were identified. For the coming years until the next FSS, data is extrapolated using the relation factor of the FSS 2020 and IACS annual cropland area of every year. Grassland areas have been interpolated in the years between the full farmstructure surveys (eg. 2010–2020). For the years after the last FSS survey year in 2020, agricultural grassland areas for 2021 and 2022 are extrapolated using the long-term annual trend derived from the 2003 and 2020 area estimates.

Further details are given in "Austria's National Inventory Report 2024, chapters *6.3.2 Cropland (Category 4.B)* and *6.4.2 Grassland (Category 4.C)* (Umweltbundesamt, 2024a).

As recommended under the NEC Review 2018 (EC, 2018), the cultivated area of wheat, rye and rape is now included in Table 298.

In the following table the relevant land use areas are presented. As recommended in the NEC Review 2021 (EC, 2021a) additional information on grassland areas is provided. Total grassland comprises one cut meadows, two cut meadows, three and more cut meadows, litter meadows, permanent pastures, rough pastures, alpine meadows and pastures, grassland where grassland management was stopped and fallow grassland (grassland in good agricultural and ecological condition no longer used for production).

Table 298: Agricultural land use data 1990–2022 for calculating NMVOC emissions (3.D.e).

Year	**Land Use Areas [ha]**					
	Cropland (total)	***Wheat***	***Rye***	***Rape***	***Remaining Cropland***	**Grassland (total)**
1990	1 405 141	278 226	93 041	40 844	993 030	1 714 917
1995	1 404 248	255 910	76 826	89 246	982 266	1 678 553
2000	1 394 457	293 806	52 473	51 762	996 416	1 643 693
2005	1 390 374	288 960	42 847	35 251	1 023 316	1 608 648
2010	1 371 428	302 852	45 699	53 803	969 074	1 509 271
2011	1 368 971	304 334	45 943	53 636	965 057	1 493 892
2012	1 366 514	308 179	48 525	55 821	953 988	1 478 512
2013	1 364 057	297 286	56 108	58 557	952 106	1 463 133
2014	1 357 532	304 645	48 241	52 816	951 830	1 456 225

[126] Integrated Administration and Control System (IACS), responsible for administering agricultural subsidies

Year	Land Use Areas [ha]					
	Cropland (total)	*Wheat*	*Rye*	*Rape*	*Remaining Cropland*	Grassland (total)
2015	1 351 006	302 965	39 563	37 529	970 950	1 449 316
2016	1 344 481	315 088	37 312	39 662	952 418	1 442 408
2017	1 339 089	295 029	34 476	40 502	969 082	1 435 500
2018	1 333 696	292 654	40 725	40 504	959 813	1 428 592
2019	1 328 304	277 291	43 679	35 966	971 368	1 421 683
2020	1 322 912	277 912	42 735	31 827	970 438	1 414 775
2021	1 321 591	277 447	32 869	28 273	983 003	1 402 546
2022	1 322 419	292 863	34 432	28 385	966 740	1 390 317

5.5.6 Use of Pesticides (3.D.f)

Key Category: HCB

Following a recommendation of the NEC Review 2019 (EC, 2019) Austria investigated the list of active substances for which impurity factors are provided in Table 4 of the EMEP/EEA Guidebook, chapter 3.D.f., 3.I *Agriculture other including use of pesticides* and reports emissions of HCB under source category *3.D.f Use of pesticides*.

Activity data

According to Regulation 1185/2009 in Austria the following substances were used in the following years:

- Atrazine: 1990–1995
- Clopyralid: 1990–2022
- Chlorothalonil: 1990–2020
- DCPA, Dacthal, Chlorthaldimethyl: 1995
- Endosulfan: 1990–2006
- Lindane: 1990–1997
- Picloram: 1990–2022
- Simazine: 1990–2004

For emission calculation, activity data on the level of active substances were used. However, in Austria these data are confidential. Thus, Table 299 provides the total amount of active substances.

Table 299: Annual total amounts of active substances containing HCB as impurity in Austria.

Year	Active substances [kg]
1990	463 422
1995	34 868
2000	22 768
2005	18 272
2010	21 309

Year	Active substances [kg]
2011	16 881
2012	15 396
2013	19 377
2014	20 054
2015	6 674
2016	26 415
2017	46 821
2018	39 570
2019	60 362
2020	7 316
2021	2 713
2022	3 097

Methodology

Austria applies the EMEP/EEA 2023 Tier 1 default approach and the proposed maximum HCB-concentrations (impurity factors) in active substances according to the EMEP/EEA Guidebook 2023, Table 4.

Depending on the usage of specific substances in the time series, the implied impurity factors vary from about 5 mg/kg to 175 mg/kg active substance.

5.5.7 Category-specific Recalculations

Update of activity data

Livestock data – cattle < 1 year
The livestock category cattle < 1 year comprises slaughtering calves < 1 year, other male calves and cattle < 1 year, and other female calves and cattle <1 year according to the official statistics (Statistics Austria). The breakdown by type of use is determined by Statistics Austria using model calculations. Methodological improvements resulted in shifts between the cattle < 1 year sub-categories in the years 2003–2021 and thus led to revised average values for gross energy intake, $N_{excretion}$ and $VS_{excretion}$ for cattle < 1 year.

Background data for feeding and nutrition of dairy and suckling cows
New figures for the protein and fat content of milk for the year 2021 became available (AMA, 2023b). This update resulted in minor revisions of the values for gross energy intake, $N_{excretion}$ and $VS_{excretion}$ of dairy and suckling cows.

Biogas plants
New data on input materials for Austria's biogas plants became available from the compost and biogas association (Kompost- und Biogasverband) resulting in slightly revised NO_x and NH_3 emissions with an impact on the source categories 3.B Manure Management, 3.D.a.2.a Animal manure applied to soils and 3.D.a.2.c Other organic fertilizers applied to soils for 2020 and 2021.

Methodological changes

Inorganic N-fertilizers (3.D.a.1)
For the first time the new Tier 2 NH_3 EF for mineral fertilizers according to the EMEP/EEA Guidebook 2023 has been used. This update resulted in revised ammonia emissions for the entire time series (+3.1 kt NH_3 for 2021).

Animal Manure Applied to Soils (3.D.a.2.a)
Updated activity and nutrition data, as described before, resulted in revised NH_3, NO_x and NMVOC emissions between 2003 and 2021. In addition, the latest subsidy data on manure amounts applied with low-emission spreading techniques for cattle and swine from the ÖPUL database of the Federal Ministry of Agriculture, Forestry, Regions and Water Management (BML) were implemented, resulting in revised estimates for ammonia from 2018 to 2021. Additionally, for NMVOC and other cattle a linkage error in the agriculture sector model was corrected (-0.1 kt NH_3, +0.02 kt NO_x and -0.6 kt NMVOC for 2021).

Other organic fertilizers (3.D.a.2.c)
As a result of the updated input materials for biogas plants, NH_3 and NO_x emissions have been revised for the years 2020 and 2021 (-0.01 kt NH_3 and -0.01 kt NO_x).

Urine and dung deposited by Grazing Animals (3.D.a.3)
Reasons for recalculations are the livestock related updates as already described above, updated NH_3-EF for sheep and deer according to the new EMEP/EEA GB 2023 and the correction of a linkage error in the sector model for NMVOC. These improvements resulted in revised NH_3 and NMVOC emissions of the entire time series. In the case of NO_x, recalculations are reported for the years between 2003 and 2021 (+0.1 kt NH_3, +0.003 kt NO_x and -0.01 kt NMVOC for 2021).

5.6 NFR 3.D Particle Emissions from Agricultural Soils

Particle emissions reported under source category 3.D result from the following activities:

- Certain steps of farm work such as soil cultivation and harvesting (field operations). The calculations are based on the EMEP/EEA GB 2023 Tier 1 methodology (EEA, 2023a). In accordance with the EMEP/EEA Guidebook 2023, chapter 3.D, Table 2-1, emissions are allocated to NFR source category *3.D.c Farm-level agricultural operations including storage, handling and transport of agricultural products*.
- Agricultural bulk material handling. These emissions are estimated under source category *2.A Mineral Products* (see Chapter 4.3) based on (Winiwarter et al., 2001) and reported under NFR source category *3.D.d Off-farm storage, handling and transport of bulk agricultural products*.

5.6.1 Methodological Issues

5.6.1.1 Farm-level agricultural operations including storage, handling and transport of agricultural products (3.D.c)

Emissions of particulate matter from field operations are linked with the usage of machines on agricultural soils. They are considered in relationship with the treated areas. In previous submissions Austria calculated its emissions based on a country-specific approach. From submission 2018 onwards, as recommended in the NEC Review 2017 (EC, 2017), the EMEP/EEA Tier 1 methodology has been applied.

Activity Data

Data of agricultural land use are taken from (Statistik Austria, 1990–2022). Land use areas (cropland, grassland, alpine grassland) are harmonized with sector Land Use, Land Use Change and Forestry (LULUCF) of Austria's GHG inventory to be consistent within the Austrian Inventory and across all sectors. Cropland areas are based on data from the national Farm Structure Surveys (FSS) and the Integrated Administration and Control System (IACS).

In the years when the full FFS was conducted (1990, 1995, 1999, 2010 and 2020) these data were taken (ÖSTAT, 1991, 1998, STATISTIK AUSTRIA, 2001, 2013 and 2022b). In some intermediate years random sample Farm Structure Surveys were carried out (1993, 1997, 2003, 2005, 2007, 2013 and 2016 – sources: ÖSTAT, 1994, 1998, STATISTIK AUSTRIA, 2005, 2006, 2008, 2014, 2018f), and these data for cropland area were also taken. Since joining the EU in 1995, Austria operates the IACS[127] data base, which in contrast to FSS is up-dated yearly, but includes only cropland and grassland area of farms that receive support under the CAP.

Since submission 2022, the annual total cropland area is linearly interpolated for the non-FSS years and over certain intermediate random sample FSS years (e.g. 2003 and 2005), for which time series consistency issues were identified. For the coming years until the next FSS, data is extrapolated using the relation factor of the FSS 2020 and IACS annual cropland area of every year. Grassland areas have been interpolated in the years between the full farmstructure surveys (eg. 2010–2020). For the years after the last FSS survey year in 2020, agricultural grassland areas for 2021 and 2022 are extrapolated using the long-term annual trend derived from the 2003 and 2020 area estimates.

Further details are given in "Austria's National Inventory Report 2024, chapters *6.3.2 Cropland (Category 4.B)* and *6.4.2 Grassland (Category 4.C)* (Umweltbundesamt, 2024a).

Table 300: Agricultural land use data 1990–2022.

	Land Use Area Data	
Year	**arable farm land [1 000 ha]**	**grassland (intensive used) [1 000 ha]**
1990	1 405	877
1995	1 404	895
2000	1 394	909
2005	1 390	908
2010	1 371	851
2011	1 369	843

[127] Integrated Administration and Control System (IACS), responsible for administering agricultural subsidies

Land Use Area Data		
Year	**arable farm land [1 000 ha]**	**grassland (intensive used) [1 000 ha]**
2012	1 367	835
2013	1 364	826
2014	1 358	821
2015	1 351	816
2016	1 344	811
2017	1 339	805
2018	1 334	800
2019	1 328	795
2020	1 323	790
2021	1 322	783
2022	1 322	776

The area of grassland intensively used is a subset of the total grassland area (see Table 298) and comprises two cut meadows, three and more cut meadows and permanent pastures.

Due to the limited number of measurements, a separate parameterization of different field crops as well as a different treatment of cropland and grassland activities is not yet possible. Thus, as activity data the sum of cropland and intensively used grassland area is taken.

Emission factors

The Tier 1 emission factors for TSP, PM_{10} and $PM_{2.5}$ are taken from the EMEP/EEA GB 2023, table 3-1 (EEA, 2023a).

Emission factors do not include a condensable component (see also chapter 12.3).

5.6.1.2 Off-farm storage, handling and transport of agricultural products (3.D.d)

PM emissions from bulk material handling are estimated under source category *2.A Mineral Products* (see Chapter 4.3) but reported under sector *3.D.d Off-farm storage, handling and transport of agricultural products*.

A simple methodology is applied. Emissions are estimated by multiplying the amount of bulk material with an emission factor.

Activity data

Activity data was taken from official Statistik Austria production statistics (see Chapter 4.3, Table 229).

Emission factors

The EMEP/EEA GB 2023 does not provide emission factors for this source category. Emission factors are taken from a national study (Winiwarter et al., 2001) (see Chapter 4.3, Table 228).

5.6.2 Category-specific Recalculations

No recalculations have been carried out.

5.7 NFR 3.F Field Burning of Agricultural Residues

This category comprises burning straw from cereals on open fields in Austria. Emissions from burning of residual wood of vinicultures are reported in category *5.C.2.1.b Incineration and Open Burning of Waste – Other* from submission 2023 onwards. This reallocation was carried out in response to a recommendation of the NEC Review 2022 (EC, 2022). The methodological description of this source is included in Chapter 6.5.2.

Burning agricultural residues on open fields in Austria is legally restricted by provincial law and since 1993 additionally by federal law and is only occasionally permitted on a very small scale. Therefore the contribution of emissions from field burning of agricultural waste to the total emissions is very low.

5.7.1 Methodological Issues

Activity Data

According to information from the Austrian Chamber of Agriculture (Austrian Chamber of Agriculture, 2022), in Austria no field burning occurred in 2021 and 2022 ("NO"). In the last years, the areas burnt were decreasing steadily, in 2020 only 5 ha were burnt. In 2004, the area burnt was larger than in previous years. This peak can be explained with the weather conditions, a very dry August and the late crop harvest. For 1990 an average value of 2 500 ha was indicated for Austria's main cultivation regions (Presidential Conference of Austrian Agricultural Chambers, 2004). The extrapolation to Austria's total cereal production area gave a value of 2 630 ha.

5.7.1.1 Cereals

NH_3, NO_x, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, Cd, Hg, Pb, PAHs

As recommended in the NEC Review 2020 (EC, 2020), PAH emissions are reported for individual PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene) in submission 2021 for the first time.

The EMEP/EEA Tier 1 default approach (EEA, 2023a) referring to the IPCC default method was used. For wheat, barley, oats, rye and other cereals the IPCC default combustion factor for wheat residues provided in Table 2.6 of the 2006 IPCC GL (IPCC, 2006) has been applied. For dry matter fraction the Austrian specific value of 0.86 was used (Löhr, 1990). Residue/crop product ratios were calculated based on the IPCC 2006 default methodology (see Austria´s National Inventory Report 2024, chapter on N from crop residues).

For wheat and barley Tier 2 emission factors are available in the guidebook (EEA, 2023a, Table 3-3 and Table 3-4). For oats, rye and other grains the EMEP/EEA Tier 1 emission factors were applied.

HCB, dioxin/furan

A country specific method was applied (Hübner, 2001b). National emission factors were taken from Hübner (2001b):

- PCDD/F..............50 µg/ha
- HCB............10 000 µg/ha.

5.7.2 Category-specific Recalculations

No recalculations have been carried out.

6 WASTE (NFR SECTOR 5)

6.1 Sector Overview

This chapter includes information on methodologies applied for estimating emissions of NEC gases, CO, heavy metals, persistent organic pollutants (POPs) and particulate matter (PM), as well as references for activity data and emission factors concerning waste management and treatment activities reported under NFR Category *5 Waste* for the period from 1990 to 2022.

Emissions addressed in this chapter include emissions from the sub categories

- *Solid Waste Disposal on Land* (NFR Sector *5.A*);
- *Composting* (NFR Sector *5.B*), comprising composting, mechanical-biological treatment of waste and anaerobic treatment of agricultural feedstock;
- *Waste Incineration* (NFR Sector *5.C*), which comprises the incineration of corpses, municipal waste and waste oil as well as small scale waste burning (agricultural wood waste);
- *Wastewater Handling* (NFR Sector 5.D);
- *Other Waste (*NFR Sector *5.E),* comprising emissions from unwanted fires in cars and various types of houses.

The following Table 301 presents the contribution of sector Waste to national total emissions of the different pollutants.

Table 301: Contribution to National Total Emissions from NFR sector 5 Waste in 2022.

Pollutant	Contribution NFR sector 5 Waste	Pollutant	Contribution NFR sector 5 Waste
SO_2	0.14%	PAH	0.21 %
NO_x	0.02%	Diox	10.2%
NMVOC	0.06%	HCB	0.79%
NH_3	1.81%	TSP	1.74%
CO	0.51%	PM_{10}	1.92%
Cd	0.27%	$PM_{2.5}$	2.71%
Hg	4.03%	PCB	0.70%
Pb	0.02%		

The overall emission trend reflects changes in waste management policies as well as waste treatment facilities. According to the Landfill Ordinance[128] waste has to be treated before being deposited in order to reduce the organic carbon content. Decreasing amounts of deposited waste result in decreasing NH_3 emissions. Although an increasing amount of waste is incinerated, NO_x, NMVOC and NH_3 emissions from 5.C (waste incineration without energy recovery) are decreasing. This is because – apart from some clinical and hazardous waste – most waste is combusted in district heating or industrial plants, where the energy is used and emissions are thus allocated to 1.A. Emissions arising from incineration of waste with energy recovery are taken into account in NFR Sector

[128] Verordnung über die Ablagerung von Abfällen (Deponieverordnung), BGBl. Nr. 164/1996, BGBl. II Nr. 49/2004; geltende Fassung: Deponieverordnung 2008 (BGBl. II Nr. 39/2008).

1.A. NH_3 emissions arising from category 5.B.1 Composting, being the highest NH_3 emission source in this category showed an increasing trend due to increasing amounts of biologically treated waste, a result of the separate collection of organic waste (regulated in an Austrian act on collection of biogenic waste[129]) and the obligatory pre-treatment of waste[130] since 2004 (with some exemptions until 2009) before deposition (regulated in Austrian Landfill Ordinance[131]).

The following list comprises primary and secondary measures which were implemented over the last years:

- Primary measures
  - waste avoidance in households: savings in packaging materials; intensive waste separation (paper, glass, plastics, metal, biogenic waste); reuse; separate collection of hazardous waste like solvents, paints or (car) batteries.
  - waste avoidance in industry and energy sector: waste separation regarding material, recyclable waste, hazardous waste; more efficient process lines; use of co- and by-product process line; (scrap) recycling; substitution of raw material/fuel; reduction in use of raw material/fuel and additive raw material; higher product quality.
  - recycling of old cars (recycling certificate).
- Secondary measures
  - general strategy: waste avoidance prior to waste recycling/reuse prior to landfilling;
  - recovery of (recyclable) material from waste like steel and aluminium recycling, and recycling of paper, glass, plastic;
  - recovery of (recyclable) material from electronic waste;
  - composting of biogenic material;
  - mechanical-biological treatment of waste;
  - fermentation of biogenic material;
  - energetic use in waste incineration.

The following figure shows the main streams of treatment and disposal of waste from households and similar sources. It also aims to transparently show the distinction between residual and non-residual waste (with regard to municipal solid waste[132]) and to demonstrate that all relevant activity data are taken into account in the inventory.

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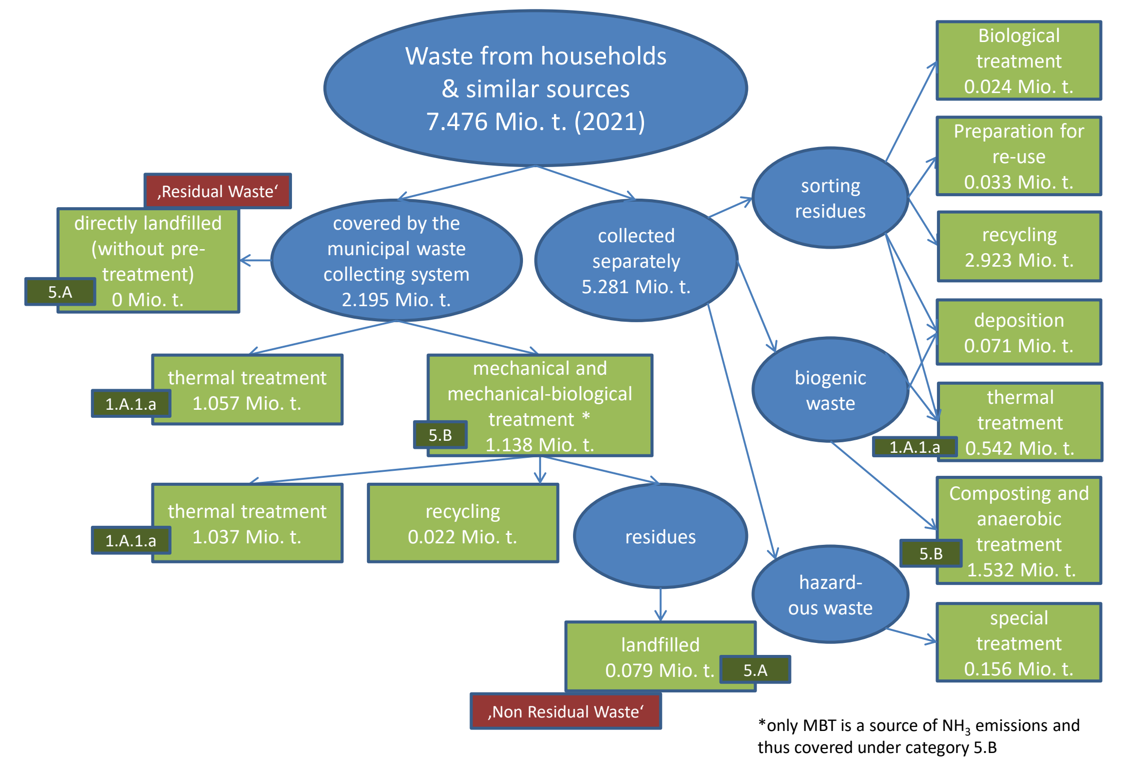
[129] Ordinance on the Separate Collection of Biogenic Waste, Federal Law Gazette II No 68/1992, as amended by Federal Law Gazette II No 456/1994.

[130] Since 2004 respectively – without exemption – 2009 no waste is allowed to be deposited any more without being pre-treated (in thermal or bio-technical treatment plants)

[131] Ordinance on Landfills (Landfill Ordinance 2004), Federal Law Gazette No 164/1996 as amended by Federal Law Gazette No 49/2004; Ordinance on Landfills (Landfill Ordinance 2008), Federal Law Gazette II No 39/2008 (Landfill Ordinance 2008) as amended by Federal Law Gazette II No 144/2021

[132] In fact non-residual waste also comprises waste from other (industrial) sources.

Figure 52: Waste from households and similar sources – treatment and disposal routes 2021. Please note: This illustration only covers data from households and similar sources. Waste from industrial and similar sources (e.g. wastewater treatment plants) which is also included in the inventory is not considered in this figure.



Source: Umweltbundesamt

Almost 100% of waste from households and similar sources is incinerated, recycled or treated mechanical-biologically. Since 2009 only minor amounts of stabilized residues have been still deposited.

6.2 General description

6.2.1 Completeness

Table 302 gives an overview of the NFR categories included in this chapter and also provides information on the status of emission estimates of all sub categories. A "✓" indicates that emissions from this sub category have been estimated.

Table 302: Overview of sub categories of Category 5 Waste and status of estimation.

NFR Category		Status														
		NEC gases				CO	PM			Heavy metals			POPs			
		NO_x	SO_2	NH_3	NMVOC	CO	TSP	PM_{10}	$PM_{2.5}$	Cd	Hg	Pb	Dioxin	PAH	HCB	PCB
5.A	Solid Waste Disposal on Land	IE*	IE*	✓	✓	✓	✓	✓	✓	✓	✓	✓	NA	NA	NA	NA
5.B	Biological Treatment of Waste (Composting, anaerobic digestion)	NA	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.C	Waste Incineration	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5.D	Wastewater Handling	NA	NA	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.E	Other Waste	NE	NE	NA	NE	NE	✓	✓	✓	✓	✓	✓	✓	NE	NE	NE

* *related emissions are covered under sector Energy*

NO_x and SO_2 emissions are covered in the energy sector, as most of the collected landfill gas is used for energy recovery.

6.2.2 Key Categories

In the following table the key categories of sector waste are presented.

Table 303: Key categories of sector Waste

NFR Category	Source Category	Key Category	
		Pollutant	KS-Assessment
5.C.1	Waste Incineration	DIOX	TA
5.C.1	Waste Incineration	Cd	TA
5.E	Other waste	DIOX	LA
5.E	Other waste	$PM_{2.5}$	LA

LA = Level Assessment 2022

TA = Trend Assessment 1990–2022

6.2.3 Methodology

In general the CORINAIR simple methodology, multiplying activity data for each sub category with an emission factor, is applied. For waste disposal the IPCC methodology (FOD method) was used to calculate the amount of landfill gas, the methodology is described in detail below.

6.2.4 Uncertainty Assessment

The uncertainties determined for air pollutants largely correspond to those of greenhouse gases as underlying data is the same in most cases. The assessment for 5.A Solid Waste Disposal is based on a national study (WINIWARTER, 2007).

The uncertainties have been determined based on the following considerations

- IPCC Tier 2 method applied;
- Country-specific activity data taken from Austrian databases;
- Availability of data on landfill recovered on a regular basis.

Table 304: Uncertainty assessment for waste subcategories.

	Activity data	Emission factor
5.A Solid Waste Disposal on Land – NH_3, NMVOC	12%	25%
5.A Solid Waste Disposal on Land – $PM_{2.5}$	12%	200%
5.B Biological Treatment of Waste – NH_3	20%	125%
5.C Waste Incineration – NH_3, NMVOC	7%	125%
5.C Waste Incineration – $PM_{2.5}$, NO_x, SO_2	7%	200%
5.D Waste water treatment and discharge	20%	50%
5.E Other Waste	50%	200%

6.2.5 Quality Assurance and Quality Control (QA/QC)

To ensure, that most up-to-date data and parameters (e.g. landfill gas recovery, connection rate etc.) are considered, national waste experts, mostly within Umweltbundesamt are contacted. Activity data is checked for plausibility and time series consistency. If dips and jumps exceeding 20 % compared to the year before are observed, other experts or data providers are consulted to either provide the explanation or to identify a possible inconsistency or an error.

Recalculations are validated in detail by comparing several parameters and partial results over the whole time series. Explanations for recalculations are documented.

Input Data Audit 2014/2015

End of 2014/beginning 2015 a multi-step audit was conducted at the BMLFUW (Department responsible for analysis and quality check of EDM data on landfilled waste) and Umweltbundesamt (Department responsible for data query on behalf of the BMK). The aim was to get insight into collection, processing and quality control of data, i.e. waste amounts deposited, and to clarify issues on transparency, accuracy, completeness, consistency, comparability and timely availability of data. The audit focused on waste amounts deposited, but partly also covered the data basis and procedures for the compilation of data on waste amounts composted. The audit showed a very strong commitment on quality. There is close cooperation with relevant data providers, in particular related to waste treating facilities. QA/QC takes place at different stages, and an improvement program ensures adaption of the system to changing requirements. Some recommendations on improvements were given by the IBE, but mainly with regard to documentation and archiving.

6.2.6 Planned Improvements

No improvements are currently planned.

6.3 NFR 5.A Waste Disposal on Land

6.3.1 NMVOC, NH_3, CO and heavy metals emissions

6.3.1.1 Source Category Description

NFR 5.A.1 *Managed waste disposal on land* accounts for the main source of NMVOC emissions of NFR Category 5 *Waste*. In Austria all waste disposal sites are managed landfills.

In the Austrian inventory two main categories of waste are distinguished: residual waste and non-residual waste. Residual waste refers only to the part of municipal solid waste[133] collected by the municipal system (mixed composition) that is directly deposited without any pre-treatment. Non-residual waste comprises among others municipal solid waste having been pre-treated, sludges from wastewater treatment and waste from industrial sources.

'Residual waste' corresponds to waste:

- originating from households and similar sources (private households, administrative facilities of commerce, industry and public administration, kindergartens, schools, hospitals, small enterprises, agriculture, market places and other generation points)
- remaining after separation of paper, glass, plastic etc. at the source
- covered by the municipal waste collecting system
- directly landfilled without having passed any pre-treatment

It has to be noted that from 2009 it is not allowed to deposit waste without prior pre-treatment (due to the Landfill Ordinance[134]), so since 2009 no disposal of 'residual waste' is reported by landfill operators and therefore no new depositions of residual waste is taken into account in the inventory. Emissions from this subcategory are therefore only affected by historical depositions. Nevertheless 'residual waste' still has a notable contribution to total landfill gas generated (86% in 1990, 73% in 2005 and 45% in 2022).

Waste from households and similar sources covered by the municipal waste collection system but undergoing a pre-treatment before deposition is not included in this category, but in category 'non-residual waste' (sub-category 'sorting residues', among others from mechanical-biological treatment) and in sector Energy respectively, as also waste incineration is a pre-treatment option.

[133] i.e. waste from households as well as other waste which, because of its nature or composition, is similar to waste from household (Article 2 (b): Council Directive 1999/31/EC of 26.April 1999 on the landfill of waste).

[134] Ordinance on Landfills (Landfill Ordinance 2004), Federal Law Gazette No 164/1996 as amended by Federal Law Gazette No 49/2004; Ordinance on Landfills (Landfill Ordinance 2008), Federal Law Gazette II No 39/2008 as amended by Federal Law Gazette II No 185/2009

'Non-residual waste':

- comprises pre-treated waste from households (e.g. residues from mechanical-biological treatment) and waste with biodegradable lots from other (industrial) sources
- is divided into the categories wood, construction waste, paper, green waste, sludge, sorting residues/stabilized material (incl. bulky waste), textiles and fats

Stabilized material and sorting residues remaining after mechanical, biological and mechanical-biological treatment and bulky waste are the main fraction deposited (95% in 2022). Only minor amounts of sludge and construction waste with little TOC content (below the threshold for TOC disposal) are landfilled as well. Green waste, paper and wood are mainly composted, recycled or re-used due to the implementation of the Waste Management Law, fats and textiles are not deposited any more.

6.3.1.2 Methodological Issues

The anaerobic degradation of landfilled organic substances results in the formation of landfill gas. NMVOC and NH_3 emissions are calculated based on their respective content in the emitted landfill gas (after consideration of gas recovery).

For the calculation of landfill gas emissions the IPCC Tier 2 method (First Order Decay) is applied. In a first step the amount of methane generated (accumulated up to the year of the current inventory) is calculated applying the first order decay model for nine different waste fractions (residual waste, green waste, paper, etc.). In a second step the amount of landfill gas collected is deducted. In a third step the remaining amount of methane in landfill gas is converted to the amount of landfill gas using the density of methane and the concentration of methane in the landfill gas. Finally this amount of landfill gas is multiplied with the respective emission factors (see Table 310).

For NMVOC a concentration of 300 mg per m³ landfill gas, for NH_3 a concentration of 10 mg per m³ landfill gas is assumed.

The amount of generated landfill gas from disposed solid waste is calculated by taking into account:

- the amounts of deposited waste, reported by landfill operators for different waste categories,
- the carbon contents of each waste fraction and
- several other parameters, among others on landfill gas recovery[135].

Activity data

For emissions calculation waste deposited from 1950 onwards has been taken into account.

Table 305 presents the waste amounts considered 1990–2022, as well as the amounts of landfill gas emitted as estimated under the GHG inventory framework (UMWELTBUNDESAMT, 2023a), which are the basis for the calculation of emissions of the air pollutants (refer to Table 310).

[135] All landfill sites for mass waste in Austria have gas collection systems – regulated in §31 Landfill Ordinance (Federal Law Gazette BGBl. Nr 39/2008.

Table 305: Activity data and landfill gas emitted 1990–2022.

Year	Non-Residual waste [t]	Residual waste [t]	Total waste [t]	Landfill gas emitted [m³/a]
1990	648 702	1 995 747	2 644 448	453 008 820
1995	716 219	1 049 709	1 765 928	417 107 749
2000	826 874	1 052 061	1 878 935	331 542 862
2005	389 660	241 733	631 393	303 061 386
2010	244 969	0	244 969	223 605 986
2011	273 313	0	273 313	208 970 943
2012	166 263	0	166 263	195 988 540
2013	185 156	0	185 156	182 144 442
2014	174 500	0	174 500	168 479 588
2015	131 959	0	131 959	157 395 387
2016	132 182	0	132 182	146 198 612
2017	151 866	0	151 866	137 209 413
2018	163 663	0	163 663	129 445 188
2019	166 659	0	166 659	122 415 954
2020	165 576	0	165 576	115 988 055
2021	197 067	0	197 067	109 682 947
2022	138 940	0	138 940	103 276 852
1990–2022	**-79%**	**-100%**	**-95%**	**- 77%**

In 1990, the Austrian Waste Management Law[136] entered into force. As a consequence, from 1990 to 1995, the deposited amount of waste decreased due to recycling activities, reuse and increased capacities for waste combustion, despite a rise in total waste generation. After 1994/1995 waste recycling still increased but was compensated by growing amounts of total waste generated so the amounts of deposited waste did not decrease any further. The amount of deposited waste peaked in 2003 due to the remediation of some contaminated sites and then dropped as from the beginning of 2004 only pre-treated waste was allowed to be deposited. This is due to the implementation of the Landfill Ordinance, which prohibits the disposal of untreated waste and therefore leads to reduced waste volumes as well as decreased carbon content in deposited waste.

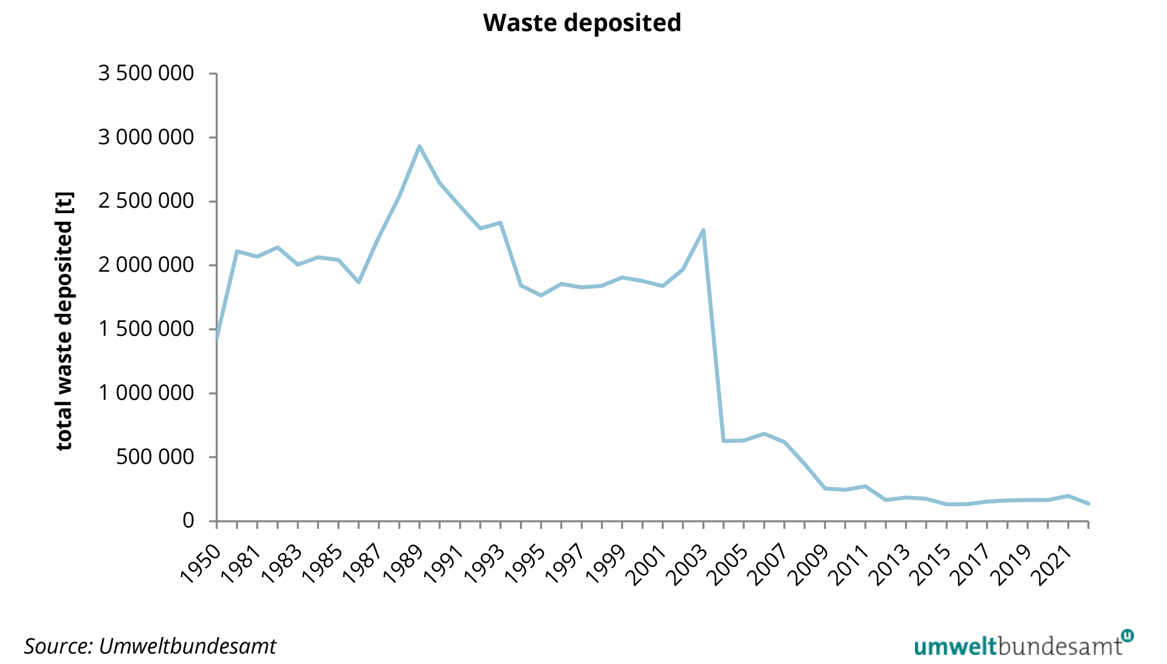
However, under certain circumstances there were some exceptions to this pre-treatment-obligation granted to some Austrian provinces.[137] In four of the nine Austrian provinces it was still allowed to deposit waste directly without any pre-treatment until the end of 2008. From 2009 on, no residual waste[138] is allowed to be deposited any more.

[136] Waste Management Act of 2002 , Federal Law Gazette I No 102/2002 as amended by Federal Law Gazette I No 9/2011

[137] Regulated in § 76.Abs. 7 AWG 2002

[138] as defined at the beginning of this sub-chapter

Figure 53: Deposited waste (residual and non-residual waste) 1950–2022.



Source: Umweltbundesamt

The quantities of 'residual waste' have been taken from the following sources:

- Data for 2008–2022 have been taken from the EDM[139], an electronic database administered by the BMK. Since the beginning of 2009 landfill operators are obliged to report their data directly and electronically (per upload) at the portal of http://edm.gv.at[141].
- Data for 1998–2007 were taken from a database for solid waste disposals called 'Deponie-datenbank' ('Austrian landfill database'), a database administered and maintained by Umweltbundesamt until the end of 2008.
- Data for 1950–1997 on the amounts of deposited residual waste were taken from national studies (HACKL & MAUSCHITZ, 1999, UMWELTBUNDESAMT, 2001b) and the respective Federal Waste Management Plans (BMLFUW, 1995, BMLFUW, 2001).

In the national study (HACKL & MAUSCHITZ, 1999) as well as in the Federal Waste Management Plans the amounts of residual waste from administrative facilities of businesses and industries were not considered and therefore originally not included in the data of the years 1950 to 1999. Waste from these sources is however deposited and hence reported by the operators of landfill sites (therefore included in the Austrian landfill database) and thus considered in the time series from 1998 onwards. To achieve a consistent time series, data of the two overlapping years[142] (1998

[139] Electronic Data Management

[140] According to § 41 (1) Landfill Ordinance, Federal Law Gazette BGBl. Nr 39/2008

[141] According to §41 (1) Landfill Ordinance, Federal Law Gazette BGBl. Nr 39/2008

[142] Data available from the Federal Waste Management Plan (Bundesabfallwirtschaftsplan - BAWP) as well as from the Austrian landfill database.

and 1999) were examined and the difference – which represents the residual waste from administrative facilities of industries and businesses – was calculated. This difference, relative to the change of residual waste from households, was then applied to the years 1950 to 1997 accordingly.

The quantities of 'non-residual waste' from 1998 to 2007 were taken from the database for solid waste disposal 'Deponiedatenbank' ('Austrian landfill database'), the values for 2008 onwards were taken from the EDM[143] (Electronic Data Management). Only the amounts of waste with biodegradable lots were considered. Table 306 presents a summary of all considered waste types and the corresponding numbers (list of waste). For calculating the emissions of residual waste the waste types were aggregated to the categories wood, paper, sludge, other waste, bio waste, textiles, construction waste and fats. There are not any data available for the years before 1998. Thus an extrapolation was carried out using the Austrian GDP (gross domestic product) per inhabitant (KAUSEL, 1998) as indicator. In order to get a more robust estimate a 20 year average value was applied.

Table 306: Considered types of waste (list of waste[144]).

Waste Identification No	Type of Waste	Waste Identification No	Type of Waste
0303	wastes from pulp, paper and cardboard production and processing	170204	Glass, plastic and wood containing or contaminated with dangerous substances
1905	wastes from aerobic treatment of solid waste	170903	other construction and demolition wastes (including mixed wastes) containing dangerous substances
1908	wastes from wastewater treatment plants not otherwise specified	170904	mixed construction and demolition waste
1909	wastes from the preparation of water intended for human consumption or water for industrial use	190805	sludge from treatment of urban wastewater
1912	wastes from the mechanical treatment of waste (for example sorting. crushing. compacting. pelletising) not otherwise specified	190809	grease and oil mixture from oil/water separation containing only edible oil and fats
20303	waste from solvent extraction	200101/ 200102	paper and cardboard
30105	Sawdust, shavings, cuttings, wood, particle board and veneer	200108	biodegradable kitchen and canteen waste
30304	de-inking sludge from paper recycling	200111	textiles
30307	mechanically separated rejects from pulping of waste paper and cardboard	200201	Bio-degradable wastes

143 Electronic Data Management (EDM): part of the eGovernment-strategy of the Austrian Government, registration requirements and reports in the field of environment.https://secure.umweltbundesamt.at/edm_portal/home.do?wfjs_enabled=true&wfjs_orig_req=/home.do

144 Commission Decision of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste.

Waste Identification No	Type of Waste	Waste Identification No	Type of Waste
30310	fibre rejects, fibre-, filler-. and coating sludge from mechanical separation	200302	waste from markets
40106	Sludge, in particular from on-site effluent treatment containing chromium	200307	bulky waste
40109	waste from dressing and finishing	190811–14	sludge from treatment of industrial wastewater
40221	wastes from unprocessed textile fibres	200125	edible oil and fat
150103	wooden packaging	170201	wood

Methodology

Where available, country specific factors are used. If these were not available IPCC default values are taken. Table 307 summarises the parameters used and the corresponding references.

Table 307: Parameters for calculating landfill gas from SWDS.

Waste category/ Parameters	residual waste	wood	paper	sludges	Sorting residues/ output MBT[145]/	bio-waste	textiles	construction waste	fats
Methane correction factor (MCF)	1 IPCC default for managed SWDS								
Fraction of degradable organic carbon dissimilated (DOC_F)	0.6	0.5	0.55	0.55	0.55	0.55	0.55	0.55	0.77
	national waste expertise (UMWELTBUNDESAMT, 2005b)[146]								
DOC (kt C/kt waste)	see Table 309	0.45	0.3	0.11	0.16	0.16	0.5	0.09	0.2
		(BAUMELER et al., 1998) (UMWELTBUNDESAMT, 2005b)							
Half life period ($t_{1/2}$)	7	25	15	7	20	10	15	20	4
	National waste experts	(GILBERG et al., 2005)	(GILBERG et al., 2005)	Assumption: same as residual waste	IPCC default slow decay	Assumption: similar to paper	Assumption: same as paper	IPCC default slow decay	(GILBERG et al., 2005)

[145] MBT: **M**echanical-**b**iological **t**reatment

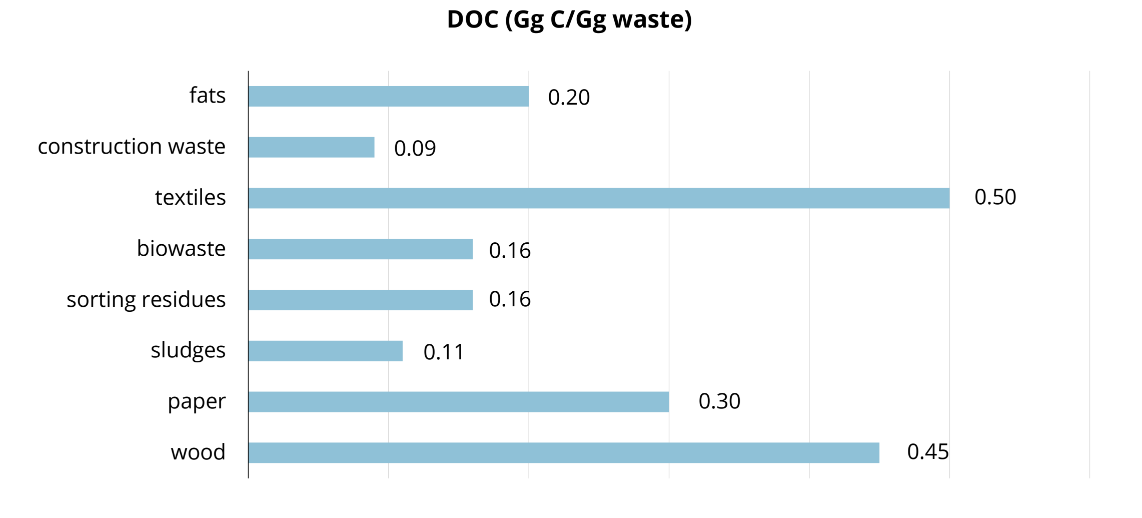
[146] Higher DOCf values than 0.5 (the IPCC 2006 default) are applied for most of the waste types (except wood) as the composition data shows a low share of lignin in the waste deposited. The DOCf for fats is set to 0.77 as lignin C is excluded here. The lower share of lignin C deposited can be justified by the fact that in Austria a high share of e.g. garden or park waste is treated biologically (considered under 5.B.1 *composting*).

Waste category/ Parameters	residual waste	wood	paper	sludges	Sorting residues/ output MBT[145]/	bio-waste	textiles	construction waste	fats
Fraction of CH_4 in Landfill Gas (F)	From 2018 onwards: 0.5 (IPCC, 2006) 2009–2018: linear decline from 0.55 (2008) to 0.5 (2018) 1950–2008: 0.55 according to various Austrian and German literature (FLÖGL, W., 2002, ÖWAV, 2003, LFU, 1992, UMWELTBUNDESAMT, 2008, UMWELTBUNDESAMT, 2014b)								
Methane Oxidation in the upper layer (OX)	10% IPCC default								
Landfill gas recov-ery (R)	see Figure 56 (UMWELTBUNDESAMT, 2004b, 2008, 2014b, 2019b, 2023c)								
Process start (M)	13 Delay time of 6 months, with an average residence time of 6 months (IPCC default)								

Biodegradable organic carbon (DOC)

The DOCs of the different waste categories under **'non-residual waste'** are constant for the entire time series and are shown in Table 307. As these categories are clearly defined (wood, paper, sludge etc.) and can therefore be considered as quite 'homogenous', there was no need to change the DOC over the years.

Figure 54: DOC of non-residual waste fractions.

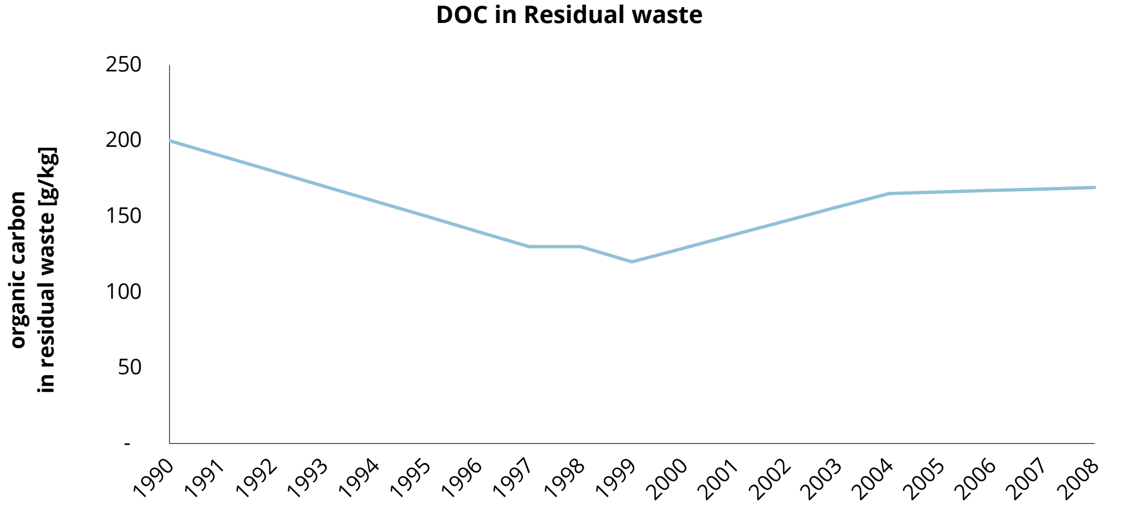


Source: Umweltbundesamt

The DOC of '**residual waste'** however has changed over the years in accordance with its changing composition. The separate collection of biogenic waste, paper and cardboard, and glass, and the increase of food waste in recent years etc. has clearly influenced the trend of the DOC.

For the year 1990, a DOC content of 200 g/kg residual waste was taken (UMWELTBUNDESAMT, 2003b). For 2008, the last year in which this waste category has been deposited, the DOC was 169 g/kg waste. It was calculated on basis of information on the composition of residual waste published in the Annual update (2009) of the Federal Waste Management Plan 2006 (BMLFUW, 2006), taking into account the different carbon content of the fractions as published in (UMWELTBUNDESAMT, 2003b). From 2009 on, only pre-treated waste, referred to as non-residual waste, is allowed to be deposited in Austria. Hence, only historical amounts are relevant and the DOC does not need to be updated any more.

Figure 55: Development of DOC in residual waste.



Source: Umweltbundesamt

The decrease during the 1990ies in DOC-content was due to the introduction of separate collection of bio-organic waste and paper waste. The amount of bio-waste that is collected separately increased over the time, while the organic share in residual waste decreased. This resulted in a change of waste composition with the effect of a decreasing DOC content. Since 2000 biogenic components in residual waste are increasing; this is due to the increasing share of biogenic components, especially of food waste, in residual waste.

Table 308 presents the composition of residual waste for several years between 1990 and 2008. On the basis of this information a time series for DOC was estimated (see Table 309). For the years before 1990, the same DOC as in 1990 was used.

Table 308: Composition of residual waste.

Residual waste	**1990[1)]**	**1996[1)]**	**1999[1)]**	**2004[2)]**	**2008[3)]**
	[% of moist mass]	**[% of moist mass]**	**[% of moist mass]**	**[% of moist mass]**	**[% of moist mass]**
Paper, cardboard	21.9	13.5	14	11	12
Glass	7.8	4.4	3	5	4
Metal	5.2	4.5	4.6	3	3
Plastic	9.8	10.6	15	10	10
Composite materials	11.3	13.8	–	8	10
Textiles	3.3	4.1	4.2	6	6

Residual waste	1990[1)]	1996[1)]	1999[1)]	2004[2)]	2008[3)]
	[% of moist mass]	[% of moist mass]	[% of moist mass]	[% of moist mass]	[% of moist mass]
Hygiene materials	–	–	12	11	8
Biogenic components	29.8	29.7	17.8	37	40
Hazardous household waste	1.4	0.9	0.3	2	1
Mineral components	7.2	3.8	–	4	3
Wood, leather, rubber, other components	2.3	1.1	2.6	1	–
Residual fraction	–	13.6	26.5	2	2

[1)] *(UMWELTBUNDESAMT, 2003b)*

[2)] *(BMLFUW, 2006)*

[3)] *Annual update (2009) of the Federal Waste Management Plan (BMLFUW, 2006)*

Table 309: Bio-degradable organic carbon content (DOC) of residual waste (mixed MSW, directly deposited)

Year	kg C/kg Residual Waste
1950–1990	0.20
1995	0.15
2000	0.13
2005	0.17
2008	0.17
2009–2022	n.r.

1950–1989: assumed to be equal to 1990; 1990–1999: based on (Umweltbundesamt, 2003b); 2004: based on waste composition 2001 (BMLFUW, 2006); 2008: based on waste composition 2009 (Status Report 2009 to BMLFUW, 2006). Years in between (2000–2003, 2005–2007) interpolated; 2009 onwards not relevant as no deposition of residual waste any more.

Decomposable DOC fraction (DOCf)

The DOCf values used for calculation are shown in Table 307.

Austria does not apply the bulk DOCf option of the IPCC 2006 GL as detailed information is available on the waste deposited (to be reported by landfill operators according to § 41 Landfill Ordinance). Based on this information the calculation is done separately for each waste fraction (wood, paper, sludges, sorting residues, bio waste, textiles, construction waste, fats, residual waste). The composition of the different landfilled waste fractions (waste types) is well known, allowing for applying an appropriate DOCf accordingly (see UMWELTBUNDESAMT, 2005b). Higher DOCf values than the IPCC 2006 default (0.5) are applied for most of the waste types (except wood) as the composition data shows a low share of lignin in the waste deposited.

The higher DOCf values used compared to the bulk DOCf can be justified by the fact that in Austria a high share of e.g. garden or park waste (i.e. branches from trees and bushes) is treated biologically in composting plants (considered under *5.B.1 composting*).

For 'residual waste', a calculation of the DOCf (0.6) was conducted based on waste analyses carried out in Austria in 2004[147] (presented in the Federal Waste Management Plan 2006 and the NIR 2008). Using the default DOCf values presented in the 2019 Refinement to the 2006 IPCC GL, Table 3.0, our calculation for residual waste would result in a DOCf of 0.592. This value would be even slightly higher if the average value of 0.523 for moderately decomposable waste would be used (indicated in the notes of Table 3.0) instead of the default value of 0.5. The relatively high DOCf for Austria is mainly due to the high share of kitchen waste (about 37% of the total waste composition or almost 49% only regarding fractions with degradable organic substance).

A justification regarding the DOCf values of further waste fractions is given hereinafter:

- 'Sludges' do not contain lignin, therefore a slightly higher DOCf is considered to be in line with the GL.
- The default DOCf of green waste according to Table 3.0 of the 2019 Refinement to the 2006 IPCC GL is 0.7 and thus even higher than the value used in Austria. However the fraction 'bio-waste' in Austria also includes branches, thus a slightly lower DOCf is considered appropriate.
- The waste category 'sorting residues' does not only include wood, but also compost like output from MBTs. Therefore a higher DOCf is considered justified.
- The decomposition rate of 'paper', even of newsprints, is higher than of 'wood' - again a higher DOCf is considered justified.

Also in (BAYARD, 2018) the biodegradation of different waste streams was investigated showing typically higher DOCf values than the recommended DOCf of the IPCC GL 2006 of 0.5.

Landfill gas recovery

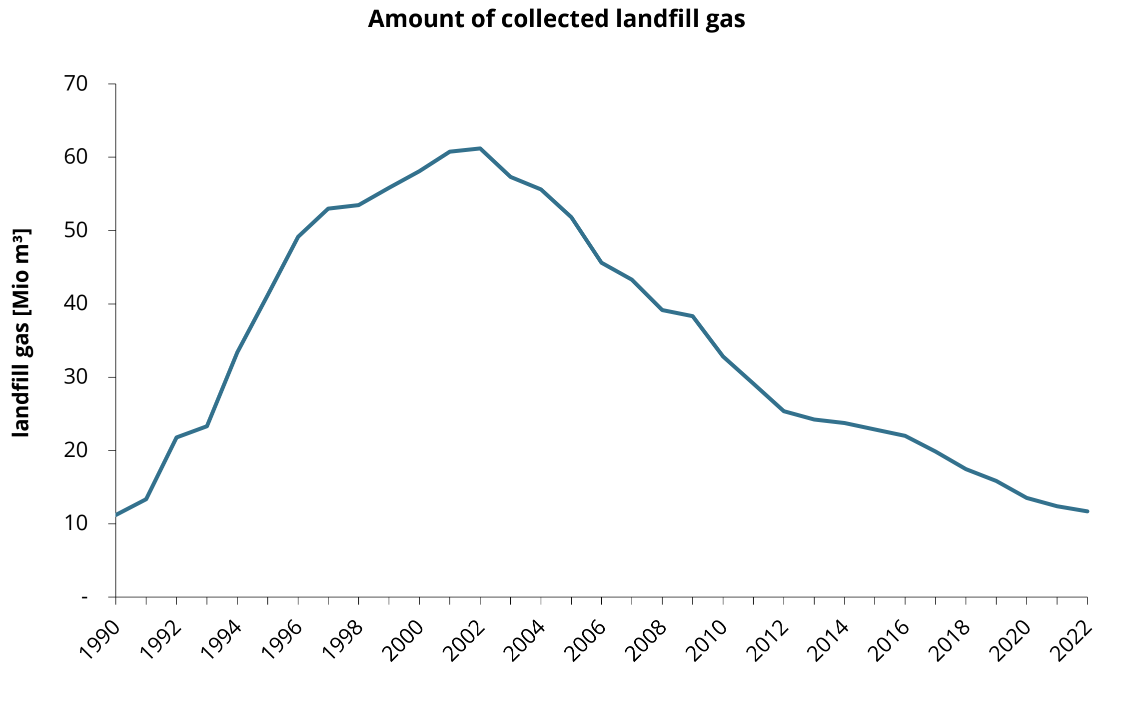
In 2004, the Umweltbundesamt investigated the amount of annually collected landfill gas by questionnaires sent to landfill operators (UMWELTBUNDESAMT, 2004b), showing that in 2001, the amount of collected landfill gas was more than 5 times higher than in 1990. In 1990 only 9 landfills were equipped with landfill gas wells. In 2001, at all operating mass landfills landfill gas was collected.

In 2008, 2013, 2018 and 2023 further surveys were conducted (UMWELTBUNDESAMT, 2008, UMWELTBUNDESAMT, 2014b, UMWELTBUNDESAMT, 2019b, UMWELTBUNDESAMT, 2023c) to get data on collected landfill gas as well as information on its use from landfill operators. Landfill gas volumes and their treatment are thus surveyed in a 5-year cycle. The most recent survey covers the period 2018 – 2022 and proves that the previous assumptions (please refer to methodological description in UMWELTBUNDESAMT 2023a) overestimated the quantities of landfill gas actually collected.

From 2002 onwards, the amount of landfill gas recovered decreased (despite a consistent recovery practice) as a consequence of the reduced carbon content of deposited waste and consequently reduced landfill gas production.

[147] the analysis of 2004 is used as since 2004 a ban of landfilling of untreated residual waste came into force (with exemptions until 2008)

Figure 56: Amount of collected landfill gas 1990 to 2022.



Source: Umweltbundesam (2004b, 2008, 2014b, 2019b, 2023c)t

Compared to 2002 (maximum), the collected amount of landfill gas decreased by 81% by 2022.

Emission Factors

NMVOC, CO, NH_3 and heavy metal emissions are calculated according to their content in the emitted landfill gas (after consideration of gas recovery, refer to Table 305).[148]

Table 310: Emission factors for CO, NMVOC, NH_3 and heavy metals.

	CO	NMVOC	NH_3	Cd	Hg	Pb
	Vol.%	**mg/Nm³**	**mg/Nm³**	**mg/Nm³**	**mg/Nm³**	**mg/Nm³**
concentration in landfill gas	2	300	10	0.003	0.00002	0.003

6.3.1.3 Category-specific Recalculations

Revisions are reported for the years 2018–2021 (2021: +0.001 kt NMVOC, +0.00002 kt NH_3, +0.06 kt CO, minor revisions for Pb, Cd and Hg (≤ 0.00001 t)) as updated data on landfill gas recovery from a national study (UMWELTBUNDESAMT 2023c) was made available and incorporated into the inventory. In the previous submissions, results from the preceding study (UMWELTBUNDESAMT 2019b) were used to derive assumptions on recovered amounts for the years 2018–2021.

[148] according to Umweltbundesamt (2001b)

6.3.2 PM emissions

6.3.2.1 Source Category Description

PM emissions reported here are from waste handling at landfill sites. Only specific waste types are considered such as residues from iron and steel production (slags, dusts), clinker, dust and ashes from thermal waste treatment and combustion plants, as well as some mineral and construction waste.

6.3.2.2 Methodological Issues

PM emissions are calculated by multiplying the waste amounts with the respective emission factors for TSP, PM_{10} and $PM_{2.5}$.

Activity Data and Emission Factors

Activity data has been taken from a database for landfill disposal and – since 2008 – the EDM[149]. For the calculation only specific waste types are considered such as residues from iron and steel production (slags, dust), from thermal waste treatment and combustion plants (clinker, dust and ashes), as well as some mineral and construction waste.

Activities and emissions for the years 1990 and 1995 originate from the national study on particulate matter (WINIWARTER et al., 2007).

Table 311: Activity data (waste amounts deposited) considered for the calculation of particulate matter.

Year	residues from iron and steel production (slags, dusts)	clinker, dust and ashes	mineral waste	construction waste
	[t]	[t]	[t]	[t]
1990		7 970 000		
1995		8 850 000		
1998	65 927	303 384	3 974 912	36 338
1999	29 402	274 628	3 002 883	46 008
2000	37 998	300 914	4 632 071	56 725
2005	156 764	685 349	9 643 097	16 555
2010	61 929	562 328	10 156 901	471
2011	69 075	596 097	11 805 373	628
2012	71 987	558 869	14 728 289	229
2013	167 368	765 275	14 775 275	619
2014	213 661	962 200	19 011 447	486
2015	191 802	974 180	23 983 199	27
2016	166 483	703 995	26 051 849	74
2017	161 709	697 007	26 217 884	48
2018	88 882	986 935	26 987 701	31

[149] Electronic Data Management

Year	residues from iron and steel production (slags, dusts)	clinker, dust and ashes	mineral waste	construction waste
	[t]	[t]	[t]	[t]
2019	78 257	754 668	31 951 641	7
2020	81 345	649 055	28 103 082	11
2021	79 874	691 178	27 567 505	2
2022	81 709	851 560	26 470 416	4
1998–2022	**24%**	**181%**	**566%**	**-100%**

Amounts of all relevant waste types have increased over the time series, especially mineral waste due to enhanced soil excavation activities. Remarkable increases can also be observed in the iron and steel production as well as the thermal waste treatment and consequently in their residues landfilled.

The following emission factors are used (WINIWARTER et al., 2007). Information on the condensable component to be included or excluded in the applied PM emission factors can be found in chapter 12.3.

Table 312: Emission factors for PM.

TSP	PM_{10}	$PM_{2.5}$
g/t WASTE	g/t WASTE	g/t WASTE
18.00	8.52	2.68

6.3.2.3 Category-specific Recalculations

Minor recalculations of particulate matter emissions are reported for 2021 (TSP: +0.001 kt; $PM_{2.5}$: +0.0001 kt; PM_{10}: +0.0004 kt) due to updated activity data (revised amounts of deposited mineral waste).

6.4 NFR 5.B Composting

6.4.1 Source Category Description

In category *5.B*, NH_3 emissions from mechanical-biological treatment, composting of waste and anaerobic treatment of agricultural feedstock are addressed. NH_3 emissions arising from this subcategory increased over the time period as a result of the increasing amount of biologically treated waste.

The amounts of waste treated in composting plants and by means of home composting have increased strongly between 1990 and 2022 (+443%). For mechanical treatment plants the amounts of waste treated almost doubled between 1990 and 2007, followed by a decrease of about 34% until 2012. Since then the waste amount treated in MBT stabilised.

For NH_3 emissions resulting from the anaerobic treatment of biowaste and green waste a rough estimate according to the method of the EMEP/EEA Guidebook has been carried out. As a worst case it was assumed that the total amount of waste input into biogas plants consist of biowaste (N content: 0.0068 kgN/kg fresh weight). Using the tier 1 method of the EMEP/EEA guidebook (as no detailed data is available) and the default emission factor (0.0286 kg NH_3-N/kg N in the feedstock), the estimate resulted in 105 t NH_3 in 2017 (corresponding to a share of 0.15% of the Austrian total NH_3-emissions, which is below the threshold of significance). It can be assumed that this is an over-estimation as in reality the waste input into biogas facilities does not consist only of biowaste but also to considerable parts of green waste showing a lower N-content. Furthermore, a part of the digestate is separated into a liquid and a solid phase (no detailed information available on the amounts). The solid phase is partly composted (included in the emission from composting (5.B.1) and partly combusted (included in 1.A), the liquid phase is treated in waste water treatment plants (included in 5.D.1). So the reporting, would also lead to a double-counting of emissions. For this reason only emissions from the digestion of manure and energy crops are reported, using the EMEP/EEA default emission factor.

6.4.2 Methodological Issues

Emissions were estimated using a simple methodology based on EMEP/EEA Guidebook. Two different fractions were considered:

- mixed waste treated in Mechanical-Biological Treatment (MBT) plants, covering waste from households and similar sources covered by the municipal waste collecting system, but also significant amounts of waste from waste water treatment (e.g. sewage sludge) or smaller amounts of waste from industrial sources (e.g. residues from processing of recovered paper) are included.
- biogenic waste composted, comprising green/biogenic waste collected and treated in composting plants (centralised composting) and biogenic waste composted at the place it is generated (home composting).
- Manure and energy crops digested in biogas plants (anaerobic digestion)

NH_3 emissions for MBT, composting and anaerobic digestion were calculated by multiplying an emission factor with the quantity of waste.

$$NH_3\ Emissions = M_i * EF_i$$

Where:

M_i = mass of organic waste treated by biological treatment type i (composting, MBT)

EF_i = emission factor for treatment i (MBT, composting)

Methodological issues concerning anaerobic treatment plants using agricultural feedstock are explained within the appropriate chapter on sector 3 Agriculture (see Chapter 5.3.4).

Activity data

Historical activity data were taken from national publications and regional sources as listed in Table 313.

Since 2008, the 'Electronic Data Management' (EDM) is the primary data basis[150], providing data for the 'Federal Waste Management Plan' 'BAWP' (BMLFUW, 2011, BMNT, 2017, BMK 2023b), which is (in part) updated annually ('Status Reports' 2012, 2013, 2014, 2015, 2018, 2020, 2021, 2023). For years where no reliable data are available inter- or extrapolation is applied.

The EDM is an information network operated by the Umweltbundesamt. It is a central *eGovernment* initiative by the Austrian Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (http://www.edm.gv.at) enabling enterprises, waste collectors and conditioners as well as authorities to handle registration, notification and reporting obligations in the waste and environment sectors online. Waste amounts collected and treated (input-output records) have to be reported on an annual basis via this electronic tool.

Mechanical-biologically treated waste for most recent years are taken directly from the EDM.

The EDM is also the main data source of biogenic waste treated in **composting plants**. Research by waste experts at the Umweltbundesamt indicates higher amounts of waste being composted than covered by the EDM due to some minor exemptions in the EDM reporting requirements and in some cases missing reports. Based on a study conducted in 2015 on municipal green waste (UMWELTBUNDESAMT, 2016b), it is assumed that in 2011 10% of waste volumes reported are additionally composted, whereas this additional share is expected to decrease linearly to 5% in 2014 as it is expected that reporting irregularities will further decrease. The 5% assumption is continued from 2015 and onwards as still reporting irregularities are expected.

Current **home composted amounts** are taken from the latest Federal Waste Management Plan 'BAWP' (BMK, 2023b). Historical amounts (2000 and earlier years) are available in national studies (AMLINGER, 2005). To create a time series, a per capita value was derived from both sources and an average per capita of 95 kg was then applied to the population figures (STATISTIK AUSTRIA, 2023g).

In submission 2023 the amounts of waste composted in private and community gardens have been entirely revised.[151] Reason is a change of the estimation method done in the course of the preparation of the BAWP 2023 (BMK, 2023b) in view of an upcoming reporting obligation regarding home-composted quantities to the European Commission[152]. Based on an estimated total volume of biogenic waste produced (covering food waste as well as grass, leaves, branches from green urban areas) the biogenic waste collected via municipal waste management system (residual waste) and via separate collection was deducted to get a value of biogenic waste potentially be composted in home and community gardens.

Table 313: Activity data for NFR Category 5.B Composting.

Year	Mechanical-Biological Treatment (MBT)	Composting plants	Home composting
		[kt]	
1990	345	48	370
1995	295	551	600

[150] In subcategory *5.A Solid Waste Disposal* waste amounts have been taken from EDM reports already since 2008.

[151] Until submission 2022 home composted amounts for the years 2010 ff were calculated based on a per-capita value of 215 kg/person/a, whereas for Vienna only 15% of the population was considered due to the lower number of gardens in this urban area. This approach was in line with the method applied for the BAWP (BMNT 2018a).

[152] In the future home composting will be included in the AT recycling rate for municipal waste.

Year	Mechanical-Biological Treatment (MBT)	Composting plants	Home composting
		[kt]	
2000	254	695	772
2005	623	903	786
2010	551	1 035	799
2011	519	1 118	802
2012	453	1 239	806
2013	379	1 168	811
2014	413	1 215	817
2015	439	1 194	825
2016	442	1 300	836
2017	414	1 303	841
2018	412	1 294	839
2019	430	1 353	849
2020	462	1 374	853
2021	492	1 437	856
2022	451	1 404	866

Activity data on **agricultural feedstock treated in anaerobic plants** is provided within NFR sector 3 Agriculture (please refer to Table 284).

Emission factors

Due to different emission factors in different national references an average value was used for each of the two fractions of bio-technically treated waste.

Table 314: Emission factors for NFR Category 5.B.1 Composting.

	NH_3 [kg/t FS]	References
Mechanical-biologically treated waste	0.6	(UMWELTBUNDESAMT BERLIN, 1999) (AMLINGER, 2003, AMLINGER et al.2005) (ANGERER & FRÖHLICH, 2002) (DOEDENS et al., 1999)
Composted waste (bio-waste, gardening waste, home composting)	0.4	(AMLINGER 2003, AMLINGER et al. 2005)

The NH_3-emission factor for anaerobic treatment plants (NFR category *5.B.2*) using agricultural feedstock is taken from the EMEP/EEA Guidebook 2023 (0.0275 kg NH_3-N/ kg N according to Table 3-1). Details are provided in the chapter 5.3.4 in sector agriculture.

6.4.3 Category-specific Recalculations

Recalculations of NH_3 reported for 5*.B.2 anaerobic digestion at biogas facilities* (+ 0.01 kt in 2021) are due to update of activity and nutrition data ($N_{excretion}$ of cattle, biogas plants). See also Chapter 5.5.7 on recalculations in the agriculture sector.

6.5 NFR 5.C Incineration and open burning of waste

6.5.1 Source Description

In this category emissions are included from

- incineration of corpses (NFR 5.C.1.b.5),
- hospital waste (NFR 5.C.1.b.3),
- waste oil (NFR 5.C.1.b.i),
- incineration of domestic or municipal solid waste without energy recovery (NFR 5.C.1.a).

Additionally heavy metal and POPs emissions of a single plant without emission control 1990 to 1991 are included here. From 1992 the plant was equipped with ESP. Emissions 1992 to 2000 are included in category 1.A.1.a. Emissions from incineration of carcasses are not estimated. Waste incineration plants are allocated to category 1.A.4.a if heat is recovered for own usage but not used for generation of public electricity or heat or if the plant operator claims that the main economic activity (NACE code 38) of the plant is treatment of waste rather than the production of heat or electricity. This approach is consistent with national energy statistics.

In Austria waste oil is incinerated in especially designed so called "USK-facilities" (**U**mwelt**s**chutz**k**omponenten). The emissions of waste oil combustion for energy use (e.g. in cement industry) are reported under NFR sector 1.A Fuel Combustion.

In general, municipal, industrial and hazardous waste are combusted in district heating plants or in industrial sites and the energy is used. Therefore their emissions are reported in NFR category 1.A Fuel Combustion. There is only one waste incineration plant which has been operated until 1991 with a capacity of 22 000 tons of waste per year without energy recovery and emission controls. This plant has been rebuilt as a district heating plant starting operation in 1996. Therefore the emissions of this plant are reported under NFR category 1.A Fuel Combustion from 1996 onwards.

Small scale waste burning

Emissions from agricultural wood waste are considered in category 5.C.2 in response to the NEC Review 2022 (EC, 2022). It is assumed that other (illegal) small scale residential combustion occurs in heatings or stoves (included in category 1.A.4). Especially when considering POPs emissions from this source the national emission factors consider this issue due to the fact that POP emission factors are derived from field measurements which consider the "memory effect" of illegal waste co-incineration. Residential biomass heatings are widely used in Austria and wood use is based on a bottom up model by using household census data. It is assumed that illegal waste incineration just replaces other solid fuels and therefore other pollutants such as TSP, heavy metals and NO_x from wood waste are also expected to be included in category 1.A.4.

Open burning of waste

Incineration of non-biogenic materials (e.g. waste tyres, rubber, plastics, paints, treaded wood…) outside of facilities is banned by federal legislation (*Bundesgesetz über das Verbrennen von Materialien außerhalb von Anlagen (Bundesluftreinhaltegesetz – BLRG)*).

6.5.2 Methodology

A tier 2 methodology is used. Emission factors are specific to type of waste and combustion technology.

Activity data

For municipal solid waste the capacity (22 000 tons of waste per year) of one operating waste incineration plant without energy recovery was used.

Waste oil activity data 1990 to 1999 were taken from (UMWELTBUNDESAMT, 1995). For 2000 to 2005 the activity data of 1999 was used. (UMWELTBUNDESAMT, 2001b) quotes that in 2001 total waste oil accumulation was about 37 500 t. Nevertheless, waste oil is mainly used for energy recovery in cement kilns or public power plants and it is consequently accounted for in the energy balance as *Industrial Waste*.

Activity data of clinical waste is determined by data interpretation of the waste flow database at the *Umweltbundesamt* considering the waste key number “971” (“Abfälle aus dem medizinischen Bereich”) for the years 1990 and 1994 and extrapolated for the remaining time series.

Since 2005 the Austrian waste incineration regulation gives strong limits for air pollution for all kind of waste incineration without any limit of quantity. Since then all operators which do have an allowance for incineration of a specific type of waste needs to be registered in a federal database. The number of waste incineration plants which are not considered under sector 1.A is:

- Waste oil: 8
- Clinical waste: 1
- Municipal solid waste: None

The average yearly quantity of each waste incineration plant has been estimated as 500 t for hazardous clinical waste (plastics only). For waste oil the maximum USK facility capacity of 60.8 t per year (UMWELTBUNDESAMT, 2001b) has been selected as activity data for each facility operating in 2010 which leads to a rounded value of 500 tons/year. Activity data for the years 2006–2009 has been interpolated.

Activity data for cremation (number of corpses) is derived from the number of deceases as yearly published by Statistik Austria. The number of cremations is derived from an analysis of information as published by a Viennese, market dominating, funeral company about the percentage of cremation of total funerals. The percentage increases from 12%[153] in 1990 (about 10 k of incinerations) to 24% in 2004 and to 35% in 2011. The percentage 2012–2020 has been linearly extrapolated to 48% in 2020 (about 44k cremations), following a general trend in Austria which has been reported by market dominating funeral companies of larger cities. Since submission 2022, a new approach has been introduced which consideres significantly lower PCDD/F and Hg emissions of new crematoria according to reference values of the german standard *DIN-VDI3891 Emission control - Human cremation facilities*. The share of cremations in new facilitities in 2020 is estimated to be 20% of total cremations and is based on the capacity of new crematoria since about 2010. The approach also considers that existing crematoria have implemented emission reduction measures to a certain extend while actual measurements and detailed statistics are not available yet.

[153] Estimate from (Hübner 2001b)

Table 315: Activity data for IPCC Category 5.C Waste Incineration.

Year	Municipal Waste [t]	Industrial waste [t]	Sewage sludge [t]	Clinical Waste [t]	Waste Oil [t]
1990	22 000	70 720	61 651	9 000	2 200
1991	22 000	70 720	61 651	7 525	1 500
1992	NO	NO	NO	6 050	1 800
1993	NO	NO	NO	4 575	2 100
1994	NO	NO	NO	3 100	2 500
1995	NO	NO	NO	3 100	2 600
1996	NO	NO	NO	3 100	2 700
1997	NO	NO	NO	3 100	2 800
1998	NO	NO	NO	3 100	2 900
1999–2005	NO	NO	NO	3 100	3 000
2006	NO	NO	NO	2 500	2 500
2007	NO	NO	NO	2 000	2 000
2008	NO	NO	NO	1 500	1 500
2009	NO	NO	NO	1 000	1 000
2010–2022	NO	NO	NO	500	500

The planted vineyard area of the basic vineyard surveys (Weingartengrunderhebungen) for the years 2009, 2015 and 2020 (STATISTIK AUSTRIA, 2011, 2016, 2021) is used for activity data, as these explicitly comprise the vineyard area planted with vine stems. For time series consistency the area of vineyards between 2009, 2015 and 2020 was interpolated. For 2021 und 2022, the value of 2020 has been taken as no more recent data is currently available. According to the EU legislation, these surveys have to be carried out every 5 years. So, in 2025 the next survey will be conducted. Land use areas are harmonized with sector Land Use, Land Use Change and Forestry (LULUCF) of Austria's GHG inventory to be consistent within the Austrian Inventory and across all sectors. Further details are given in "Austria's National Inventory Report 2024, chapter *6.3.2 Cropland (Category 4.B)* (UMWELTBUNDESAMT, 2024).

According to an expert judgement from the Federal Association of Viniculture (Bundesweinbauverband Österreich) in 2001 the amount of residual wood per hectare viniculture was 1.5 to 2.5 t residual wood and the part of it that is burnt was estimated to be 1 to 3%. For the calculations the upper limits (3% of 2.5 t/ha) were used, resulting in a factor of 0.075 t burnt residual wood per hectare viniculture area. Based on recent information from the Federal Association of Viniculture, the area of vineyards with open burning activities has decreased over time and is assessed to be no more than 1% of the total vineyard areas for the years from 2010 onwards. The burning of vine is either prohibited or only permitted to a very limited extent in the relevant federal provinces. The areas of vineyards with open burning activities between 2001 and 2010 were determined by linear interpolation between the two, respective expert judgement estimates. The value of 2010 (1%) is used for the subsequent years.

Table 316: Activity data for the open burning of wood residues from vineyards 1990–2022.

Year	Viniculture Area [ha]	Burnt Residual Wood [t]
1990	58 364	4 377
1995	55 627	4 172
2000	50 304	3 773
2005	46 892	2 475
2010	45 517	1 138
2011	45 502	1 138
2012	45 486	1 137
2013	45 470	1 137
2014	45 454	1 136
2015	45 439	1 136
2016	45 584	1 140
2017	45 729	1 143
2018	45 874	1 147
2019	46 020	1 150
2020	46 165	1 154
2021	46 165	1 154
2022	46 165	1 154

The amount of agricultural waste burned is multiplied with a default or a country specific emission factor.

Emission factors

Heavy metal emission factors are taken from (HÜBNER, 2001a). POPs emission factors are taken from (HÜBNER, 2001b). Main pollutant emission factors: For municipal waste the industrial waste emissions factors from (BMWA, 1990) are taken and converted by means of a NCV of 8.7 TJ/kt. Waste oil emission factors are selected similar to uncontrolled industrial residual fuel oil boilers. Clinical waste emission factors selected by means of industrial waste emissions factors from (BMWA, 1990). Table 317 shows emission factors of main pollutants.

Table 317: NFR 5.C Waste Incineration: emission factors for main pollutants by type of waste.

Type of waste		NO_x	CO	NMVOC	SO_2	NH_3
Waste oil	[g/t]	8 060.0	604.5	403.0	18 135.0	110.0
Municipal waste	[g/t]	870.0	1 740.0	330.6	1 131.0	0.2
Clinical waste	[g/t]	7 000.0	840.0	330.0	700.0	0.2
Cremation	[g/corps]	300.0	430.0	32.0	-	-

Table 318: NFR 5.C Waste Incineration: emission factors for PM by type of waste.

Type of waste		TSP	PM_{10}	$PM_{2.5}$
Waste oil	[g/t]	10.00	7.00	4.00
Municipal waste	[g/t]	IE(1)	IE(1)	IE(1)
Industrial waste	[g/t]	28.00	25.00	21.00
Clinical waste	[g/t]	10.00	7.00	4.00
Cremation	[g/corps]	14.60	13.14	11.68

(1) PM emissions for MSW are included in NFR category 1.A.1.a.

Table 319: NFR 5.C. Waste incineration: emission factors for heavy metals and POPs.

Municipal waste	**Cd**	**Hg**	**Pb**	**PAH**	**DIOX**	**HCB**
	[mg/t]				**[µg/t]**	
1990	71.0	299.0	1 170.0	0.7	250.0	850.0
1991	59.2	263.2	966.0	0.7	250.0	850.0

Industrial Waste	**Cd**	**Hg**	**Pb**	**PAH**	**DIOX**	**HCB**
	[mg/t]				**[µg/t]**	
1990	510.0	112.0	2 400.0	1.6	160.0	970.0
1991	414.0	99.4	1 922.0	1.6	160.0	970.0

Sludges from waste water treatment	**Cd**	**Hg**	**Pb**	**PAH**	**DIOX**	**HCB**
	[mg/t]				**[µg/t]**	
1990	235.0	55.0	730.0	1.6	1.5	300.0
1991	191.8	45.8	585.2	1.6	1.5	300.0

Clinical waste	**Cd**	**Hg**	**Pb**	**PAH**	**DIOX**	**HCB**
	[mg/t]				**[µg/t]**	
1990	4.77	5.76	540.00	0.00	1.08	216.00
1991	3.99	4.82	451.50	0.00	0.68	135.45
1992	3.21	3.87	363.00	0.00	0.36	72.60
1993	2.42	2.93	274.50	0.00	0.14	27.45
1994	1.64	1.98	186.00	0.00	0.00	0.19
1995–2005	0.62	0.71	7.75	0.00	0.00	0.19
2006	0.50	0.58	6.25	0.00	0.00	0.16
2007	0.40	0.46	5.00	0.00	0.00	0.12
2008	0.30	0.35	3.75	0.00	0.00	0.09
2009	0.20	0.23	2.50	0.00	0.00	0.06
2010–2022	0.10	0.12	1.25	0.00	0.00	0.03

<table>
<tr><th>Waste oil</th><th>Cd</th><th>Hg</th><th>Pb</th><th>PAH</th><th>DIOX</th><th>HCB</th></tr>
<tr><td></td><td colspan="4">[mg/t]</td><td colspan="2">[µg/t]</td></tr>
<tr><td>1990</td><td rowspan="5">360.0</td><td rowspan="6">30.0</td><td>106 300.0</td><td rowspan="6">6.7</td><td>17.0</td><td>17 020.0</td></tr>
<tr><td>1991</td><td>87 560.0</td><td rowspan="5">0.4</td><td rowspan="5">370.0</td></tr>
<tr><td>1992</td><td>68 820.0</td></tr>
<tr><td>1993</td><td>50 080.0</td></tr>
<tr><td>1994</td><td>31 340.0</td></tr>
<tr><td>1995–2022</td><td>13.0</td><td>60.0</td></tr>
</table>

Table 320: NFR 5.C.1.b.v cremation of corpses: emission factors.

SO_2	Cd	Hg	Pb	PAH	Dioxin	HCB	PCB
			[mg/corps]		[µg/corps]		
113[(8)]	5.03[(8)]	3 000[(4)]	0.02[(1)]	0.40[(1)]	16.60[(2)]	3 320[(2)]	410[(8)]
		2 500[(5)]			8.30[(3)]	1 660[(3)]	
		2 000[(6)]			0.02[(9)]		
		1 000[(7)]					
		10[(9)]					

[0(1)] *for all years*

[(2)] *for 1990–1992*

[(3)] *for 1993–2020 existing facilities*

[(4)] *for 1990*

[(5)] *for 1991*

[(6)] *for 1992–1995*

[(7)] *for 2000–2019*

[(8)] *EMEP/EEA Guidebook 2019*

[(9)] *for new facilities 2015–2022*

PAH emissions factors have been split into benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and ideno[1,2,3-c,d]pyrene by means of the calculated share of the default emission factor values as provided in the EMEP/EEA 2019 GB tables:

- 5C1a - Table 3-1 (5.C.1.a, 5.C.1.b.i, 5.C.1.b.iii)
- 5C1bv - Table 3-1 (5.C.1.b.v)

Emission factors for agricultural wood waste burning

NO_x, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, Cd, Pb, PAHs

As recommended in the NEC Review 2020 (EC, 2020), PAH emissions are reported for individual PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene) in submission 2021 for the first time. Calculations follow the EMEP/EEA Tier 2 technology-specific approach provided in the EMEP/EEA Guidebook 2023, chapter 5.C.2 Open burning of waste (EEA, 2023). The Tier 2 emission factors for orchard crops were used (EEA, 2023a, Table 3-3).

NH_3

The EMEP/EEA 2023 Guidebook does not provide a default emission factor for NH_3. In consistency to previous submissions, the EF of 1.9 kg per ton burnt wood was taken (EEA, 2007).

Hg

The EMEP/EEA 2023 Guidebook does not provide a default emission factor for Hg. For emission calculation a country specific methodology was used.

National emission factors were taken from (HÜBNER, 2001a), the dry matter content of residual wood was assumed to be 80%:

- Hg ....0.038 mg/kg dm_{wood}, 0% remaining in ash

HCB, dioxin/furan

A country specific method was applied. The national emission factors per ton burnt wood were taken from (Hübner, 2001b):

- PCDD/F....12 000 µg/Mg Waste
- HCB .... 2 400 µg/Mg Waste

6.5.3 Category-specific Recalculations

In previous inventories a constant share of 3% for Austria's areas of vineyards was used as activity data (Bundesweinbauverband Österreich 2001). According to updated information, this share was decreased to 1% for the years from 2010 onwards. This improvement resulted in revised emissions for the years 2002–2021.

6.6 NFR 5.D Wastewater handling

6.6.1 Source Category Description

This category includes NMVOC emissions from domestic and industrial wastewater handling. *Domestic wastewater handling (5.D.1*) covers wastewater treated in municipal wastewater treatment plants, including also commercial and industrial wastewater treated together with domestic wastewater. *Industrial wastewater handling (5.D.2)* however is related to wastewater treated on-site, i.e. at the premises of the industrial facilities.

NH_3 emissions are not reported as in Austria there are no latrines or dry toilets in use. Due to the improved technical possibilities for connecting rural areas, as well as the increasing urbanization most of the population is connected to a municipal wastewater treatment system. The small remaining part of population either uses septic tanks or smaller, decentralized domestic sewage treatment plants.

6.6.2 Methodological Issues

Emissions were calculated following the Tier 1 approach by multiplying the wastewater amounts with the emission factor taken from the EMEP/EEA 2019 Guidebook (15 mg/m^3 wastewater).

$$NMVOC\ Emissions = AD * EF$$

Where:

AD ....activity data / volume of total wastewater treated in municipal wastewater treatment plants (m^3)
EF ....emission factor

Activity data

Waste water volumes treated are collected in the Electronic Emission Register of Surface Water Bodies (‘Emissionsregister – Oberflächenwasserkörper’, abbreviated ‘EMREG-OW’[154]), an electronic register of material emissions to surface water bodies from point sources, especially municipal sewage treatment plants. It is administered by the Federal Ministry of Agriculture, Forestry, Regions and Water Management and serves the collection of information for the National Water Management Plan and for management plans for international river catchment areas.

Wastewater volumes treated in municipal wastewater treatment plants 2010 to 2022 were retrieved from this emission register (UMWELTBUNDESAMT, 2023d). Wastewater treated in individual septic systems are excluded as recommended by the ERT in 2017. Data for 2006–2008 were taken from the Austrian sewage sludge database administered by the Umweltbundesamt. Historical data (1991, 1995, 1998, 2001, 2003) were obtained from the Water Quality Reports (BMLFUW, 2002a and previous reports); data in between were interpolated.

Wastewater volumes treated at industrial facilities 2010–2022 were taken from the EMREG (UMWELTBUNDESAMT, 2023d). For the earlier years (1996–2009) the annual GDP growth was taken to establish a time series.

Table 321: Activity data considered for 5.D Wastewater handling (5.D.1, 5.D.2).

Year	Wastewater treated in municipal WWTP [m³]	Industrial wastewater treated on-site [m³]	Year	Wastewater treated in municipal WWTP [m³]	Industrial wastewater treated on-site [m³]
1990	639 572 918	340 175 440	2015	1 039 118 740	384 766 097
1995	736 657 915	340 175 440	2016	1 114 562 002	387 461 844
2000	995 830 000	381 722 856	2017	1 071 235 694	452 729 631
2005	1 037 850 090	421 367 185	2018	1 048 316 784	255 504 674
2010	1 111 589 652	445 709 567	2019	1 090 633 868	266 155 554
2011	996 666 022	585 018 935	2020	1 076 625 987	434 239 434
2012	1 058 654 346	367 919 400	2021	1 056 566 667	431 819 019
2013	1 165 341 536	250 301 589	2022	995 576 658	415 562 008
2014	1 109 792 568	256 757 830			

In 2022, 96.2% of the Austrian population was connected to municipal wastewater treatment plants (BML, 2023b). The remaining wastewater was either collected in septic tanks (2.3%), treated in domestic wastewater handling systems (1.3%), or disposed otherwise (‘unspecified disposal routes’: 0.2%).

6.6.3 Category-specific Recalculations

No recalculations were carried out in this years’ submission.

[154] BGBl. II Nr. 29/2009: Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über ein elektronisches Register zur Erfassung aller wesentlichen Belastungen von Oberflächenwasserkörpern durch Emissionen von Stoffen aus Punktquellen (EmRegV-OW)

6.7 NFR 5.E Other Waste

6.7.1 Source Category Description

In this category TSP, PM_{10}, $PM_{2.5}$, Pb, Cd, Hg and PCDD/F emissions from accidential fires of cars and various types of buildings (industrial buildings, detached houses and apartments) are included. Following the EMEP/EEA Guidelines a Tier 2 methodology was applied, using country specific activity data and the given default values.

6.7.2 Methodological Issues

Emissions were calculated following the Tier 2 approach by multiplying the number of fires per category with the emission factor taken from the EMEP/EEA 2019 Guidebook.

*Emissions = AD * EF*

Where:

AD ... activity data (number of fires)
EF ... emission factor

Activity data

Activity data for **car fires** are from a national fire statistic and include car and truck fires for the years 1996 to 2009, as well as for 2015 to 2017 (ÖBFV, 2017). To get data for the upcoming years 2018, 2019, 2020, 2021and 2022, the Austrian Fire Brigade Association (Österreichischer Bundes-Feuerwehr-Verband – 'ÖBFV') was contacted (ÖBFV, 2019–2023). For missing years (prior to 1996 and 2010–2014), a mean value of car fires by 1 000 inhabitants from the available years was applied to the total number of inhabitants.

The determination of the **building fires** required an estimate of the number of buildings in the various types of houses.

There are national statistics for Industry, Business (called 'Gewerbe' in Austria) and Civil fires available from 2005 onwards. As number of industrial building fires of the years 1990 to 2004, a mean value derived from available data for the years 2005–2015 was taken as proxy. The number of civil fires during 1990–2005 was extrapolated based on the mean value of fires in the years 2005–2010 per inhabitant.

As only a share of the total civil fires can be attributed to detached houses and apartments, a split is necessary. The split into the different building types for the residential sector is based on a detailed fire indemnity statistics of a representative Austrian province, available for the years 2010 and 2015. Of the categories covered in the EMEP/EEA Guidebook 2019, data is available for detached houses, apartments and industrial buildings; undetached houses are included in the detached houses category. This is the same approach as used by Slovakia. The building stock in Slovakia is similar to Austria – traditionally in Austria exist only very few undetached houses.

For 2005–2022, national fire statistics are available on fires in civil and industrial buildings (BV, 2023). For 1990 to 2004 the number of fires was determined based on the mean value of fire accidents per inhabitant 2005–2010 and the population numbers 1990–2004.

Table 322: Activity data for 5.E Other Waste - accidental fires.

Year	Car fires	Industrial building fires	Detached house fires	Apartment fires
1990	1 586	1 373	935	687
1995	1 642	1 373	968	711
2000	1 682	1 373	976	717
2005	1 759	1 161	839	617
2010	1 727	1 358	1 261	927
2011	1 733	1 411	1 201	883
2012	1 741	1 524	1 212	891
2013	1 751	1 266	1 045	768
2014	1 765	1 488	1 224	900
2015	1 584	1 574	1 210	890
2016	2 266	1 334	1 135	834
2017	1 540	1 462	1 141	839
2018	1 552	1 186	943	693
2019	2 077	1 381	1 089	800
2020	1 696	1 231	1 196	879
2021	1 793	1 448	1 277	939
2022	1 991	1 530	1 359	999

Emission Factors

The following emission factors have been used, which are the Tier 2 default values as presented in the EMEP/EEA Guidebook 2019.

Information on the condensable component to be included or excluded in the applied PM emission factors can be found in chapter 12.3.

Table 323: Emission factors for unwanted fires.

Year	EF for car fires	EF for detached houses	EF for industrial buildings	EF for apartments
TSP	2.3 kg/fire	143.82 kg/fire	27.23 kg/fire	43.78 kg/fire
PM_{10}	2.3 kg/fire	143.82 kg/fire	27.23 kg/fire	43.78 kg/fire
$PM_{2.5}$	2.3 kg /fire	143.82 kg/fire	27.23 kg/fire	43.78 kg/fire
PCDD/F	0.048 mg/fire	1.44 mg/fire	0.27 mg/fire	0.44 mg/fire
Pb	NE	0.42 g/fire	0.08 g/fire	0.13 g/fire
Cd	NE	0.85 g/fire	0.16 g/fire	0.26 g/fire
Hg	NE	0.85 g/fire	0.16 g/fire	0.26 g/fire

6.7.3 Category-specific Recalculations

In this category *5.E* recalculations for 2021 were reported for particulate matter emissions (TSP, PM_{10}, $PM_{2.5}$: +0.2 kt) as well as for Cd, Hg, Pb and dioxine (< 0.00001 t) as updated statistical information on accidental building fires became available (BV, 2022).

7 RECALCULATIONS AND IMPROVEMENTS

7.1 Relation to data reported earlier

As a result of the continuous improvement of Austria’s National Air Emission Inventory, emissions of some sources have been recalculated based on updated data or revised methodologies, thus emission data for 1990 to 2021 submitted this year might differ from data reported previously.

CLRTAP Review

The Stage 1 review (initial check of submissions for timeliness, completeness and formats) and Stage 2 review (check of consistency, comparability, KCA, trends and IEFs) are carried out annually. Stage 3 or so-called In-depth reviews take place for selected inventories as in the work plan approved by the EMEP Steering Body[155]. The last In-depth (Stage 3) review of the Austrian Inventory took place in 2017 (United Nations, 2017); the findings are summarised in Table 339. In 2022, an In-depth review of all Parties (so called ad-hoc Review) took place with a special focus on the condensable component of PM for sectors Residential heating and Transport. The recommendations for Austria are presented in Table 340. In 2023, the ad-hoc Review focused on Agriculture (emission inventories and gridded data). The recommendations for Austria are presented in Table 341.

NEC Review

From 2017 onwards the national emission inventory data will be also checked by the European Commission as set out in Article 10 of Directive 2016/2284 (NEC Directive). The inventories are checked annually in order to verify the transparency, accuracy, consistency, comparability and completeness of information submitted and to identify possible inconsistencies with the requirements set out under international law, in particular under the LRTAP Convention. Synergies are maximised with the 'Stage 3' reviews conducted by the LRTAP Convention. The findings under the NEC Review 2023 for Austria are summarised and commented in Table 342.

The figures presented in this report replace data reported earlier by the Umweltbundesamt under the reporting framework of the UNECE/LRTAP Convention and NEC Directive of the European Union.

NACP Review

In 2023 the National Air Pollutant Projections were checked by the European Commission during the National Air Pollutant Projections Review (NACP Review). The findings are summarised in Table 343.

[155] http://www.ceip.at/ms/ceip_home1/ceip_home/review_process/stage3_review_ae/

7.2 Explanations and Justifications for Recalculations, including in response to the review process

Explanations for recalculations per sector are given in the respective chapters, the tables indicating the recalculations can be found in the Chapter 7.7.

Compiling an emission inventory includes data collecting, data transfer and data processing. Data has to be collected from different sources, for instance

- national statistics,
- associations,
- plant operators,
- studies,
- personal information,
- other publications.

The provided data must be transferred from different data formats and units into a unique electronic format to be processed further. The calculation of emissions by applying methodologies on the collected data and the final computing of time series into a predefined format (NFR) are further steps in the preparation of the final submission. Finally the submission must be delivered in due time. Even though a QA/QC system gives assistance so that potential error sources are avoided as far as possible it is necessary to make some revisions – so called recalculations – under the following circumstances:

- An emission source was not considered in the previous inventory.
- A source/data supplier has delivered new data because previous data were preliminary data only (by estimation, extrapolation) or the methodology has been improved.
- Occurrence of errors in data transfer or processing: wrong data, unit-conversion, software errors etc.
- Methodological changes: a new methodology must be applied to fulfil the reporting requirements because one of the following reasons:
- to decrease uncertainties;
  - an emission source becomes a key source;
  - consistent input data needed for applying the methodology is no longer accessible;
  - input data for more detailed methodology is now available;
  - the methodology is no longer appropriate.

The following sections describe the methodological changes made to the inventory since the previous submission (for each sector).

7.3 Energy (1)

7.3.1 Stationary combustion 1.A.1.a-c, 1.A.2.a-g, 1.A.3.e.i and 1.A.4.a-1.A.4.c

7.3.1.1 Update of activity data

Revision of the energy balance

The federal statistics office "Statistik Austria" revised the energy balance (mainly for year 2021) with the following **main implications** for energy consumption as used in the inventory:

- Natural gas 2021: Gross inland consumption has not been revised. Transformation input has been revised by +0.6 PJ (*1.A.1.a*). Own use by the energy sector has been revised by +0.4 PJ (*1.A.1.c*). -1.8 PJ of final energy consumption has been subtracted from *1.A.4* and +0.8 PJ has been shifted to *1.A.2*.
- Gasoil 2021: Gross inland consumption has been revised by -2.2 PJ, leading to revisions of -1.1 PJ final energy consumption for *1.A.2* and -1.1 PJ for *1.A.4*.
- LPG 2021: Minor shifts (0.1 PJ) from *1.A.4* and Transport to 'non energy use'.
- Residual fuel oil: 0.7 PJ (59 kt CO_2) has been shifted from *1.A.4* to *1.A.2*.
- Coal 2021: Final energy consumption has been revised by -0.1 PJ (mainly *1.A.4*).
- Solid biomass 2021: Final energy consumption has been revised by +6.9 PJ, which has been mostly allocated to the residential sector (*1.A.4.b*).

Non-road mobile Machinery in Industry (1.A.2.g.7)

Energy consumption for non-road mobile machinery in the industrial sector has been revised for 2021 due to an update of the industrial production index.

7.3.1.2 Methodological Changes

Energy Industries (1.A.1) and Manufacturing Industries (1.A.2)

For the categories *1.A.1* and *1.A.2*, the revisions follow those of the energy balance. The methods applied (emission factors and data sources) remain unchanged.

Minor revisions of PM emissions from *1.A.1.a* are due to an error correction of plant specific data allocation. Minor revisions of PM emissions from *1.A.2.f* were reported because an erroneous change in the previous year's submission were reversed.

Other Sectors (1.A.4)

For 1990 to 2021, minor changes in air pollutant emissions of categories Commercial/Institutional *(1.A.4.a)* and Residential *(1.A.4.b)* occur because of updated heating stock data and newly allocated shares of combustion technologies per energy carrier (updated energy demand model for space heating).

7.3.2 Fugitive emissions (1.B)

7.3.2.1 Distribution of oil products (1.B.2.a.5)

Activity data (gasoline) in 1.B.2.a.5 Distribution of oil products (transport and depots except service stations) had to be corrected by one data supplier for the year 2021, resulting in slightly revised NMVOC emissions for 2021 (-0.3 t).

7.3.2.2 Storage of solid fuels (1.B.1.a)

PM emissions for 2021 were revised by +0.9% (+3.1 t TSP, +1.5 t PM_{10}, + 0.5 t $PM_{2.5}$) due to revised coal consumption activity data.

7.3.3 TRANSPORT (1.A.3)

7.3.3.1 Update of activity data

Road Transport (1.A.3.b)

Update/improvement of activity data

- Revision of real fuel consumption for PC and LDV PHEV

  The energy consumption in hybrid vehicles is subject to high uncertainties. The fact is that in reality there are use cases with a high proportion of kilometers driven electrically, but on the other hand also cases that are almost exclusively powered with the combustion engine (ITNA, 2023, p.9). For this reason, a more pessimistic charging behavior for PHEV vehicles has been assumed, which increased the real fuel consumption of PHEV cars (petrol) and LDV (petrol), especially in 2021.
- Update of specific vehicle mileage per year

  Improvement of data evaluation in the central vehicle assessment database (ZBD - annual "sticker check" in accordance with §57a KFG): An update of the relevant input data made it possible to evaluate half-years for 2021 and 2022 and thus define the specific annual mileage of vehicles more precisely. This has led to an increase for LDV and 2-wheelers for 2021 compared to last year's inventory.

  In general, data from ZBD is used to evaluate the specific yearly mileage for vehicle categories PC, LDV, buses and 2-wheelers.

All these changes resulted in recalculations in *1.A.3.b. Road Transport* for 2021 of +0.3 kt NO_x, +0.00004 kt SO_2, +0.002 kt NH_3, -0.02 kt NMVOC and +0.5 kt $PM_{2.5}$.

Military (1.A.5)

Confidential data (fuel consumption) became available from a survey for military off-road vehicles for the year 2021. The evaluation for 2021 and a separate expert assessment helped to refine the trend from 1990 to 2022. Consequently, the entire time series has been recalculated.

Military air traffic continues to be subject to great uncertainty due to a lack of actual data. In the previous inventory, the year 2021 was an extrapolated value, which has been revised in the current inventory based on an update of the inventory of Austrian military helicopters and aircraft available for 2022.

All these changes resulted in recalculations in *1.A.5. Other* for 2021 of + 0.0018 kt NO_x, - 0.0006 kt SO_2, + 0.0000003 kt NH_3, - 0.0002 kt NMVOC and + 0.0004 kt $PM_{2.5}$.

Memo Item International Bunkers - Navigation

Due to a linking error in the GEORG "Danube Shipping" module, the value for 2021 was incorrect and has been corrected.

7.4 Industrial Processes (2)

7.4.1 Update of activity data

7.4.1.1 Cement production (2.A.1)

Emissions data for the years from 2011 onwards were updated using available data based on measurements (-0.02 kt $PM_{2.5}$, -0.02 kt PM_{10}, -0.02 kt TSP in 2021).

7.4.1.2 Construction and demolition (2.A.5.b)

Activity data taken from national statistics for the years from 2010 onwards were updated, which also impacted the extrapolation back to 1990. This resulted in minor recalculations of the whole time series (+ 0.003 kt $PM_{2.5}$, +0.03 kt PM_{10}, +0.09 kt TSP in 2021).

7.4.1.3 Iron and steel production (2.C.1)

Activity data for 2007, 2010 and 2014 were updated for pig iron production and PM emissions for 2016 and 2020 were updated resulting in minor recalculations of heavy metals, PM and POPs (previously rounded values were used; recalculation effect e.g. -0.00008 t Pb in 2014, and 0.0003 kt TSP in 2020).

7.4.1.4 Copper production (2.C.7.a)

Activity data for 2020 and 2021 were updated (e.g. + 0.00001 kt $PM_{2.5}$ and + 0.01 kt SO_2 in 2021).

7.4.2 Methodological changes

7.4.2.1 Ammonia production (2.B.1)

NMVOC emissions from ammonia production were previously reported together with emissions from another production site under *2.B.10.a other*. They are now allocated according to the EMEP/EEA GB 2023 (no effect on overall emissions level).

SO_2 emissions from ammonia production were reported by the plant operator, and have been included in the inventory (+ 0.00003 kt SO_2).

7.4.2.2 Chemical industry other (2.B.10.a) - Ammonia production (2.B.1) – Nitric acid production (2.B.2)

A time series inconsistency was eliminated: for the years 1990-1993 NO_x emissions previously were taken from a study that upscaled emissions from some installations to total chemical production using business volumes. Now emissions from these years are estimated in accordance with the methodology for subsequent years considering relevant production processes (- 2.74 kt NO_x in 1990).

PM emissions from fertilizer and urea production were reassessed incorporating recent measurement data and also correcting some inconsistencies of the time series (+0.04 kt $PM_{2.5}$, +0.04 kt PM_{10}, +0.02 kt TSP in 2021).

7.4.2.3 Iron and steel production (2.C.1)

Emissions of POPs were reassessed:

- For all POPs a double counting of emissions was eliminated (emissions from steel production were accounted for twice)
- For dioxins the time series was corrected as emissions from one site had not been included for some years. This also affected PCB and HCB emissions as emissions of these species are correlated with dioxins.
- PAH emissions were corrected as previously PAH7 was reported instead of PAH4. In addition, the split into the different components was recalculated based on actual measurement data for two compounds and assumptions for the other two.

Effect on recalculations in 2021: -1.38 g for Dioxine, -0.07 t PAHs, -3.8 kg HCB. For PCB, emissions in the years before 2021 were revised (except for 2018 and 2019).

7.4.2.4 Solvent and other product use (2.D.3 except 2.D.3.b and 2.D.3.c)

Data on installation basis that is prepared by the operators according to the VOC directive were collected and incorporated. During intensive QC, which included comparison with the data of 2015 and 2019, some corrections of the data for 2015 and 2019 were made, leading to a recalculation for most sub-categories from 2015 onwards.

Also, corrections on the top down data were made: besides correction of minor transcription errors for the years from 2016 onwards, non-solvent use of a new company became available which was considered for 2021 leading to a decrease of total solvent use in Austria. As bottom up data is extrapolated to this value, this resulted in lower activity data and thus lower emissions for 2021.

Overall, the recalculation difference for 2021 of this subcategory is – 1.34 kt NMVOC.

7.4.2.5 Wood Processing (2.I)

During extensive QA/QC a transcription error was corrected, resulting in minor recalculations of the whole time series (e.g. – 0.0004 kt $PM_{2.5}$ in 2021).

7.5 Agriculture (3)

7.5.1 Update of activity data

7.5.1.1 Manure Management (3.B), Agricultural Soils (3.D)

Livestock data – cattle < 1 year

The livestock category cattle < 1 year comprises slaughtering calves < 1 year, other male calves and cattle < 1 year, and other female calves and cattle <1 year according to the official statistics (Statistics Austria). The breakdown by type of use is determined by Statistics Austria using model calculations. Methodological improvements resulted in shifts between the cattle < 1 year sub-categories in the years 2003–2021 and thus lead to revised average values for gross energy intake, $N_{excretion}$ and $VS_{excretion}$ for cattle < 1 year.

Background data for feeding and nutrition of dairy and suckling cows

New figures for the protein and fat content of milk for the year 2021 became available (AMA, 2023b). This update resulted in minor revisions of the values for gross energy intake, $N_{excretion}$ and $VS_{excretion}$ of dairy and suckling cows.

Biogas plants

New data on input materials for Austria's biogas plants became available from the compost and biogas association (Kompost- und Biogasverband) resulting in slightly revised NO_x and NH_3 emissions with an impact on the source categories *3.B Manure Management, 3.D.a.2.a Animal manure applied to soils* and *3.D.a.2.c Other organic fertilizers applied to* soils for 2020 and 2021.

7.5.2 Methodological changes

7.5.2.1 Manure Management (3.B) – NH_3, NO_x, and NMVOC

One reason for the revised estimates is the improved activity and nutrition data as already explained above. Additionally, a linkage error in the NMVOC agriculture sector model for other cattle was corrected.

Overall, NH_3 and NO_x emissions from manure management have increased, whereas NMVOC emissions have decreased compared to the previous submission (+0.2 kt NH_3, +0.002 kt NO_x and -2.2 kt NMVOC for 2021).

7.5.2.2 Agricultural Soils (3.D) – NH_3, NO_x and NMVOC

Inorganic N-fertilizers (3.D.a.1)

For the first time the new Tier 2 NH_3 EF for mineral fertilizers according to the EMEP/EEA Guidebook 2023 has been used. This update resulted in revised ammonia emissions for the entire time series (+3.1 kt NH_3 for 2021).

Animal Manure Applied to Soils (3.D.a.2.a)

Updated activity and nutrition data, as described before, resulted in revised NH_3, NO_x and NMVOC emissions between 2003 and 2021. In addition, the latest subsidy data on manure amounts applied with low-emission spreading techniques for cattle and swine from the ÖPUL database[156] of the Federal Ministry of Agriculture, Forestry, Regions and Water Management (BML) were implemented, resulting in revised estimates for ammonia from 2018 to 2021. Additionally, for NMVOC and other cattle a linkage error in the agriculture sector model was corrected (-0.1 kt NH_3, +0.02 kt NO_x and -0.6 kt NMVOC for 2021).

Other organic fertilizers (3.D.a.2.c)

As a result of the updated input materials for biogas plants, NH_3 and NO_x emissions have been revised for the years 2020 and 2021 (-0.01 kt NH_3 and -0.01 kt NO_x).

Urine and dung deposited by Grazing Animals (3.D.a.3)

Reasons for recalculations are the livestock related updates as already described above, updated NH_3-EF for sheep and deer according to the new EMEP/EEA GB 2023 and the correction of a linkage error in the sector model for NMVOC. These improvements resulted in revised NH_3 and NMVOC emissions of the entire time series. In the case of NO_x, recalculations are reported for the years between 2003 and 2021 (+0.1 kt NH_3, +0.003 kt NO_x and -0.01 kt NMVOC for 2021).

7.6 Waste (5)

7.6.1 Update of activity data

7.6.1.1 Solid waste disposal on land (5.A.1)

Revisions are reported for the years 2018–2021 (2021: +0.001 kt NMVOC, +0.00002 kt NH_3, +0.06 kt CO, minor revisions for Pb, Cd and Hg (≤ 0.00001 t)) as updated data on landfill gas recovery became available from a national study (UMWELTBUNDESAMT 2023c). In the previous submissions, results from the preceding study (UMWELTBUNDESAMT 2019b) were still used to derive assumptions on recovered amounts for the years 2018–2021.

[156] The Agri-environmental Programme ÖPUL intends to foster the environmentally sound management of the agricultural areas in Austria. One of the objectives is the reduction of greenhouse gas and ammonia emissions from agriculture.

Furthermore, minor recalculations of particulate matter emissions are reported for 2021 (TSP: +0.001 kt; $PM_{2.5}$: +0.0001 kt; PM_{10}: +0.0004 kt) due to updated activity data (revised amounts of deposited mineral waste).

7.6.1.2 Anaerobic digestion at biogas facilities (5.B.2)

Recalculations of NH_3 reported for 5*.B.2 anaerobic digestion at biogas facilities* (+0.01 kt in 2021) are due to updates of activity and nutrition data ($N_{excretion}$ of cattle, biogas plants). See also Chapter 7.5 on recalculations in the agriculture sector.

7.6.1.3 Open burning of waste (5.C.2)

In previous inventories, a share of 3 % was assumed for the area of vineyards burnt for the entire time series according to an expert judgement from the Federal Association of Viniculture in 2001 (Bundesweinbauverband Österreich). According to current information from the Federal Association of Viniculture, the area of vineyards burnt has decreased over time and is assessed to be no more than 1 % of the total vineyard areas for the years 2010 onwards. The burning of vine is either prohibited or permitted to a only very limited extent in the relevant federal provinces. The area of vineyards burnt between 2001 and 2010 was determined by linear interpolation between the two, respective expert judgement, estimates. This improvement resulted in revised emissions for the years 2002–2021.

7.6.1.4 Other waste (5.E)

In this category *5.E* recalculations for 2021 were reported for particulate matter emissions (TSP, PM_{10}, $PM_{2.5}$: +0.2 kt) as well as for Cd, Hg, Pb and dioxine (< 0.00001 t) as updated statistical information on accidental building fires became available (BV, 2021).

7.7 Recalculations per Pollutant

The following tables present the changes in emissions[157] for all relevant pollutants compared to the previous submission (IIR 2023). Detailed explanations are provided in the sectoral chapters.

Table 324: Recalculation difference of SO_2 emissions [kt] with respect to submission 2023.

		1990			2021			Absolute Diff.	
SO_2 emissions [kt]		**Δ%**	**Subm. 2023**	**Subm. 2024**	**Δ%**	**Subm. 2023**	**Subm. 2024**	**1990**	**2021**
1.A.1	Energy Industries	=	14.07	14.07	0.0%	1.14	1.14	-	-0.00
1.A.2	Manufacturing Industries & Construction	=	17.83	17.83	1.1%	7.46	7.38	-	-0.08
1.A.3	Transport	0.0%	5.13	5.13	-0.6%	0.21	0.21	0.00	0.00

[157] An equals sign “=” in the field for relative difference indicates that reported emissions do not differ from the previous submission; blank fields indicate that no such emissions occur from this sector;

SO_2 emissions [kt]		1990 Δ%	1990 Subm. 2023	1990 Subm. 2024	2021 Δ%	2021 Subm. 2023	2021 Subm. 2024	Absolute Diff. 1990	Absolute Diff. 2021
1.A.4	Other Sectors	=	32.66	32.66	-5.7%	1.41	1.50	-	0.09
1.A.5	Other	15.8%	0.01	0.01	-6.2%	0.01	0.01	-0.00	0.00
1.B	Fugitive Emissions	=	2.00	2.00	=	0.03	0.03	-	-
2	Industrial Processes and Product Use	0.0%	1.93	1.93	0.9%	0.59	0.59	-0.00	-0.01
3	Agriculture	=	0.00	0.00	=	NA	NA	-	NA
5	Waste	=	0.07	0.07	-2.9%	0.01	0.02	-	0.00
	Total Emissions	***0.0%***	***73.70***	***73.70***	***0.0%***	***10.88***	***10.87***	***-0.00***	***-0.00***

Table 325: Recalculation difference of NO_x emissions [kt] with respect to submission 2023.

NO_x emissions [kt]		1990 Δ%	1990 Subm. 2023	1990 Subm. 2024	2021 Δ%	2021 Subm. 2023	2021 Subm. 2024	Absolute Diff. 1990	Absolute Diff. 2021
1.A.1	Energy Industries	=	17.78	17.78	0.8%	10.07	9.99	-	-0.08
1.A.2	Manufacturing Industries & Construction	=	33.04	33.04	0.3%	24.71	24.63	-	-0.08
1.A.3	Transport	0.0%	120.14	120.17	0.0%	57.28	57.26	0.03	-0.02
1.A.4	Other Sectors	0.0%	29.81	29.81	2.0%	19.59	19.20	0.00	-0.38
1.A.5	Other	33.0%	0.10	0.07	3.8%	0.05	0.05	-0.02	-0.00
1.B	Fugitive Emissions	=	IE	IE	=	IE	IE	IE	IE
2	Industrial Processes and Product Use	-64.1%	1.53	4.27	=	0.46	0.46	2.74	-
3	Agriculture	=	13.66	13.66	0.2%	11.03	11.01	-	-0.02
5	Waste	=	0.12	0.12	-30.0%	0.03	0.04	-	0.01
	Total Emissions	***-1.3%***	***216.19***	***218.95***	***0.5%***	***123.21***	***122.64***	***2.75***	***-0.57***

Table 326: Recalculation difference of NMVOC emissions [kt] with respect to submission 2023.

NMVOC emissions [kt]		1990 Δ%	1990 Subm. 2023	1990 Subm. 2024	2021 Δ%	2021 Subm. 2023	2021 Subm. 2024	Absolute Diff. 1990	Absolute Diff. 2021
1.A.1	Energy Industries	=	0.32	0.32	0.2%	0.31	0.31	-	-0.00
1.A.2	Manufacturing Industries & Construction	0.0%	1.68	1.68	-0.3%	0.96	0.96	0.00	0.00
1.A.3	Transport	1.1%	98.94	97.89	-1.9%	4.28	4.37	-1.05	0.08
1.A.4	Other Sectors	-0.1%	48.43	48.49	5.0%	30.78	29.33	0.06	-1.45
1.A.5	Other	34.0%	0.02	0.01	-1.8%	0.01	0.01	-0.00	0.00
1.B	Fugitive Emissions	=	15.59	15.59	0.0%	2.02	2.02	-	0.00
2	Industrial Processes and Product Use	0.0%	118.97	118.97	-3.5%	37.08	38.42	0.00	1.34
3	Agriculture	-12.3%	44.66	50.94	-7.9%	32.55	35.36	6.28	2.81
5	Waste	=	0.17	0.17	-2.6%	0.06	0.06	-	0.00
	Total Emissions	***-1.6%***	***328.77***	***334.05***	***-2.5%***	***108.05***	***110.83***	***5.29***	***2.78***

Table 327: Recalculation difference of NH_3 emissions [kt] with respect to submission 2023.

		1990			2021			Absolute Diff.	
NH_3 emissions [kt]		**Δ%**	**Subm. 2023**	**Subm. 2024**	**Δ%**	**Subm. 2023**	**Subm. 2024**	**1990**	**2021**
1.A.1	Energy Industries	=	0.20	0.20	0.2%	0.44	0.44	-	-0.00
1.A.2	Manufacturing Industries & Construction	=	0.33	0.33	-0.1%	0.40	0.40	-	0.00
1.A.3	Transport	-0.1%	0.80	0.80	0.3%	0.95	0.95	0.00	-0.00
1.A.4	Other Sectors	=	0.63	0.63	4.1%	0.71	0.68	-	-0.03
1.A.5	Other	10.0%	0.00	0.00	0.5%	0.00	0.00	-0.00	-0.00
1.B	Fugitive Emissions	=	IE	IE	=	0.00	0.00	IE	-
2	Industrial Processes and Product Use	=	0.34	0.34	=	0.14	0.14	-	-
3	Agriculture	7.2%	71.42	66.60	5.3%	65.22	61.96	-4.82	-3.26
5	Waste	=	0.37	0.37	0.7%	1.28	1.27	-	-0.01
	Total Emissions	***7.0%***	***74.09***	***69.27***	***5.0%***	***69.15***	***65.85***	***-4.82***	***-3.30***

Table 328: Recalculation difference of CO emissions [kt] with respect to submission 2023.

		1990			2021			Absolute Diff.	
CO emissions [kt]		**Δ%**	**Subm. 2023**	**Subm. 2024**	**Δ%**	**Subm. 2023**	**Subm. 2024**	**1990**	**2021**
1.A.1	Energy Industries	=	6.10	6.10	0.1%	4.74	4.73	-	-0.01
1.A.2	Manufacturing Industries & Construction	=	231.22	231.22	0.0%	182.60	182.58	-	-0.03
1.A.3	Transport	0.0%	535.16	535.38	0.0%	53.48	53.47	0.22	-0.01
1.A.4	Other Sectors	-0.1%	426.78	427.01	5.5%	279.75	265.26	0.23	-14.50
1.A.5	Other	12.2%	0.25	0.22	-5.7%	0.16	0.17	-0.03	0.01
1.B	Fugitive Emissions	=	IE	IE	=	IE	IE	IE	IE
2	Industrial Processes and Product Use	=	37.19	37.19	=	14.07	14.07	-	-
3	Agriculture	=	0.95	0.95	=	NA	NA	-	NA
5	Waste	=	10.59	10.59	-3.4%	2.58	2.67	-	0.09
	Total Emissions	***0.0%***	***1 248.24***	***1 248.66***	***2.8%***	***537.39***	***522.95***	***0.42***	***-14.44***

Table 329: Recalculation difference of Cd emissions [t] with respect to submission 2023.

		1990			2021			Absolute Diff.	
Cd emissions [t]		**Δ%**	**Subm. 2023**	**Subm. 2024**	**Δ%**	**Subm. 2023**	**Subm. 2024**	**1990**	**2021**
1.A.1	Energy Industries	=	0.33	0.33	0.0%	0.30	0.30	-	-0.00
1.A.2	Manufacturing Industries & Construction	=	0.31	0.31	-1.5%	0.13	0.14	-	0.00
1.A.3	Transport	9.1%	0.02	0.02	21.6%	0.03	0.03	-0.00	-0.01
1.A.4	Other Sectors	0.0%	0.40	0.40	6.2%	0.36	0.34	-0.00	-0.02
1.A.5	Other	6.7%	0.00	0.00	-1.1%	0.00	0.00	-0.00	0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	NA	NA
2	Industrial Processes and Product Use	=	0.63	0.63	0.0%	0.12	0.12	-	-0.00
3	Agriculture	=	0.01	0.01	=	NA	NA	-	NA
5	Waste	=	0.06	0.06	-1.5%	0.00	0.00	-	0.00
	Total Emissions	***0.1%***	***1.76***	***1.76***	***2.7%***	***0.94***	***0.92***	***-0.00***	***-0.02***

Table 330: Recalculation difference of Hg emissions [t] with respect to submission 2023.

Hg emissions [t]		1990 Δ%	1990 Subm. 2023	1990 Subm. 2024	2021 Δ%	2021 Subm. 2023	2021 Subm. 2024	Absolute Diff. 1990	Absolute Diff. 2021
1.A.1	Energy Industries	=	0.36	0.36	0.0%	0.18	0.18	-	-0.00
1.A.2	Manufacturing Industries & Construction	=	0.80	0.80	-0.3%	0.30	0.30	-	0.00
1.A.3	Transport	0.0%	0.00	0.00	-0.1%	0.00	0.00	0.00	0.00
1.A.4	Other Sectors	0.0%	0.43	0.43	5.9%	0.20	0.19	-0.00	-0.01
1.A.5	Other	6.7%	0.00	0.00	-1.1%	0.00	0.00	-0.00	0.00
1.B	Fugitive Emissions	=	NA	NA	=	0.00	0.00	NA	-
2	Industrial Processes and Product Use	=	0.88	0.88	0.0%	0.33	0.33	-	-0.00
3	Agriculture	=	0.00	0.00	=	NA	NA	-	NA
5	Waste	=	0.05	0.05	0.1%	0.04	0.04	-	-0.00
	Total Emissions	***0.0%***	***2.52***	***2.52***	***1.0%***	***1.05***	***1.04***	***-0.00***	***-0.01***

Table 331: Recalculation difference of Pb emissions [t] with respect to submission 2023.

Pb emissions [t]		1990 Δ%	1990 Subm. 2023	1990 Subm. 2024	2021 Δ%	2021 Subm. 2023	2021 Subm. 2024	Absolute Diff. 1990	Absolute Diff. 2021
1.A.1	Energy Industries	=	1.45	1.45	0.0%	2.50	2.50	-	0.00
1.A.2	Manufacturing Industries & Construction	=	5.59	5.59	-3.9%	1.47	1.53	-	0.06
1.A.3	Transport	0.2%	179.29	178.95	25.7%	5.64	4.49	-0.34	-1.15
1.A.4	Other Sectors	0.0%	8.12	8.12	5.8%	2.54	2.40	0.00	-0.14
1.A.5	Other	6.7%	0.00	0.00	-1.1%	0.00	0.00	-0.00	0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	NA	NA
2	Industrial Processes and Product Use	=	37.42	37.42	0.0%	1.61	1.61	-	-0.00
3	Agriculture	=	0.00	0.00	=	NA	NA	-	NA
5	Waste	=	1.02	1.02	-31.9%	0.00	0.00	-	0.00
	Total Emissions	***0.1%***	***232.89***	***232.54***	***9.8%***	***13.76***	***12.53***	***-0.34***	***-1.23***

Table 332: Recalculation difference of PAH emissions [t] with respect to submission 2023.

PAH emissions [t]		1990 Δ%	1990 Subm. 2023	1990 Subm. 2024	2021 Δ%	2021 Subm. 2023	2021 Subm. 2024	Absolute Diff. 1990	Absolute Diff. 2021
1.A.1	Energy Industries	=	0.01	0.01	0.0%	0.03	0.03	-	-0.00
1.A.2	Manufacturing Industries & Construction	=	0.06	0.06	-0.8%	0.22	0.22	-	0.00
1.A.3	Transport	-0.2%	0.29	0.29	-0.5%	0.32	0.32	0.00	0.00
1.A.4	Other Sectors	0.0%	11.07	11.07	1.7%	6.51	6.40	0.00	-0.11
1.A.5	Other	112.1%	0.00	0.00	-20.8%	0.00	0.00	-0.00	0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	NA	NA
2	Industrial Processes and Product Use	-2.5%	6.96	7.14	-39.4%	0.11	0.18	0.18	0.07
3	Agriculture	=	0.04	0.04	=	NA	NA	-	NA
5	Waste	=	0.05	0.05	-66.6%	0.01	0.04	-	0.02
	Total Emissions	***-1.0%***	***18.47***	***18.65***	***0.1%***	***7.20***	***7.20***	***0.18***	***-0.01***

Table 333: Recalculation difference of Dioxin/Furan (PCDD/F) emissions [g] with respect to submission 2023.

		1990			2021			Absolute Diff.	
Dioxin/Furan emissions [g]		**Δ%**	**Subm. 2023**	**Subm. 2024**	**Δ%**	**Subm. 2023**	**Subm. 2024**	**1990**	**2021**
1.A.1	Energy Industries	=	12.14	12.14	0.0%	1.55	1.55	-	-0.00
1.A.2	Manufacturing Industries & Construction	=	1.68	1.68	-1.8%	3.49	3.55	-	0.07
1.A.3	Transport	0.0%	4.15	4.15	-0.4%	1.49	1.49	-0.00	0.01
1.A.4	Other Sectors	0.0%	42.62	42.62	6.4%	20.76	19.51	0.00	-1.25
1.A.5	Other	112.1%	0.00	0.00	-21.1%	0.00	0.00	-0.00	0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	NA	NA
2	Industrial Processes and Product Use	-6.2%	40.63	43.33	-16.1%	6.97	8.31	2.71	1.33
3	Agriculture	=	0.13	0.13	=	NA	NA	-	NA
5	Waste	=	20.34	20.34	6.0%	3.05	2.87	-	-0.17
	Total Emissions	***-2.2%***	***121.68***	***124.39***	***0.0%***	***37.29***	***37.28***	***2.71***	***-0.01***

Table 334: Recalculation difference of HCB emissions [kg] with respect to submission 2023.

		1990			2021			Absolute Diff.	
HCB emissions [kg]		**Δ%**	**Subm. 2023**	**Subm. 2024**	**Δ%**	**Subm. 2023**	**Subm. 2024**	**1990**	**2021**
1.A.1	Energy Industries	=	0.28	0.28	-0.2%	0.53	0.53	-	0.00
1.A.2	Manufacturing Industries & Construction	=	0.29	0.29	-1.7%	0.58	0.59	-	0.01
1.A.3	Transport	0.0%	0.83	0.83	-0.4%	0.30	0.30	-0.00	0.00
1.A.4	Other Sectors	0.0%	49.64	49.64	6.9%	8.62	8.06	0.00	-0.56
1.A.5	Other	112.1%	0.00	0.00	-21.1%	0.00	0.00	-0.00	0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	NA	NA
2	Industrial Processes and Product Use	0.0%	20.07	20.07	-59.8%	2.55	6.35	-0.00	3.79
3	Agriculture	=	10.14	10.14	=	0.01	0.01	-	-
5	Waste	=	0.40	0.40	-6.6%	0.08	0.08	-	0.01
	Total Emissions	***0.0%***	***81.66***	***81.65***	***-20.5%***	***12.66***	***15.92***	***-0.00***	***3.26***

Table 335: Recalculation difference of PCB emissions [kg] with respect to submission 2023.

		1990			2021			Absolute Diff.	
PCB emissions [kg]		**Δ%**	**Subm. 2023**	**Subm. 2024**	**Δ%**	**Subm. 2023**	**Subm. 2024**	**1990**	**2021**
1.A.1	Energy Industries	=	1.16	1.16	0.0%	0.00	0.00	-	-0.00
1.A.2	Manufacturing Industries & Construction	=	2.64	2.64	1.1%	0.96	0.95	-	-0.01
1.A.3	Transport	-0.1%	0.00	0.00	0.4%	0.00	0.00	0.00	-0.00
1.A.4	Other Sectors	0.0%	4.92	4.92	-24.8%	0.09	0.11	-0.00	0.03
1.A.5	Other	109.3%	0.00	0.00	159.4%	0.00	0.00	-0.00	-0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	NA	NA
2	Industrial Processes and Product Use	-7.1%	27.68	29.80	0.0%	2.01	2.01	2.12	-0.00
3	Agriculture	=	NA	NA	=	NA	NA	NA	NA
5	Waste	=	0.00	0.00	=	0.02	0.02	-	-
	Total Emissions	***-5.5%***	***36.41***	***38.53***	***-0.6%***	***3.08***	***3.09***	***2.12***	***0.02***

Table 336: Recalculation difference of TSP emissions [kt] with respect to submission 2023.

TSP emissions [kt]		1990 Δ%	1990 Subm. 2023	1990 Subm. 2024	2021 Δ%	2021 Subm. 2023	2021 Subm. 2024	Absolute Diff. 1990	Absolute Diff. 2021
1.A.1	Energy Industries	0.0%	1.06	1.06	0.6%	1.31	1.30	-0.00	-0.01
1.A.2	Manufacturing Industries & Construction	0.8%	2.37	2.35	0.4%	0.82	0.82	-0.02	-0.00
1.A.3	Transport	2.5%	9.30	9.07	24.9%	7.31	5.85	-0.23	-1.46
1.A.4	Other Sectors	0.0%	15.04	15.05	4.9%	8.88	8.47	0.01	-0.41
1.A.5	Other	36.4%	0.02	0.02	4.7%	0.01	0.01	-0.01	-0.00
1.B	Fugitive Emissions	=	0.85	0.85	0.9%	0.35	0.35	-	-0.00
2	Industrial Processes and Product Use	-0.5%	28.72	28.86	0.4%	24.37	24.28	0.14	-0.09
3	Agriculture	=	4.96	4.96	=	4.49	4.49	-	-
5	Waste	=	0.37	0.37	1.1%	0.78	0.78	-	-0.01
	Total Emissions	***0.2%***	***62.69***	***62.59***	***4.3%***	***48.33***	***46.34***	***-0.11***	***-1.99***

Table 337: Recalculation difference of PM_{10} emissions [kt] with respect to submission 2023.

PM_{10} emissions [kt]		1990 Δ%	1990 Subm. 2023	1990 Subm. 2024	2021 Δ%	2021 Subm. 2023	2021 Subm. 2024	Absolute Diff. 1990	Absolute Diff. 2021
1.A.1	Energy Industries	0.0%	1.00	1.00	0.6%	1.19	1.19	-0.00	-0.01
1.A.2	Manufacturing Industries & Construction	0.8%	2.18	2.17	0.4%	0.75	0.75	-0.02	-0.00
1.A.3	Transport	2.0%	7.48	7.34	25.6%	4.53	3.60	-0.14	-0.92
1.A.4	Other Sectors	-0.1%	14.10	14.11	4.9%	8.29	7.91	0.01	-0.38
1.A.5	Other	36.4%	0.02	0.02	4.7%	0.01	0.01	-0.01	-0.00
1.B	Fugitive Emissions	=	0.40	0.40	0.9%	0.17	0.16	-	-0.00
2	Industrial Processes and Product Use	-1.1%	13.63	13.78	0.5%	10.08	10.03	0.15	-0.05
3	Agriculture	=	4.23	4.23	=	3.83	3.83	-	-
5	Waste	=	0.30	0.30	1.6%	0.52	0.51	-	-0.01
	Total Emissions	***0.0%***	***43.35***	***43.34***	***4.9%***	***29.36***	***27.98***	***-0.01***	***-1.38***

Table 338: Recalculation difference of $PM_{2.5}$ emissions [kt] with respect to submission 2023.

$PM_{2.5}$ emissions [kt]		1990 Δ%	1990 Subm. 2023	1990 Subm. 2024	2021 Δ%	2021 Subm. 2023	2021 Subm. 2024	Absolute Diff. 1990	Absolute Diff. 2021
1.A.1	Energy Industries	0.0%	0.85	0.85	0.6%	1.01	1.00	-0.00	-0.01
1.A.2	Manufacturing Industries & Construction	0.8%	1.90	1.88	0.4%	0.64	0.63	-0.01	-0.00
1.A.3	Transport	1.2%	6.48	6.40	23.0%	2.79	2.27	-0.08	-0.52
1.A.4	Other Sectors	-0.1%	13.30	13.31	4.9%	7.82	7.45	0.01	-0.37
1.A.5	Other	36.4%	0.02	0.02	4.7%	0.01	0.01	-0.01	-0.00
1.B	Fugitive Emissions	=	0.11	0.11	0.9%	0.05	0.05	-	-0.00
2	Industrial Processes and Product Use	-0.7%	4.07	4.09	1.4%	1.96	1.93	0.03	-0.03
3	Agriculture	=	0.34	0.34	=	0.25	0.25	-	-
5	Waste	=	0.25	0.25	2.5%	0.35	0.34	-	-0.01
	Total Emissions	***0.2%***	***27.33***	***27.26***	***6.7%***	***14.88***	***13.94***	***-0.07***	***-0.93***

7.8 Planned improvements, including status of implementation of ERTs recommendations

Improvements made in response to the review process

Improvements made in response to the issues raised in the last CLRTAP stage 3 review process (United Nations, 2017) and the CLRTAP ad-hoc Reviews 2022 und 2023 (United Nations, 2022 & 2023) are summarized in Table 339, Table 340 and Table 341. The improvements made in response to the review process under the NEC Directive 2023 (EC, 2023a) are indicated in Table 342.

Planned improvements

Planned improvements on sectoral level are presented in the respective sectoral Chapters 3–6.

Goals

The overall goal is to produce emission inventories, which are fully consistent with the 2023 CLRTAP Reporting Guidelines and the latest version of the EMEP/EEA Air Pollutant Emission Inventory Guidebook. An improvement programme has been established to help meet this goal.

Linkages

The improvement programme is driven by the results of the various review processes, as e.g. the internal Austrian review, review under the European Union Governance Regulation, under the UNFCCC and/or under the Kyoto Protocol, under the UNECE/LRTAP Convention and under Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants. Improvement is triggered by the improvement programme that plans improvements sector by sector and also identifies actions outside the Umweltbundesamt.

The improvement programme is supported by the QA/QC programme based on the international standard EN ISO/IEC 17020:2012.

Updating

The improvement programme is updated every year after each review.

Responsibilities

The Umweltbundesamt is responsible for the management of the improvement programme.

Table 339: Improvements made in response to the latest CLRTAP Stage 3 Review in 2017.

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
General (cross-cutting)			
KCA: For the upcoming years Austria will focus mostly on improving the uncertainty analysis on the whole. The next step would be the implementation of approach 2 of the KCA. The ERT welcomes these plans and encourages Austria to include approach 2 for the KCA in its future submissions.	Para 12, 27	Austria considers implementing approach 2 of the KCA as well as improving the uncertainties for future submissions.	-

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
QAQC: Austria has elaborated and implemented a quality assurance/quality control (QA/QC) plan in accordance with the EMEP/CORINAIR Guidebook (Inventory Management Chapter). This includes general QC procedures (tier 1) as well as source category-specific procedures (tier 2) for categories and for those individual categories in which significant methodological revisions and/or data revisions have occurred. The ERT encourages Austria to keep expanding the QA/QC activities in future submissions.	Para 23	Austria considers keeping expanding its QA/QC activities for future submissions.	-
Transparency: The ERT encourages Austria to continue improving the transparency of the IIR by providing more details on methodologies and tier level implementations for each of the sector presented in the IIR.	Para 27	Please refer to the sectoral chapters.	-
Energy (stationary)			
Transparency: The ERT encourages Austria to include the answers that were provided to questions raised by the ERT during the 2017 review week in future submissions (see sub-sector specific recommendations).	Para 30	Please refer to category specific paragraphs below.	-
Consistency: The time series are in general consistent for the energy sector. Austria has justified most of the identified outliers but the ERT encourages Austria to include explanations for all large fluctuations highlighted during the stage 2 review in the IIR report.	Para 32	Please refer to category specific paragraphs below.	-
1.A.1.a Public electricity and heat production – NO_x, SO_x and TSP: The ERT notes that large point source emission measurements are the basis for the reported emissions. During the review Austria provided the share of emissions measured for the year 2000 and the year 2015 as well as an explanation for the decreasing trend of this share throughout the time series. The ERT encourages Austria to include similar information in the IIR in order to increase transparency.	Para 39	Information about the share of reported emissions and calculated emissions has been included in the relevant chapter of category *1.A.1.a.*	Chapter 3.1.3.1
1.A.1.a Public electricity and heat production – NMVOC and NH_3: The ERT notes that emission factors for NMVOC and NH_3 for combustion installations > 50 MWth aren't presented in the IIR. During the review Austria provided these emission factors by fuel type for the year 2015. The ERT encourages Austria to include similar information in the IIR in order to increase transparency.	Para 40	NMVOC and NH_3 emission factor information has been included in relevant chapter of category *1.A.1.a.*	Chapter 3.1.3.1
1.A.1.a Public electricity and heat production – NO_x: The ERT tried to recalculate emissions by using activity data and emission factors from table 65 in the IIR but the calculated emissions weren't consistent with the NFR data. Austria answered that the NO_x emission factor of heavy fuel oil was misleading in the table. The ERT encourages Austria to correct the table accordingly.	Para 41	Emission factors have been updated accordingly.	Chapter 3.1.3.1

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
1.A.1, 1.A.2, 1.A.3.e.i, 1.A.4 Stationary Combustion – SO_x: The ERT noted that according to the IIR, the emissions of SO_x are not applicable ("NA") for the combustion of natural gas and biogas while the EMEP/EEA GB 2016 suggests emission factors for SO_x for natural gas. In that case the biogas contains sulphur. For example, biogas has an SO_x emission factor of 19,2–25 g/GJ in the Danish IIR and an SO_x emission factor of 10 g/GJ in the Finnish IIR. No emission factor could be a result of a total desulphurization, which is not common in Europe. If there are H2S emission limit values for biogas, an emission factor could also be deduced to estimate the SO_x emissions. The ERT recommends that Austria investigates and estimates SO_x emissions from biogas combustion and estimates SO_x emissions from natural gas combustion.	Para 42	SO_2 emissions from natural gas combustion have been estimated.	NFR tables, Chapters 3.1.3, 3.1.4, 3.1.5, 3.1.6
1.A.2.g – SO_2: The ERT tried to recalculate emissions by using activity data and emission factors from table 101 in the IIR but the calculated emissions weren't consistent with the NFR data. Austria answered that the SO_2 emission factor of industrial waste had been revised from 130 g/GJ to 11g/GJ because the fuel, which was reported in the energy statistics, was mainly used in pulp and paper and wood manufacturing industries and the "waste" was more equal to solid biomass. Therefore the emission factor for fuel wood had been selected. Austria will update the table 101 accordingly for the next submission.	Para 43	Emission factors have been updated accordingly.	Chapter 3.1.4.8
1.A.5.a Other stationary – All pollutants: In source category 1.A.5.a all emissions are flagged as "NO". However in the IIR (p. 141), Austria had written that the emissions from military facilities were included in 1.A.4.a. Austria answered it was a mistake and will change the notation key to "IE" for the next submission.	Para 44	The notation keys were changed in the NFR tables since submission 2018.	NFR tables
1.A.4.b.i Residential – NMVOC: The ERT notes an increase of the NMVOC emissions in the residential sector. Austria answered that the increase of NMVOCs was due to added emissions from char coal use which was estimated for the first time in the 2017 submission. The amount of char coal was 267 TJ in 2015 and an emission factor of 2000 g NMVOC/GJ had been selected. This led to additionally 0.5 kt of NMVOC in 2015. The ERT recommends that Austria explains this new source of NMVOC emissions in the IIR to increase transparency.	Para 45	Due to substantial changes in the emission model for residential fuel combustion (in submission 2018) the finding should be obsolete.	Chapter 3.1.9

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
Energy (mobile)			
1.A.3.b.iv – $PM_{2.5}$: For category 1.A.3.b.iv, $PM_{2.5}$ emissions are indicated as "IE" and the ERT asked where these emissions are included. The Party answered that $PM_{2.5}$ emissions from mopeds and motorcycles should be reported as "NE" and not as "IE" as there are no CS measurements for $PM_{2.5}$ exhaust emissions of 2-wheelers in Austria and the Guidebook suggests no calculation method for estimating those emissions according to Tier 3 (EMEP/EEA Update Dec. 2016 p.57). Austria will consider implementing the suggested Tier 2 default $PM_{2.5}$ emission factors for mopeds and motorcycles in the emission model NEMO for the next submission. Although the contribution of this source is under the 2% threshold compared to national total, it is recommended that the Party calculates and reports these emissions in the next submission.	Para 57	The suggested Tier 2 (EMEP/EEA 2016) default $PM_{2.5}$ EFs for mopeds and motorcycles have been implemented in the emission model NEMO since submission 2018.	Chapter 3.2.6
1.A.3.b.vi, 1.A.3.b.vii – PMs, HMs: Emissions from category 1.A.3.b.vi are reported as "NA" and the ERT asked the Party to explain the reason. The ERT also noted that "PM emissions from tyre and brake wear are included in road abrasion"; nevertheless, the ERT wants to encourage Austria to provide separate estimates for both sub-categories in future submissions. In any case, the notation key "IE" should be used instead of "NA", since the emissions from 1.A.3.b.vi are included in 1.A.3.b.vii. Austria answered that emissions from 1.A.3.b.vi tyre and break wear are definitely included in 1.A.3.b.vii automobile road abrasion. Hence, the notation key indeed should be "IE" instead of "NA". The Party will discuss if the emissions model NEMO can provide $PM_{2.5}$ non-exhaust emissions for tyre/break wear and road abrasion separately. The ERT welcomes this plan.	Para 58	The separate reporting of $PM_{2.5}$ non-exhaust emissions from tyre/break wear and road abrasion has been implemented in the emission model NEMO since submission 2018.	NFR tables, Chapter 3.2.6
1.A.3.b.vi, 1.A.3.b.vii – PMs, HMs: Following up on a relevant question from previous Stage 3 review report (2010, Transport, Category issue 5), the ERT wants to encourage Austria to provide estimates for "Additional HMs" for the categories 1.A.3.b.vi, 1.A.3.b.vii, although these are not mandatory to report.	Para 59	Austria has included this issue in it's sectoral improvement plan, but considers this as "not of high priority" due to the non-mandatory reporting obligation	-
1.A.4.a.ii – All pollutants: Following up on a relevant question from previous Stage 3 review report (2010, Transport, Category issue 6), the ERT wants to encourage Austria again to provide separate emission estimates for categories 1.A.4.aii, 1.A.4.bii (commercial/institutional: mobile, and residential: household and gardening (mobile), respectively). Currently, the emissions from 1A4aii are included in 1.A.4.bii. Austria clarifies this in the IIR and mentions that a new study on fuel consumption and pollutant emissions of NRMM is considered for future submissions. Then, input data for the off-road sector will be updated and recalculated with the model GEORG. The ERT welcomes this plan.	Page 16	Emissions from *1.A.4.bii. Residential: household and gardening (mobile)* are reported separately. Currently there is neither a statistical basis nor any new study on NRMM which would enable Austria to report emissions from *1.A.4.aii. Commercial/institutional* separately. So, commercial/ institutional NRMM are included in *1.A.2.g.7 Industry* and *1.A.4.c.2 Agriculture and Forestry.* This information and the cross-reference are included since IIR 2018.	Chapter 3.2.7.4
Fugitive Emissions			

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
1.B.1.b – All pollutants: In source category 1.B.1.b all emissions are flagged as "NO". Austria explained that all emissions from the solid fuels transformation were reported under category 1.A.2.a. The ERT recommends that Austria changes the notation keys from "NO" to "IE" or "NA" and explains the allocation of the emissions in the IIR.	Para 46	Notation keys in category *1.B.1.b* were corrected for all pollutants; an explanation for the allocation of the emissions is given. This recommendation has been implemented in submission 2018.	NFR tables; Chapter 3.3.1
1.B.2.a and 1.B.2.b – NMVOC: During the review the ERT tried to recalculate emissions by using activity data and emission factors from tables 172 and 173 in the IIR but the calculated emissions weren't consistent with the NFR data. Austria answered during the review that these tables were misleading. The ERT encourages Austria to correct these tables in order to be consistent.	Para 47	Tables 172 and 173 of the IIR 2017 (Table 220 and Table 221) in the current IIR) were corrected and completed to ensure consistency with the NFR tables.	Chapters 0, 3.3.4
1.B.2.a.iv – All pollutants: In source category 1.B.2.a.iv all emissions are flagged as "NA" (except NMVOC). The ERT recommends that Austria changes the notation keys from "NA" to "IE" and explains the allocation of the emissions in the IIR.	Para 48	Notation keys in category *1.B.2.a.iv* were corrected for all pollutants, an explanation for the allocation of the emissions is given. This recommendation has been implemented in submission 2018.	NFR tables, Chapter 3.3.1
Industrial Processes and Other Product Use			
Comparability: Methods for many sectors are country-specific and in some cases the emission factors used are not expressed in a way which is compatible with the factors provided in the Guidebook. As a result, it is difficult to compare the country-specific methods with those recommended in the Guidebook and to identify if these country-specific methods result in estimates that are significantly higher or lower than would be obtained using Guidebook methods. The ERT therefore recommends that the Party provides additional information that will aid comparisons with the Guidebook – for example by providing country-specific factors expressed on the same basis as those in the Guidebook wherever possible.	Para 64	Austria included information on the comparison of the applied country-specific EF with the GB factors.	Chapter 4.3.3
Accuracy: The Party includes an assessment of uncertainty in the IIR for individual NFR categories and pollutants within the industrial processes sector. This indicates that the uncertainty ranges from 20% to 200%, although it is not clear to what extent these assessed uncertainties are then used to prioritize improvements. For example, the estimates for $PM_{2.5}$ from 2.A.1, 2.A.2 and 2.A.5 are all reported to have the highest uncertainty but there is no discussion of whether improvements are feasible or planned. The ERT therefore encourages the Party to provide more contexts for the improvement options: where emission estimates are most uncertain, what options exist to improve them, and what country-specific barriers are there to collecting better data.	Para 65	In submission 2018 uncertainties have been improved as national plant-specific data (NMVOC for *2.B.10*) has been included in the inventory.	Chapter 4.2.4

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
2.A.1, 2.A.2: The ERT asked for clarification on the reporting of emissions from cement and lime kilns, since the approach to reporting does not seem to be consistent across all member states. The Party confirmed that pollutants other than particulate matter are reported in 1.A.2.f, while for particulate matter, emissions are reported in 2.A.1 & 2.A.2. This is consistent with the Guidebook, but the Party agreed that, for 2.A.1, changing the notation key for pollutants other than particulate matter from the current "NA" to "IE" would improve transparency. The Party indicated that this would be done in the next submission. The ERT noted that the implied emission factors for particulate matter from 2.A.1 are significantly lower than the 2016 Guidebook factors for uncontrolled processes: the Party stated that abatement technologies are commonly used at Austrian cement works.	Para 69	Austria clarified its reporting and revised its notation keys (since submission 2018).	NFR tables; Chapter 4.3
2.A.5.a: The ERT notes that country-specific methods are used for this sector. The emission factors are specific to particular minerals, whereas those in the Guidebook are generic for all minerals, but many of the Austrian factors are higher than the generic Guidebook factor, so that the Austrian approach does yield higher estimates. The Party commented, however, that the country-specific factors also cover 2.A.5.c, and so the ERT concludes that it is plausible for Austrian factors to be higher than the generic Guidebook factor. The ERT encourages Austria to include information on the comparison of EFs in the sectoral QA/QC section of the IIR.	Para 70	A comparision with the EMEP default EF and further explanation of the methodology has been included in the QA/QC section.	Chapter 4.3.3
2.A.5.b: The ERT notes that country-specific methods are used and that $PM_{2.5}$ emissions for 2.A.5 are subject to an uncertainty of 200%. A single emission factor is taken for all construction activity which is comparable to the Guidebook factor for the construction of houses (the lowest of the four factors in the GB, with significantly higher emission factors for apartments, non-residential construction and road construction). The Guidebook factors can be modified in order to account for local conditions (abatement, soil moisture etc.). The Austrian method does distinguish between building construction and road construction. The ERT recommends that: a) Austria should calculate emissions of $PM_{2.5}$ using the Guidebook approach in order to determine how those estimates compare with the country-specific method, and b) if the two methods give significantly different results, either provide an appropriate level of justification for continuing to use the country-specific method given the uncertainty of that method, or use the Guidebook method instead.	Para 71	In 2023, the EMEP methodology using German parameters was applied.	Chapter 4.3.2
2.B.10: In response to a review question, the Party confirmed that the Austrian inventory does include emission estimates for 2.B.10.b but that these are reported in 2.B.10.a. The Party agreed that the notation key "IE" would be used in future submissions.	Para 72	Austria revised the notation keys as indicated during the review (since submission 2018).	NFR tables; Chapter 4.4.2

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
2.C.1 Iron & Steel: The ERT noted that some factors for this sector are referenced to earlier versions of the Guidebook. The Party responded that the factors actually corresponded to the values given in the 2016 Guidebook and that they would update the reference in future.	Para 73	This information is included in the IIR (since submission 2018).	Chapter 4.5.1
2.C.3 Secondary aluminium: The ERT noted that the Party reports lead emissions for this category but not particulate matter. Aluminium production data are confidential but lead emissions from the sector were 0.3% of national totals in 2005 and 0.2% of national totals in 2015. So, the ERT believes that emissions of particulate matter are likely to be of similar significance, but it is unlikely to exceed the threshold of significance. The ERT recommends including emission estimates for TSP, PM_{10} and $PM_{2.5}$ in the next submission.	Para 74	The calculations have been improved according to the latest version of the GB and particulate matter emissions are included since submission 2018.	NFR tables, Chapter 4.5.2
2.C.5 Secondary lead: The ERT noted that the Party reports lead emissions for this category but not particulate matter. Lead production is given as 24 kt in both 2005 and 2015, so applying the 2016 Guidebook Tier 1 factor for $PM_{2.5}$ would yield an emission estimate of 0.06 tonnes for both years, which is well below the 2% threshold of significance. The ERT recommends including emission estimates for TSP, PM_{10} and $PM_{2.5}$ in the next submission.	Para 75	The calculations have been improved according to the latest version of the GB and particulate matter emissions are included since submission 2018.	NFR tables, Chapter 4.5.2
2.C.7.c Other metal production: In response to a review question, the Party stated that emissions of metals from this sector are reported in 1.A.2.b.	Para 76	In submission 2018, the calculations have been improved according to the 2016 GB and particulate matter emissions are now included. Emissions from Copper production have been reallocated from *1.A.4.* to *2.C.7.c.*	NFR tables
Product Use			
Comparability: Methods for the solvents sector are mostly country-specific and it is not possible to compare the country-specific methods with those recommended in the Guidebook and to identify if these country-specific methods result in estimates that are significantly higher or lower than would be obtained using Guidebook methods. However, the Party estimates the uncertainty in NMVOC emissions from 2.D as 20% so among the lowest for NFR 2. The Party has given a detailed description of the method used to estimate NMVOC emissions for 2.D.3 so the ERT is satisfied that the country-specific method is able to produce more accurate results than the default methods in the Guidebook. The ERT encourages the Party to provide additional information that will aid comparisons with the Guidebook – for example by generating per capita emission factors for 2.D.3.a from the Austrian estimates for this sector, which can then be compared with the Tier 1 emission factor in the Guidebook.	Para 81	As discussed in the respective chapter, the method for the calculation of solvent use has been revised in submission 2019. Updated uncertainties of NMVOC emissions are as well as information on per capita EFs per SNAP are included in the respective chapter.	Chapters 4.2.4, 4.6.2

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
Accuracy: The Party includes an assessment of uncertainty in the IIR for individual NFR categories and pollutants within the solvents sector – these are relatively low compared with the uncertainties quoted for some categories within the industrial processes sector. ERT encourages the Party to provide information tangling the uncertainty assessment the IIR.	Para 82	As discussed in the respective chapter, the method for the calculation of solvent use has been revised in submission 2019. Updated uncertainties of NMVOC emissions as well as information on per capita EFs per SNAP are included in the respective chapter.	Chapters 4.2.4, 4.6.2
2.D.3 Solvent use: Table 199 in the IIR presents implied emission factors for NMVOC from solvent use sectors. These factors are expressed in terms of g/t solvent used and so should not exceed the value 1,000,000. Some of the implied factors are actually greater than this and the Party has explained that this is an error in the way in which the AD are calculated and that they are working on a solution to this problem. The ERT recommends that the Party provides corrected emission factors and/or activity data in future submissions.	Para 83	Information on activity data and IEFs as used in the currently improved solvents model has been included in the sectoral chapter.	Chapter 4.6.2
2.G Other product use: The Party confirmed that for use of tobacco, Austria only reports emissions of particulate matter. The 2016 Guidebook provides emission factors for many other pollutants including NO_x, CO, NMVOC, NH_3, metals and POPs. No activity data was available and so no technical correction could be made. The ERT recommends that emission estimates for all pollutants listed in the Guidebook are included in the next submission.	Para 84	Calculations using the EFs provided in the latest version of the EMEP/EEA Guidebook have been included since submission 2018.	Chapter 4.7
Agriculture			
Accuracy: The ERT encourages Austria to further extend the uncertainty analysis of the activity data by including other animal categories in the inventory, such as sheep, goats, laying hens and turkeys in order to further promote the reliability of the inventory data.	Para 95	Austria's uncertainty analysis includes all livestock categories for which emissions were reported. Source category *3.B.4 Other Livestock* comprises uncertainties for goats, poultry, horses and other animals.	Chapter 5.2.4
3.D.f Use of pesticides – HCB: The ERT notes that Austria does not estimate emissions of HCB from the use of pesticides (3.D.f) reporting as not occurring ("NO"). However, the ERT informed the Party that there has been a consumption of pesticides between 2011 and 2014 according to the Eurostat Agri-environmental indicator. Austria clarified that the EMEP/EEA GB 2016 provides default emission factors for 11 pesticides (Table 3-1). All of the listed pesticides are not occurring in Austria as they are forbidden compliant with the Stockholm Convention on Persistent Organic Pollutant and European legislation (POP Regulation (EG) Nr. 850/2004). However, Austria agrees that there is some pesticide consumption in the country. As for these types of pesticides no emission factors and methodologies are available in the Guidebook, Austria considers to use the notation key "NA" instead of "NO" in the next submission. The ERT encourages the Party to report emissions of HCB from relevant pesticides when reliable methodologies are available.	Para 89, 98, 99	Austria applied the notation key "NA" instead of "NO" for source category *3.D.f*. From submission 2020 onwards Austria reported HCB emissions from this source category.	NFR tables, Chapter 5.5.6

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
Waste			
Accuracy and uncertainties: Austria describes QA/QC procedures and uncertainty analyses for waste sector in its IIR. The ERT encourages Austria to continue the development of an uncertainty analyses.	Para 105	An estimate of the uncertainty for emissions of the sector *5.D* has been included since IIR 2018.	Chapter 6.2.4
Improvement: There are no improvements mentioned for the waste sector in Austria's IIR. The ERT encourages Austria's to plan improvements for waste sector regarding the transparency of the inventory.	Para 106	In 2018, it was planned to carry out a study on the amounts of landfill gas recovered. This information was included in the IIR 2018.	Chapter 6.2.6 (IIR 2018)
5.A Solid waste disposal on land: Descriptions of emission calculations and activity data estimations are comprehensive and transparent. Austria uses notation key "IE" (included elsewhere) for NO_x and SO_x emissions. The ERT assumed according to the previous Stage 3 review that these emissions are from landfill gas recovery. The ERT encourages Austria to provide an explanation about that in IIR.	Para 107	An explanation that NO_x and SO_2 emissions are covered in the energy sector, as the landfill gas is used for energy recovery, has been added since submission 2018.	Chapter 6.2.1
5.B Biological treatment of waste: Austria reports emissions in 5.B.1 biological treatment of waste – composting. The calculations are described in good quality and in detail. For the sub-sector 5.B.2 anaerobic digestion at biogas facilities Austria reports the notation key "NA" (not applicable). The ERT encourages the Party to provide an explanation in IIR tangling the use of notation key.	Para 108	In submission 2019 Austria included NH_3 emissions from biogas facilities, which were calculated under NFR sector Agriculture, but reported in sector Waste. Methodological descriptions have been added in the relevant chapter.	Chapters 6.4.1, 5.3.4
5.C Incineration of waste: According to NFR tables Austria reports emissions in 3 sub-sectors industrial waste incineration, clinical waste incineration and cremation. For sewage sludge, municipal and industrial waste incineration activity data is only estimated for the years 1990–1991. For open burning of waste the notation key "NO" (not occurring) is used. The ERT encourages Austria provide a short description about the open burning of wastes in the IIR. Austria should clarify in its IIR if such activities also occur if forbidden.	Para 109	Due to national legislation any waste incineration/co-incineration needs an explicit permit. However, POP emissions from illegal waste co-incineration in the residential sector had been considered in emission measurements and emission factors used for calculation of emissions from 1.A.4.	Chapter 6.5.1
5.D Wastewater handling: Austria calculated emissions for the sub-sector 5.D.1 domestic wastewater handling. Calculations were provided for the first time. The ERT accepts Austria's approach of activity data estimation and chosen EF. Regarding NH_3 emissions from 5.D.1 the ERT encourages to add a description of latrine uses in Austria in the IIR of the next submission.	Para 110	A description of latrine uses in Austria is included since IIR 2018.	Chapter 6.6.2
5.E Other waste: Austria reports the notation key "NO" (not occurring) for 5.E. In EMEP/EEA Guidebook 2016 sludge spreading, car fires and building fires emissions calculations are described for this sub-sector. The ERT encourages investigating the possibility to obtain activity data for car and building fires. Default emission factors for calculations could be used. In most European countries fire and rescue services collect information about fires. In the EMEP/EEA Guidebook 2016 EFs regarding the number of fire accidents are provided.	Para 102, 111	Emissions for source category 5.E have been added based on national data on car and house fires and the emission factors from the EMEP/EEA guidebook since submission 2018.	Chapter 6.7

Table 340: Improvements made in response to the CLRTAP ad-hoc Review in 2022.

Finding CLRTAP Review 2022	Reference	Improvement made	Chapter
1.A.4.b.i Residential: stationary			
The ERT notes that the activity data are transparently described in the Informative Inventory Report, distinguished by primary fuel type. In order to improve overall transparency, the ERT suggests that Austria provides the detailed biomass consumption for the time series in the 1A4bi sector between "fuel wood" and "waste wood" in the IIR for the next submission.	Para 10	The required information has been provided in the sectoral chapter (Table 147) since submission 2023.	Chapter 3.1.9.2
The activity data for Austria, provided by the census survey on energy use in households (including type of heating) and conducted biannually by Statistics Austria, include collected wood, i.e. wood directly harvested from the forest outside formal market activity. The ERT recommends that the Party adds this information in the IIR for the next submission in order to improve overall transparency.	Para 11	The required information has been added in the sectoral chapter since submission 2023.	Chapter 3.1.9.2
Austria uses both the EMEP/EEA Guidebook 2016 (without 2017 update) for 9 appliance types and country specific methodologies for 14 appliance types for the compilation of its PM emissions from this category. The ERT recommends Austria to use the 2019 version of the EMEP/EEA Guidebook instead of an earlier version for the next submission.	Para 13	In the current IIR the new 2023 version of the EMEP/EEA GB has been applied. For further information, please refer to the sectoral chapter.	Chapter 3.1.9.3
The ERT noted that there was a lack of transparency in the IIR regarding the PM emission factor for the biomass burning appliance type n°14 ("Mixed-fuel wood-boilers"). In response to a question raised during the review, the Party explained that the PM emission factor n°14 was derived as a weighted average between emission factors for conventional and new appliances from the two emission factors. The ERT recommends that Austria include this explanation and also the exact reference used for the next submission.	Para 14	The required information has been provided in the sectoral chapter (Table 178) since submission 2023.	Chapter 3.1.9.3
The ERT noted that there was a lack of transparency in the IIR regarding the PM emission factor for the biomass burning appliance type n°15 ("Natural-draft wood boilers"). In response to a question raised during the review, the Party explained precisely why and how the PM emission factor was derived (lower limit of the 95% confidence interval from the EMEP/EEA 2016 Guidebook - Table 3-34). The ERT recommends that Austria provide the appropriate explanations for both the exact reference used and the reasoning behind this choice for the next submission.	Para 15	The required information has been included in the sectoral chapter since submission 2023.	Chapter 3.1.9.3
The Party uses measurements based on the PM gravimetric method but was not able to provide detailed information on the sampling method for each quoted study. The ERT recommends to collect information on the sampling and measurement standards and/or equipment used and include this in the IIR in future submissions. In case different measurements/equipments are used for different types of equipment it is recommended that these are also documented in the IIR.	Para 17	In the current IIR additional information was added, but further investitgation is needed. This recommendation has been added to the improvements plan and its implementation is planned for future submissions.	Chapter 3.1.9.3, 3.1.9.6

Finding CLRTAP Review 2022	Reference	Improvement made	Chapter
The ERT recommends that the Party continues its investigation to determine whether or not fraction is included in this PM emission factor used for biomass burning appliance type n°12. The ERT also recommends Austria to update in its IIR the condensable fraction status declared from "Included" to "Unknown" until the necessary investigation are completed.	Para 19	The required information has been provided in the sectoral chapter (Table 178).	Chapter 3.1.9.3
The ERT recommends Austria to include emissions during the start and end phases of the combustion cycle in the emission factors used for inventory compilation for all appliance types, to reflect the actual emission levels occurring during combustion. The ERT also recommends Austria to add in its IIR for each biomass burning appliance type whether it is known if the PM emissions factors take into account the entire combustion cycle in order to improve overall transparency.	Para 20	The required information on each biomass burning appliance type has been provided in the sectoral chapter (Table 178). In the current IIR additional information was added, but further investitgation is needed. The recommendation on including emissions during the start and end phases of the combustion cycle has been added to the improvements plan and its implementation is planned for future submissions.	Chapters 3.1.9.3, 3.1.9.6
The measurements used to derive the emission factors for the two coal burning appliance type also cover the entire combustion cycle. In response to a question raised during the review, the Party stated that the emission factors used in the inventory derived from these measurements include the start phase (ignition) and end (ember) phase as well. The ERT recommends Austria to add in its IIR for each coal burning appliance type whether it is known if the PM emissions factors take into account the entire combustion cycle in order to improve overall transparency.	Para 21	The required information on each biomass burning appliance type has been provided in the sectoral chapter (Table 178) since submission 2023.	Chapters 3.1.9.3
In response to a question raised during the review, the Party explained that only for one of the 7 biomass burning appliances for which country specific emission factors are used, the user-related impact is taken into account. The ERT recommends the Party to: Collect data on national circumstances (e.g. through studies or expert judgement/data collection by chimney sweepers) and to incorporate the information in the inventory throughout the entire time series for the next submissions. Add in its IIR for each appliance type whether it is known if the PM emissions factors take into account the "user-related impact" (and to what extent) in order to improve overall transparency for the next submission.	Para 22	In the current IIR additional information was added, but further investitgation is needed. The collection of data on national circumstances (within a household survey) has been added to the improvements plan and its implementation is planned for future submissions.	Chapters 3.1.9.3, 3.1.9.6
The emission factors partially include the condensable component of PM2.5 emissions. The ERT recommends the Party to further investigate for each biomass and coal PM emission factor whether or not condensables are included.	Para 23	In the current IIR additional information was added in the sectoral chapter (Table 178), but further investitgation is needed. This recommendation has been added to the improvements plan and its implementation is planned for future submissions.	Chapters 3.1.9.3, 3.1.9.6

Finding CLRTAP Review 2022	Reference	Improvement made	Chapter
1.A.3.b.i-iv Road transport exhaust emissions			
The ERT commends Austria for its improvement plans and recommends implementing them as scheduled: Update of emission factors according to HBEFA version V4.2 Update of specific yearly mileage of passenger cars for the years 2019, 2020, 2021 according to data of the annual inspection of traffic and operational safety through section 57a of the 1967 Motor Traffic Act (KFG)	Para 32	Both planned improvements were implemented in since submission 2023.	Chapter 3.2.6
In response to a question raised during the review, Austria provided details of how national fleet data is allocated to vehicle layers in NEMO. The ERT recommends Austria to provide summary information on vehicle fleet and the NEMO categories in future IIR submissions.	Para 33	The summary information on vehicle fleet and the NEMO categories are included in the sectoral chapter.	Chapter 3.2.6
In response to a question raised during the review, Austria provided details of average speeds modelled in HBEFA for Austria for each vehicle type for urban, rural and motorways. The ERT recommends that Austria provide summary information on average speeds used and their source in future IIR submissions.	Para 33	The summary information on average speeds used is included in the sectoral chapter.	Chapter 3.2.6

Table 341: Improvements made in response to the CLRTAP ad-hoc Review in 2023.

Finding CLRTAP Review 2023	Reference	Improvement made	Chapter
The ERT recommends the Party to provide an explanation in the 2024 submission of the IIR for the trend in emissions from sector 3F.	AT-2023-3F-1	The required information has been included in the sectoral chapter in order to improve transparency.	Chapter 5.7

Table 342: Improvements made in response to the NEC Review in 2023.

Finding NEC Review 2023	Reference	Improvement made	Chapter
Fugitive Emissions			
1B2aiv Fugitive emissions oil: Refining / storage, SO_2, 2016, 2019, 2020: For 1B2aiv Fugitive emissions oil: Refining / storage, pollutant SO_2 and years 2016, 2019 and 2020, the TERT notes that there is a lack of transparency regarding the notation key 'NA' being used when emissions occur. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Austria explained that all SO_2 emissions from refining are reported under 1A1b Petroleum refining, covering combustion emissions, process emissions, evaporation losses as well as venting and flaring. The source of data are reports by the Austrian Association of Oil, based on measurements at the refinery. Fugitive emissions from refining (1B2aiv Fugitive emissions oil: Refining / storage) are thus included under 1A1b Petroleum refining. The TERT recommends that Austria change the notation key to 'IE' in all years and document the allocation in the IIR in the 2024 submission.	AT-1B2aiv-2023-0001	The notation key has been changed to 'IE' accordingly and information is provided in the sectoral chapter.	NFR Tables, Chapter 3.3.1, Table 217
Transport			
1A3bii Road transport: Light duty vehicles, NO_x, 2005: For category 1A3bii Road transport: Light duty vehicles and pollutant NOX, the TERT notes that Austria has a high NO_X Implied Emission Factor (IEF) when compared to the other Member States for the year 2005. In response to a question raised during the review, Austria provided the share of activity data and emission factors (in g/km) by Euro standard, which helped to clarify the reason for the high IEF. They explained that it was due to the dominant share of Euro 2 and 3 diesel Light Goods Vehicles (LGVs) with emissions calculated based on real world emission factors from the Handbook Emission Factors for Road Transport (HBEFA) (which have higher IEFs than the default values from the 2019 EMEP/EEA Guidebook). The TERT recommends that Austria include the explanation in their 2024 IIR.	AT-1A3bii-2023-0002	The required information has been included in the sectoral chapter in order to improve transparency.	Chapter 3.2.6
1A3c Railways, $PM_{2.5}$, PM_{10}, 1990-2021: For category 1A3c Railways, pollutants $PM_{2.5}$ and PM_{10}, all years, the TERT notes with reference to the IIR page 314 that non-exhaust emission from brake wear and rail abrasion are calculated assuming constant yearly vehicles kilometres. This was raised during the 2022 NECD inventory review. The TERT notes that the IIR states that the issue has been included in the list of improvements (i.e. Austria will improve accuracy of the emission calculation by considering the yearly train mileage upon publication of the value by the Federal Austrian Railways) and that the recommendation will be addressed in the 2024 submission. The TERT reiterates the recommendation that Austria improve the accuracy of the PM_{10} and $PM_{2.5}$ estimates from category 1A3c Railways for the time series based on yearly train kilometres data in their 2024 submission.	AT-1A3c-2022-0001	The emission calculations have been improved accordingly in the current submission.	Chapter 3.2.7.2

Finding NEC Review 2023	Reference	Improvement made	Chapter
Industrial Processes and Product Use			
2A5b Construction and demolition, $PM_{2.5}$, PM_{10}, 1990-2021: For category 2A5b Construction and Demolition and pollutants PM_{10} and $PM_{2.5}$ (and TSP) in all years, the TERT notes that there is a lack of transparency regarding how the emission estimates have been derived. This does not relate to an over- or under-estimate of emissions. This was raised during the 2022 NECD inventory review. In response to a question raised during the review, Austria explained the basis of the parameters used to develop emission estimates and provided summary calculations. The TERT acknowledges that there is no Tier 2 methodology in the 2019 EMEP/EEA Guidebook for category 2A5b and that a Tier 3 method from the 2019 EMEP/EEA Guidebook is not possible to be implemented at a national scale and seems more suitable for individual projects. In addition, the Tier 1 method from the 2019 EMEP/EEA Guidebook necessitates sufficient country-specific information for its implementation. The TERT recommends that Austria provide all details of the country-specific amendments made to parameters to align the method to Austria in the IIR for the 2024 submission.	AT-2A5b-2022-0001	A description of the applied parameters has been included in the IIR.	Chapter 4.3.2
2D Non energy products from fuels and solvent uses, NMVOC, 1990-2021: For 2D3 Non energy products from fuels and solvent uses, for pollutant NMVOC and all years, the TERT notes that there is a lack of transparency regarding the methods used for estimating NMVOCs, such as Figure 52 in the IIR, which has not been updated and might cause some confusion. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Austria provided detailed explanations to each question of the TERT. The TERT recommends that Austria provide the updated figure and the information provided during the review in its 2024 IIR submission.	AT-2D-2023-0001	The chapter in the IIR has been updated accordingly.	Chapter 4.6
2I Wood processing, $PM_{2.5}$, PM_{10}, 1990-2021: For category 2I Wood Processing and pollutants PM_{10} and $PM_{2.5}$ (and TSP) and for all years, the TERT notes that there is a lack of transparency regarding elements of the emission estimates. This does not relate to an over- or under-estimate of emissions. Category 2I is a key category for PM_{10} for Austria and the IIR (Section 4.9) sets out the methodology applied for sawmills and the chipboard industry. The TERT noted that emission factors differ between similar activities and there may be potential for double-counting between the different activities. In response to a question raised during the review, Austria explained that there is some information missing in the IIR and a draft of the revised version of the chapter was provided. The TERT recommends that Austria update the IIR section for category 2I Wood Processing to provide a clear explanation in the IIR for the 2024 submission.	AT-2I-2023-0001	The IIR section for 2I Wood Processing has been improved accordingly in the current submission.	Chapter 4.9

Finding NEC Review 2023	Reference	Improvement made	Chapter
Agriculture			
3B4f Manure management - Mules and asses, SO_2, 1990-2021: For category 3B4f Manure management - Mules and asses, for pollutant SO_2 and for years 1990-2021 the notation key 'IE' has been reported. The TERT would not expect emissions of this pollutant from the NFR category. In response to a question raised during the review, Austria stated that it will change the notation key from 'IE' to 'NA' for the next submission. The TERT recommends that Austria change the notation key for SO_2 emissions from category 3B4f Manure management – Mules and asses from 'IE' to 'NA' in its 2024 submission.	AT-3B4f-2023-0001	The notation key has been changed to NA in the current submission.	NFR Tables
3B4gii Manure management - Broilers, NH_3, 1990-2021: For 3B4gii Manure management - Broilers, NH_3 and all years 1990-2021, the TERT notes that on page 405 of the IIR there is a lack of transparency regarding the use of the abatement technology for drying of poultry manure. It is stated that no information on the drying is available. Thus, only half of the abatement potential from the Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions (UNECE, 2015) has been used. In response to a question raised during the review, Austria clarified that even though drying can be expected, no explicit information for broilers is available in the case of the use of manure belts for frequent collection and removal of manure to closed storage areas. Consequently, a conservative approach has been chosen by applying half of the abatement potential as provided in the UNECE Ammonia Abatement Guidance Document from 2014 (-35% instead of -70%) for the proportion of broilers with manure belts. The TERT recommends that Austria include the information provided to the TERT in the IIR of its 2024 submission to improve transparency	AT-3B4gii-2023-0001	The required information has been included in the sectoral chapter in order to improve transparency.	Chapter 5.3.3
3Da2a Animal manure applied to soils, NH_3, 2005-2021: For category 3Da2a animal manure applied to soil, pollutant NH_3 and years 2005-2021, the TERT notes that in Table 301, page 427 of the IIR, there is a lack of transparency regarding the proportions of cattle and pig slurry applied through various emission abatement techniques. Specifically, it is noted that the same percentage values are applied to all cattle subcategories and to all pig subcategories in each of the years 2017, 2020 and 2021, when the percentage applied for each cattle and each pig subcategory is likely to differ. In response to a question raised during the review, Austria explained that the data presented in Table 301 refers to total cattle and swine and does not distinguish between the different subcategories of cattle and swine and that it will amend Table 301 in future submissions to increase transparency. The TERT recommends that Austria amend the information in Table 301 in the 2024 IIR submission to increase transparency of the calculation.	AT-3Da2a-2023-0001	Table 290 has been improved accordingly in order to increase transparency.	Chapter 5.5.3

Table 343: Improvements made in response to the National Air Pollution Projections Review in 2023.

Finding NACP Review 2023	Reference	Improvement made	Chapter
0A National total (based on fuel sold), NH_3, WM, WAM: The TRT notes that Austria's WM scenario shows it missing its 2030 NH_3 emission reduction commitment (ERC) (by 4%). Austria responded to a question raised during the review to explain that negotiations on additional measures are currently ongoing at national level and that additional measures will be reported in a revision of the national air pollution control programmes as soon as available. The TRT recommends that Austria provides an updated scenario to demonstrate how all the emission reduction commitments will be met for 2030.	AT-NATIONAL TOTAL-2021-0001	Information on the WAM results are included in the current IIR, demonstrating that emission reduction commitments are met for all pollutants. Please refer also to Report "AUSTRIA'S NATIONAL AIR EMISSION PROJECTIONS 2023 FOR 2025 AND 2030" (Umweltbundesamt, 2023e).	Chapter 8
1A3a,c,d,e off-road transport, NH_3, WM: For category 1A3a,c,d,e Off-road transport, pollutant NH_3, years 2025 and 2030 the TRT noted that there is a lack of transparency regarding the projected emission trend for NH_3 between the base year and the projection years. In response to a question raised during the review, Austria explained that there is an error for the subcategory 1A3a which led to an inconsistent trend for NH_3. Austria provided the correct emissions for 1A3a,c,d,e for: NH_3 (2025), NMVOC (2025, 2030) and $PM_{2.5}$ (2025, 2030). The TRT notes that this issue relates to an over or under-estimate and recommends that the correct emission values to be reported in the next submission.	AT-1A3a,c,d,e-2023-0001	Austria will correct the emissions for subcategory 1A3a in its next projections submission (2025).	-
3B Animal husbandry and manure management, NMVOC, NH_3, WM: For 3B Animal husbandry and manure management, the TRT notes with reference to NH_3 and NMVOC emissions of 3B1a and 3B1b and 3B3 (key categories) that there is a lack of transparency regarding the uptake of manure management systems. In response to a question raised during the review, Austria explained that the main driver for the projected NH_3 and NMVOC emission trends of 3B are the decreasing livestock numbers. However, NH_3 emissions of dairy cattle are increasing due to the higher N excretion rates (largely effected by rising milk yields), which compensate the falling livestock numbers. Furthermore, the share of dairy cattle held in loose housing systems is also rising. For non-dairy cattle NH_3 emissions are projected to decrease as the N excretion rates remain quite stable and although loose housing systems are increasing, the decrease in livestock numbers has a stronger effect. Projected NMVOC emissions from 3B are mostly influenced by the livestock numbers. The TRT notes that this issue does not relate to an over or underestimate and recommends that Austria provides in the IIR further clarification on the main drivers for the projected trend emissions (i.e. livestock number, characteristics and management practices).	AT-3B-2023-0001	Austria will provide further clarification on the main drivers for the projected trend emissions (i.e. livestock number, characteristics and management practices) in the next submission (2025).	-

Finding NACP Review 2023	Reference	Improvement made	Chapter
3B4g Poultry, NH_3, WAM: For category 3B4g Poultry, NH_3 emissions in 2019-2030, the TRT noted that there is a lack of transparency regarding the measurement for emission reduction. This was raised during the 2021 Projections review. In response to a question raised during the review, Austria explained that in the WM scenario for poultry the same MMS distribution as in the national inventory for 2021 has been used for all years (see IIR, Table 291). The TRT asked Austria to clarify the reference to "OLI" and Austria explained that this refers to Österreichische Luftschadstoff-Inventur. The TRT notes that this issue does not relate to an over or under-estimate and recommends that Austria includes in the IIR the main assumptions regarding MMS distribution applied to estimate emission projections. The TRT also recommends that Austria adds further details regarding the references in the IIR.	AT-3B4g-2021-0001	Austria will include the main assumptions regarding MMS distribution and further details regarding references in the next submission (2025).	-
3D Plant production and agricultural soils, NMVOC, NH_3, NO_x, WM: The TRT notes with reference to NH_3, NMVOC and NO_X emissions of 3D Plant production and agricultural soils that there is a lack of transparency regarding the uptake of animal manure and N-fertiliser application techniques that lead to emission reductions. In response to a question raised during the review, Austria provided detailed information and explained that data until 2022 were taken from the ÖPUL promotion database and reflect Austria's subsidised slurry quantities for low emission spreading. Inventory projections for 2022 to 2027 are based on the official values corresponding to Austria's GAP Strategic Plan (https://info.bml.gv.at/dam/jcr:ea385170-f6ef-437b-8865-782bd6257366/GAP_1_2.pdf). These are officially approved planning figures combined with a concrete funding. From 2028-2030 the amounts are slightly extrapolated forward as it is very likely that these kinds of subsidies will be prolonged. For the modelling of the agricultural sector (activity data such as e.g. development of livestock, crop yields, land development, fertiliser use) including the macroeconomic impacts, a specific study was prepared by the Austrian Institute of Economic Research (WIFO) and the University of Natural Resources and Life Sciences, Vienna (BOKU) on behalf of the Umweltbundesamt (WIFO & BOKU 2023). The WM results indicate that more commercial fertiliser, especially nitrogen, is being applied to agricultural land as less manure is available due to declining livestock numbers. The nutrient deficit is compensated by increased use of commercial fertiliser Austria also provided several reference reports. The TRT notes that this issue does not relate to an over or under-estimate and recommends that Austria provides in the IIR further explanation regarding the type of fertilisers applied to soils and the assumptions on the uptake of animal manure and N-fertiliser application techniques that lead to emission reductions and the actual figures used for the estimate of emission projections.	AT-3D-2023-0001	Austria will include further explanation regarding the type of fertilisers applied to soils and the assumptions on the uptake of animal manure and N-fertiliser application techniques that lead to emission reductions and the actual figures used for the estimate of emission projections in the next submission (2025).	-

8 PROJECTIONS

As outlined in the '2023 Guidelines for Reporting Emission Data under the Convention on Long-Range Transboundary Air Pollution' (adopted in December 2022)

§ 45 Parties to the 1999 Gothenburg Protocol and 2012 amended Gothenburg Protocol within the geographical scope of EMEP shall regularly update their projections and report every four years from 2015 onward their updated projections, for the years 2025 and 2030 and, where available, also for 2040 and 2050.

§ 46 Projected emissions for substances listed in paragraph 7 above and, where appropriate, BC, should be reported using the template contained in annex IV to these Guidelines. Parties should complete the tables at the requested level of aggregation. Where values for individual categories are not available, the notation keys defined in paragraph 12 above should be used.

§ 47 Quantitative information on parameters underlying emission projections should be reported using the templates set out in annex IV to these Guidelines. These parameters should be reported for the projection target year and the historic year chosen as the starting year for the projections.

Austria's emission projections for the scenarios 'with existing measures' and 'with additional measures' were publicated in October 2023 for the years 2025 and 2030 and are described in the accompanying report 'Austria's National Air Emission Projections 2023 for 2025 and 2030' (Umweltbundesamt, 2023e). The report includes background information to enable a quantitative understanding of the key socioeconomic assumptions used in the preparation of the projections. It updates previous projections for air pollutants published in 2021 (Umweltbundesamt, 2021c).

The following table shows Austria's national total emissions and projections based on 'fuel sold' in accordance with the reporting provisions under the UNECE LRTAP Convention as well as under the revised NEC Directive (EU) 2016/2284. Emissions from fuel sold were also the basis for compliance with Austria's emission reduction commitments under NEC Directive 2001/81/EC.

The scenario 'with existing measures' results in significant emission reductions by 2030 for all pollutants. The most substantial reduction (about 67%) from 2005 to 2030 is projected for NO_x, provided that the latest and new emission standards for road vehicles meet their specifications under real-world driving conditions. Emission reductions for most of the other pollutants are in the range of 37% to 56%; NH_3 emissions, however, are projected to decrease by just 8%. Compared to the WEM scenario, the 'with additional measures' scenario leads to higher emission reductions for all pollutants, with the greatest change noticeable for the pollutant NH_3 (see Table 344).

Table 344: Austrian national total emissions trend in kt in comparison with the base year 2005 in % based on fuel sold for the scenarios 'with existing measures' and 'with additional measures' (Source: Umweltbundesamt).

Pollutant [kt]	Emission Inventory 2023					Emission Scenario			
						WEM		WAM	
	1990	2005	2010	2020	2021	2025	2030	2025	2030
NO_x*	218.95	247.85	206.02	124.47	122.64	100.28	82.16	98.15	76.9
		0%	*-17%*	*-50%*	*-51%*	*-60%*	*-67%*	*-60%*	*-69%*

Pollutant [kt]	Emission Inventory 2023					Emission Scenario			
						WEM		WAM	
	1990	2005	2010	2020	2021	2025	2030	2025	2030
SO_2	73.70	25.89	15.99	10.41	10.87	11.20	11.45	11.10	10.33
		0%	*-38%*	*-60%*	*-58%*	*-57%*	*-56%*	*-57%*	*-60%*
NMVOC*	334.05	157.17	137.90	110.53	110.83	102.95	98.73	102.00	97.47
		0%	*-12%*	*-30%*	*-29%*	*-35%*	*-37%*	*-35%*	*-38%*
NH_3	69.27	62.70	65.15	65.53	65.85	62.27	57.62	58.46	51.13
		0%	*4%*	*5%*	*5%*	*-1%*	*-8%*	*-7%*	*-18%*
$PM_{2.5}$	27.26	22.75	19.89	13.35	13.94	12.64	12.39	12.65	12.21
		0%	*-13%*	*-41%*	*-39%*	*-44%*	*-46%*	*-44%*	*-46%*

** NO_x and NMVOC emission in the subsector 3 B and 3 D are included in the sums and should not be taken into account for checking compliance with emission reduction commitments.*

Compliance with national emission reduction commitments

According to Article 4(3) of NEC Directive (EU) 2016/2284, emissions of NO_x and NMVOC from the source categories NFR 3.B (manure management) and 3.D (agricultural soils) are not taken into account for compliance purposes. The following table meets this requirement.

With regard to the achievement of the 2030 targets, Austria will comply for all pollutants in the ‘with additional measures’ scenario.

Table 345: Austrian national total emissions in kt for compliance purposes in comparison with the 2030 target and the scenarios ‘with existing measures’ and ‘with additional measures’ (Source: Umweltbundesamt).

Pollutant [kt]	Emission Inventory 2023			*Emission Scenario*				Target	Difference From Target	
				WEM		WAM			WEM	WAM
	2005	2020	2021	*2025*	*2030*	*2025*	*2030*	2030	2030	2030
NO_x	237.09	113.63	111.63	89.74	72.11	88.01	68.30	73.50	-1.39	-5.20
	0%	-52%	-53%	-62%	-70%	-63%	-71%	-69%	-1%	-2%
NMVOC	118.82	75.13	75.47	70.12	68.83	69.96	69.03	76.05	-7.22	-7.01
	0%	-37%	-36%	-41%	-42%	-41%	-42%	-36%	-6%	-6%
SO_2	25.89	10.41	10.87	11.20	11.45	11.10	10.33	15.28	-3.82	-4.94
	0%	-60%	-58%	-57%	-56%	-57%	-60%	-41%	-15%	-19%
NH_3	62.70	65.53	65.85	62.27	57.62	58.46	51.13	55.17	2.45	-4.04
	0%	5%	5%	-1%	-8%	-7%	-18%	-12%	4%	-6%
$PM_{2.5}$	22.75	13.35	13.94	12.64	12.39	12.65	12.21	12.28	0.11	-0.07
	0%	-41%	-39%	-44%	-46%	-44%	-46%	-46%	0%	0%

8.1 Nitrogen Oxides (NO_x)

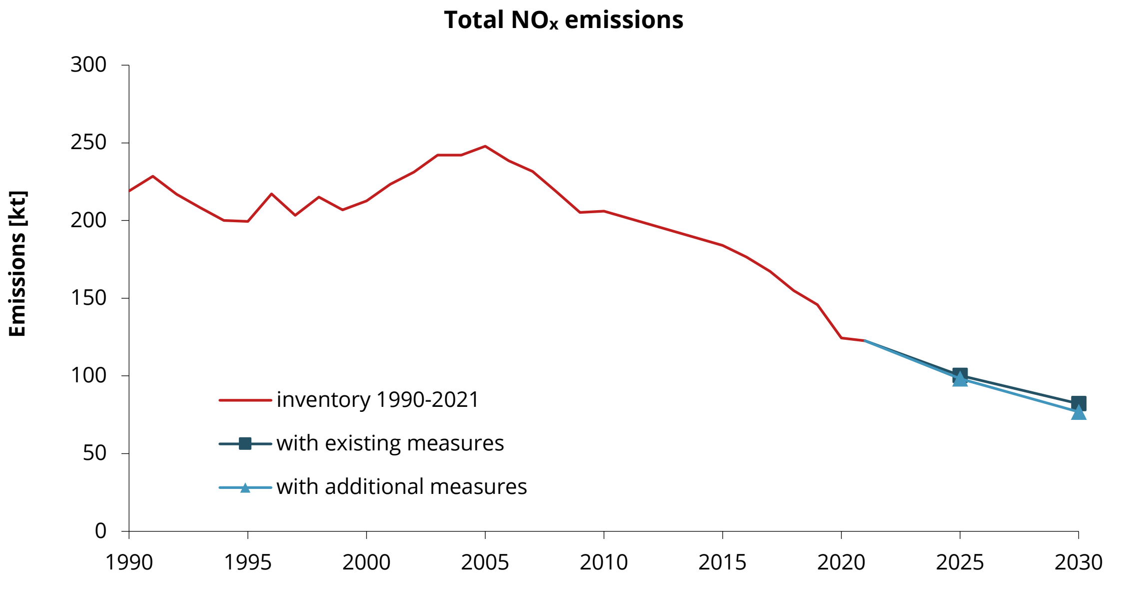
Austria's total NO_x emissions amounted to 218.9 kt in 1990 and 122.6 kt in 2021, meaning a decrease of 44.0% over the period. Since 2005, an emission reduction of about 50.5% has been achieved.

The majority of Austria's national NO_x emissions comes from fuel combustion activities. At 44.4%, road transport accounted for the biggest share of Austria's total NO_x emissions in the year 2021. In the years 2003 to 2005, NO_x emissions from road transport peaked and have since decreased continuously. They have been reduced by 65.0%. In particular, emissions from heavy-duty vehicles (trucks and busses) have fallen due to improvements in exhaust after-treatment technology.

In the scenario **'with existing measures'**, the national total emissions are expected to decrease to 82.2 kt by 2030 (-66.9% compared to 2005).

The main drivers of the NO_x emissions trend over the period to 2030 are expected to be road transport, households and the energy industry. Contrary to the overall trend, emissions from manufacturing industries are expected to remain stable.

Figure 57: Historical (1990–2021) and projected NO_x emissions for WEM and WAM (2022–2030) based on fuel sold.



Source: Umweltbundesamt

NO_x emissions from road transport (NFR 1.A.3.b.) are projected to decrease by 63.7% (i.e. -34.7 kt) from 2021 to 2030. In particular, heavy-duty vehicles are forecast to fall by 78.8%, while emissions from passenger cars will decrease by 57.1%.

This decline is based on the following assumptions:

- vehicle fleet turnover in combination with decreasing specific emission factors for Euro VI (HDVs), Euro 6d_temp and EURO 6d (PCs);

- from 2025 onwards, we will see substantial registrations of new BEVs (battery electric vehicles) of over 100 000 cars per year. 2035 will be the first year with 100% BEV registrations in the PC and LDV sectors.

Emissions from NFR 1.A.4. Other Sectors (households, commercial and agriculture) are projected to decrease by 28.1% (i.e. -5.4 kt) from 2021 to 2030. This is mainly due to a modernisation of (and decline in emissions from) non-road mobile machinery (NRMM, known as off-road vehicles) and a switch to low-emission technology. A transition from fossil to electric propulsion systems in these categories is partly assumed. Mobile sources in households and agriculture (off-road) show a decrease of 37.6% (-2.3 kt) by 2030. Stationary sources are expected to fall by 23.7% (-3.1 kt) by 2030 because of a decline in the use of gas oil, ongoing stock replacement with condensing boilers and the impact of eco-design provisions for the installation of new heating systems.

Reduced inputs of gas and oil to fuel thermal power stations and a decrease in oil and gas extraction are responsible for lower emissions in NFR 1.A.1 Energy Industries (-26.8%, i.e. -3.8 kt) by 2030 compared to 2005.

Emissions from NFR 1.A.2 Manufacturing Industries and Construction decreased by 27.5% between 2005 and 2021 due to the installation of primary and secondary NO_x abatement measures. More of these measures will be implemented by 2030, but the effect is expected to be offset by an increase in emissions due to economic growth.

In the scenario **'with additional measures'**, the national total emissions are expected to decrease to 76.9 kt by 2030 (-69.0% compared to 2005).

NO_x emissions from road transport (especially cars and heavy-duty vehicles) are projected to fall by 65.5% (i.e. -35.7 kt) from 2021 to 2030.

Emissions from NFR 1.A.4. Other Sectors (households, commercial and agriculture) are projected to decline by 28.7% (i.e. -5.5 kt) from 2021 to 2030. Mobile sources in households and agriculture (off-road) show a decrease of 37.6% (i.e. -2.3 kt) by 2030. Stationary sources are expected to fall by 24.6% (i.e. -3.3 kt) by 2030 because of a further reduction in the use of gas oil for heating.

Reduced inputs of coal and oil to fuel thermal power stations and a higher consumption of biomass in NFR 1.A.1 Energy Industries results in a decrease of 27.8% (i.e. -4.0 kt) by 2030 compared to 2005.

Table 346: Austrian national NO_x emissions in kt and trend based on 'fuel sold' (source:Umweltbundesamt).

NFR	Description	Emission Inventory 2023* [kt]					Scenario [kt]		Type of Scenario
		1990	2005	2010	2020	2021	2025	2030	
	Total	218.95	247.85	206.02	124.47	122.64	100.28	82.16	WEM
		218.95	247.85	206.02	124.47	122.64	98.15	76.89	WAM
1.A.1	Energy Industries	17.78	14.30	12.80	9.93	9.99	10.58	10.47	WEM
		17.78	14.30	12.80	9.93	9.99	10.23	10.33	WAM
1.A.2	Manufacturing Industries and Construction	33.04	33.98	32.15	24.30	24.63	23.97	23.72	WEM
		33.04	33.98	32.15	24.30	24.63	23.46	21.31	WAM
1.A.3.a, c, d, e	Off-Road Transport	4.01	6.03	5.11	2.36	2.76	3.59	3.74	WEM
		4.01	6.03	5.11	2.36	2.76	3.56	3.70	WAM

NFR	Description	Emission Inventory 2023* [kt]					Scenario [kt]		Type of Scenario
		1990	2005	2010	2020	2021	2025	2030	
1.A.3.b	Road Transport	116.17	155.57	121.32	58.25	54.50	35.77	19.79	WEM
		116.17	155.57	121.32	58.25	54.50	35.05	18.79	WAM
1.A.4	Other Sectors	29.81	26.32	23.65	18.21	19.20	15.27	13.81	WEM
		29.81	26.32	23.65	18.21	19.20	15.14	13.69	WAM
1.A.5	Other	0.07	0.09	0.08	0.05	0.05	0.05	0.05	WEM
		0.07	0.09	0.08	0.05	0.05	0.05	0.05	WAM
1.B	Fugitive Emissions	IE	IE	IE	IE	IE	IE	IE	WEM
		IE	IE	IE	IE	IE	IE	IE	WAM
2.A,B,C, H,I,J,K,L	Industrial Processes	4.24	0.67	0.52	0.46	0.44	0.46	0.46	WEM
		4.24	0.67	0.52	0.46	0.44	0.46	0.38	WAM
2.D, 2.G	Solvent and Other Product Use	0.03	0.03	0.03	0.02	0.02	0.02	0.02	WEM
		0.03	0.03	0.03	0.02	0.02	0.02	0.02	WAM
3.B	Manure Management	0.67	0.60	0.59	0.58	0.58	0.53	0.45	WEM
		0.67	0.60	0.59	0.58	0.58	0.53	0.41	WAM
3.D	Agricultural Soils	12.97	10.16	9.74	10.26	10.43	10.00	9.59	WEM
		12.97	10.16	9.74	10.26	10.43	9.61	8.17	WAM
3.F, I	Field Burning and Other Agriculture	0.03	0.02	0.02	0.00	0.00	0.00	0.00	WEM
		0.03	0.02	0.02	0.00	0.00	0.00	0.00	WAM
5	Waste	0.12	0.07	0.03	0.04	0.04	0.04	0.04	WEM
		0.12	0.07	0.03	0.04	0.04	0.04	0.04	WAM

* *Data source: Austrian Emission Inventory 2023*

IE: included elsewhere; NA: not applicable; NO: not occurring

8.2 Sulphur Dioxide (SO_2)

In 2021, SO_2 emissions amounted to 10.9 kt. Emissions have decreased by 85.2% since 1990 (73.7 kt) and by 58.0% since 2005.

This decline is mainly due to a reduction in the sulphur content in mineral oil products and fuels (as prescribed by the Austrian Fuel Ordinance (*Kraftstoffverordnung*), the installation of desulphurisation units in plants (in accordance with the Clean Air Act for Steam Boilers (*Emissionsschutzgesetz für Kesselanlagen*)) and an increased use of low-sulphur fuels such as natural gas.

From 2020 to 2021, SO_2 emissions rose by 4.4% (+0.5 kt), mainly because emissions rose by 7.0% (+0.3 kt) in the iron and steel industry (NFR 1.A.2.a), which accounts for the largest share of SO_2 emissions (43%), as a result of increased production of pig iron and steel. Compared to the previous year, SO_2 emissions also increased significantly in the residential (NFR 1.A.4.b.1) and commercial/institutional heating sectors (NFR 1.A.4.a.1) due to a higher consumption of heating oil, coal and firewood (cooler weather compared to 2020). In the oil refinery sector (NFR 1.A.1.b), a rise in SO_2 emissions could also be observed.

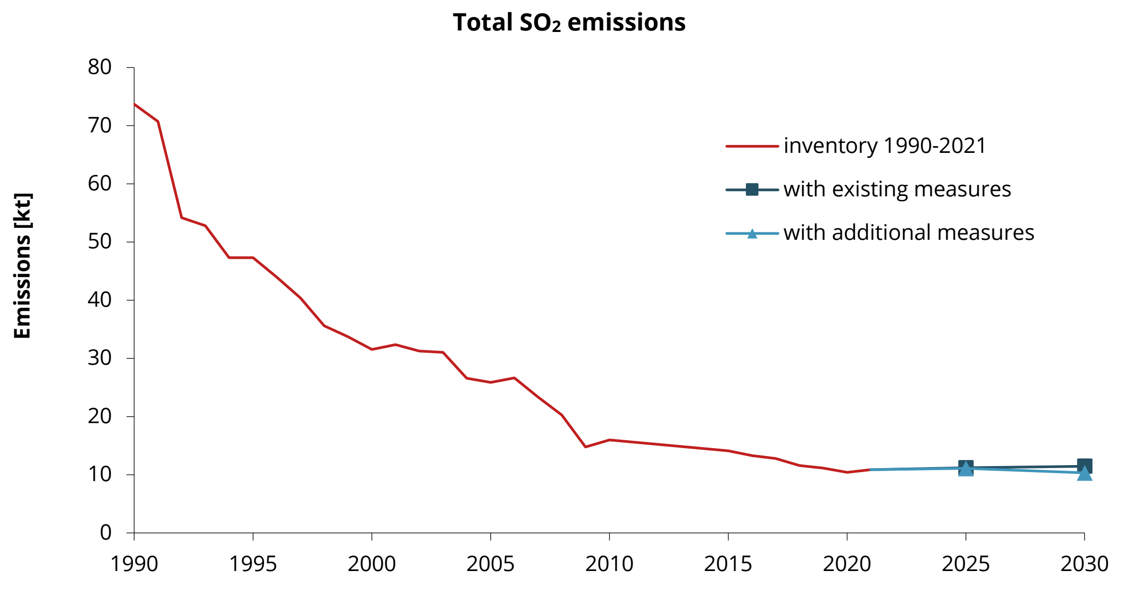
In the scenario **'with existing measures' (WEM)**, the national total SO_2 emissions are projected to reach 11.4 kt by 2030. Compared to 2005, this is a reduction of 55.8%. Compared to 2021, however, this means an increase of 5.3% (i.e. 0.58 kt). Appropriate mitigation measures (e.g. reduction of the sulphur content in liquid fuels, waste gas treatment) have largely already been implemented. The reduction potential is therefore only minor.

The highest decrease by 2030 is expected in NFR 1.A.4 Other Sectors (-26.7%;
-0.4 kt) mainly due to a further shift in residential heating from solid and liquid fossil fuels (coal, oil) towards the use of heat pumps, district heat and biomass heating systems in gradually more energy-efficient buildings. Emissions from manufacturing industries and construction (NFR 1.A.2) are expected to increase by 10.0% (+0.7 kt).

In the scenario **'with additional measures' (WAM),** national total emissions are expected to decrease to 10.3 kt by 2030 (-60.1% compared to 2005).

Minor effects can be expected at the sectoral level over the period from 2021 to 2030: emissions from other sectors (NFR 1.A.4) are expected to decrease by 2030 (WEM: -26.7%, i.e. -0.40 kt; WAM: -28.9%, i.e. -0.43 kt) due to a further shift from fossil fuels (oil, coal) to renewables.

Figure 58: Historical (1990–2021) and projected SO_2 emissions for WEM and WAM (2022–2030) based on fuel sold.



Source: Umweltbundesamt

Table 347: Austrian national SO_2 emissions in kt and trend based on 'fuel sold' (Source: Umweltbundesamt).

NFR	Description	Emission Inventory 2023* [kt]					Scenario [kt]		Type of Scenario
		1990	2005	2010	2020	2021	2025	2030	
	Total	73.70	25.89	15.99	10.41	10.87	11.20	11.45	WEM
		73.70	25.89	15.99	10.41	10.87	11.10	10.33	WAM
1.A.1	Energy Industries	14.07	6.71	2.74	1.04	1.14	1.25	1.35	WEM
		14.07	6.71	2.74	1.04	1.14	1.33	1.51	WAM
1.A.2	Manufacturing Industries and Construction	17.83	10.12	9.40	7.26	7.38	7.94	8.12	WEM
		17.83	10.12	9.40	7.26	7.38	7.78	6.87	WAM
1.A.3.a, c, d, e	Off-Road Transport	0.36	0.19	0.18	0.08	0.09	0.13	0.15	WEM
		0.36	0.19	0.18	0.08	0.09	0.13	0.15	WAM
1.A.3.b	Road Transport	4.77	0.16	0.13	0.12	0.13	0.12	0.11	WEM
		4.77	0.16	0.13	0.12	0.13	0.12	0.10	WAM
1.A.4	Other Sectors	32.66	7.88	2.77	1.27	1.50	1.12	1.10	WEM
		32.66	7.88	2.77	1.27	1.50	1.11	1.07	WAM
1.A.5	Other	0.01	0.01	0.01	0.01	0.01	0.01	0.01	WEM
		0.01	0.01	0.01	0.01	0.01	0.01	0.01	WAM
1.B	Fugitive Emissions	2.00	0.04	0.05	0.02	0.03	0.02	0.01	WEM
		2.00	0.04	0.05	0.02	0.03	0.02	0.01	WAM
2.A,B,C, H,I,J,K,L	Industrial Processes	1.93	0.72	0.70	0.58	0.59	0.59	0.59	WEM
		1.93	0.72	0.70	0.58	0.59	0.59	0.59	WAM
2.D, 2.G	Solvent and Other Product Use	0.00	0.01	0.01	0.00	0.00	0.00	0.00	WEM
		0.00	0.01	0.01	0.00	0.00	0.00	0.00	WAM
3.B	Manure Management	NA	NA	NA	NA	NA	NA	NA	WEM
		NA	NA	NA	NA	NA	NA	NA	WAM
3.D	Agricultural Soils	NA	NA	NA	NA	NA	NA	NA	WEM
		NA	NA	NA	NA	NA	NA	NA	WAM
3.F, I	Field Burning and Other Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	WEM
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	WAM
5	Waste	0.07	0.06	0.01	0.02	0.02	0.02	0.02	WEM
		0.07	0.06	0.01	0.02	0.02	0.02	0.02	WAM

** Data source: Austrian Emission Inventory 2023*

IE: included elsewhere; NA: not applicable; NO: not occurring

8.3 Non-Methane Volatile Organic Compounds (NMVOCs)

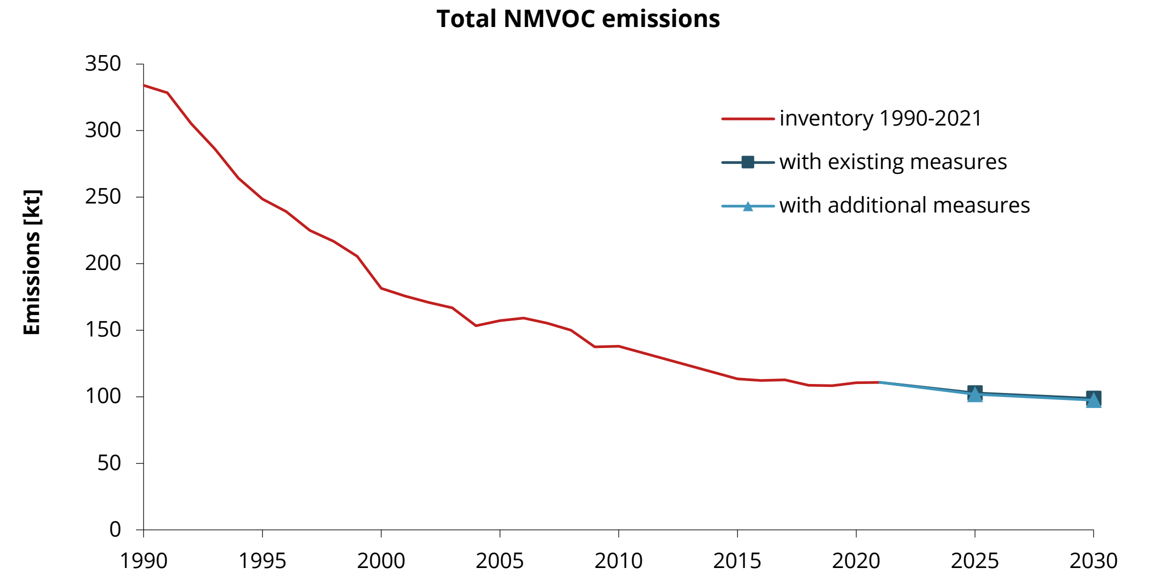
Emissions of non-methane volatile organic compounds amounted to 334.1 kt in 1990 and 110.8 kt in 2021. This corresponds to a reduction of 66.8%. From 2020 to 2021, NMVOC emissions increased by 0.3 kt (+0.3%).

The largest reductions since 1990 have been achieved in the road transport sector due to an increased use of catalytic converters and diesel cars. Currently, the road transport sector (NFR 1.A.3.b.) accounts for only a small share (3.4%) of Austria's total NMVOC emissions.

In 2021, the main sources of NMVOC emissions in Austria were NFR 2.D.3 Solvent Use with a share of 31.2%, the agricultural sector (NFR 3) with 31.9% and NFR 1.A.4.b.1 Residential Stationary Heating with 22.7% of the total NMVOC emissions.

In the scenario **'with existing measures' (WEM)**, national total NMVOC emissions are expected to decrease to 98.7 kt by 2030 (-37.2% compared to 2005).

Figure 59: Historical (1990–2021) and projected NMVOC emissions for WEM and WAM (2022–2030) based on fuel sold.



Source: Umweltbundesamt

Total NMVOC emissions are projected to decrease by 10.9% by 2030 (compared to 2021). The largest reduction is expected to be achieved in NFR 1.A.4 Other Sectors (mainly households and commercial), with a decrease of 25.7% (i.e. -7.5 kt) over the period from 2021 to 2030. This is mainly due to a trend towards low-emission technologies (heating types) and projected lower emission factors for new boilers in the building sector as well as a decline in the use of fuel wood as a source of energy.

Emissions in road transport (NFR 1.A.3) are projected to fall by 22.9% (i.e. -0.9 kt) by 2030, owing to state-of-the-art exhaust gas treatment (regulated catalytic converter) in earlier years and a substantial share of electric vehicles in the long term causing zero direct emissions.

On the other hand, emissions from NFR 2.D.3 Solvent Use are expected to increase by 5.1% by 2030 (i.e. 1.8 kt) due to projected economic growth resulting in an increase in solvent use. Emission regulations for the relevant sectors have been enforced at EU level, with some of the legal requirements in Austria being even stricter. The requirements for paints and varnishes have been harmonised at EU level, and existing regulations do not forsee a further tightening of emission standards. Calculations are based on solvent balances from companies and linked to economic projections for the respective sub-sectors, coupled with expert judgement on the actual increase of solvent use, taking into account the offset due to new technologies.

Emissions from agriculture are projected to decrease by 15.4% (i.e. 5.5 kt) by 2030 compared to 2021, mainly caused by livestock developments in Austria.

In the scenario **'with additional measures' (WAM)**, the national total emissions are expected to decrease to 97.5 kt by 2030 (-38.0% compared to 2005).

NMVOC emissions from agriculture are projected to fall by 19.6% (i.e. -6.9 kt) from 2021 to 2030, mainly due to assumed livestock developments in Austria.

Table 348: Austrian national NMVOC emissions in kt and trend based on 'fuel sold' (Source: Umweltbundesamt).

NFR	Description	Emission Inventory 2023* [kt]					Scenario [kt]		Type of Scenario
		1990	2005	2010	2020	2021	2025	2030	
	Total	334.05	157.17	137.90	110.53	110.83	102.95	98.73	WEM
		334.05	157.17	137.90	110.53	110.83	102.00	97.47	WAM
1.A.1	Energy Industries	0.32	0.24	0.35	0.30	0.31	0.31	0.31	WEM
		0.32	0.24	0.35	0.30	0.31	0.31	0.31	WAM
1.A.2	Manufacturing Industries and Construction	1.68	2.06	1.94	0.97	0.96	0.89	0.88	WEM
		1.68	2.06	1.94	0.97	0.96	0.89	0.88	WAM
1.A.3.a, c, d, e	Off-Road Transport	1.53	1.79	1.45	0.51	0.62	0.67	0.65	WEM
		1.53	1.79	1.45	0.51	0.62	0.67	0.65	WAM
1.A.3.b	Road Transport	96.36	20.26	10.11	3.95	3.75	3.50	2.89	WEM
		96.36	20.26	10.11	3.95	3.75	3.43	3.24	WAM
1.A.4	Other Sectors	48.49	33.64	34.79	26.60	29.33	23.08	21.79	WEM
		48.49	33.64	34.79	26.60	29.33	23.00	21.66	WAM
1.A.5	Other	0.01	0.02	0.01	0.01	0.01	0.01	0.01	WEM
		0.01	0.02	0.01	0.01	0.01	0.01	0.01	WAM
1.B	Fugitive Emissions	15.59	3.46	2.57	2.03	2.02	2.16	2.01	WEM
		15.59	3.46	2.57	2.03	2.02	2.15	1.99	WAM
2.A,B,C, H,I,J,K,L	Industrial Processes	4.36	3.56	3.72	3.84	3.86	3.90	3.93	WEM
		4.36	3.56	3.72	3.84	3.86	3.90	3.93	WAM
2.D, 2.G	Solvent and Other Product Use	114.61	53.63	44.99	36.86	34.57	35.55	36.32	WEM
		114.61	53.63	44.99	36.86	34.57	35.55	36.32	WAM
3.B	Manure Management	33.52	26.95	27.03	25.91	26.03	24.60	22.60	WEM
		33.52	26.95	27.03	25.91	26.03	24.11	21.47	WAM
3.D	Agricultural Soils	17.37	11.40	10.82	9.50	9.33	8.23	7.31	WEM
		17.37	11.40	10.82	9.50	9.33	7.93	6.97	WAM

NFR	Description	Emission Inventory 2023* [kt]					Scenario [kt]		Type of Scenario
		1990	2005	2010	2020	2021	2025	2030	
3.F, I	Field Burning and Other Agriculture	0.06	0.04	0.03	0.00	0.00	0.00	0.00	WEM
		0.06	0.04	0.03	0.00	0.00	0.00	0.00	WAM
5	Waste	0.17	0.12	0.10	0.06	0.06	0.05	0.05	WEM
		0.17	0.12	0.10	0.06	0.06	0.05	0.05	WAM

** Data source: Austrian Emission Inventory 2023*

IE: included elsewhere; NA: not applicable; NO: not occurring

8.4 Ammonia (NH_3)

Ammonia emissions amounted to 65.8 kt in 2021. Since 1990, NH_3 emissions have decreased by 4.9%, although they have increased by 5.0% since 2005.

The main source of NH_3 emissions is the agricultural sector with a share of 94.1% in 2021. Within the agricultural sector, about 51% of NH_3 emissions result from manure management (NFR 3.B) and 49% from agricultural soils (NFR 3.D).

There was a fall of 7.0% in NH_3 emissions from the agricultural sector between 1990 and 2021. This reduction can be explained mainly by declining cattle numbers, more efficient feeding and an increased application of low-emission spreading techniques (e.g. band spreading, trailing shoe, rapid incorporation of manure).

Agricultural NH_3 emissions mainly arise from animal husbandry and the application of organic and mineral N fertilisers.

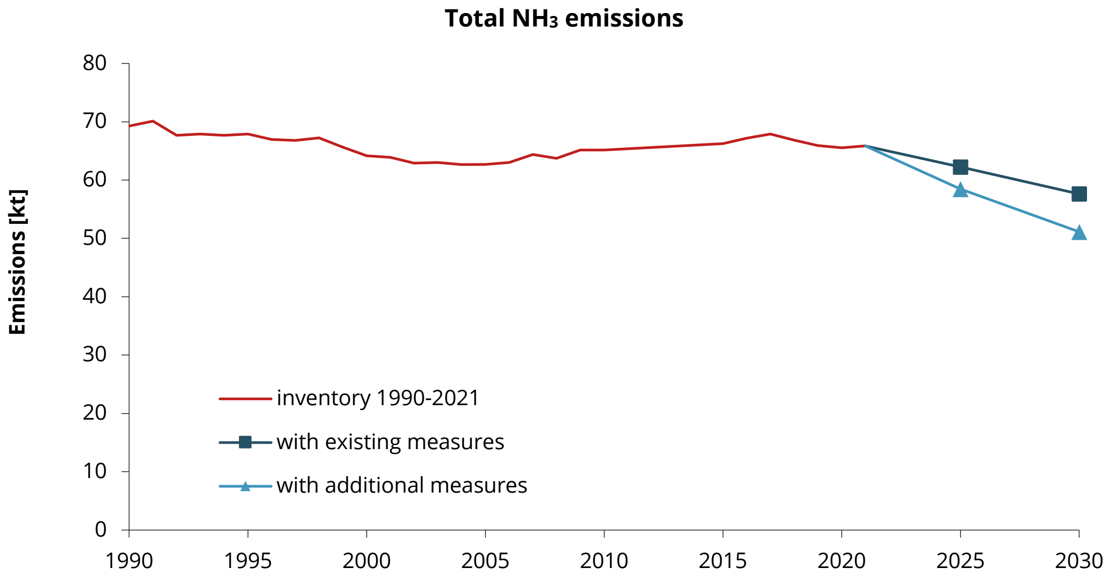
Within NFR 3.B Manure Management, emissions result from animal husbandry and the storage of manure. In manure management, cattle accounts for the highest share (62.6% in 2021). Levels of emissions depend on livestock numbers, but also on housing systems and manure treatment (e.g. NH_3 emissions from loose housing systems are considerably higher than those from tied housing systems). Since 2005, NH_3 emissions from agriculture have increased by 7.8%, mainly due to higher emissions from cattle, which are increasingly housed in loose housing systems for animal welfare reasons.

Ammonia emissions from NFR 3.D Agricultural Soils occur as a result of the application of mineral N fertilisers as well as organic fertilisers (including animal manure, sewage sludge, digestates from biogas plants and compost). Another source of NH_3 emissions is urine and dung deposited on pastures by grazing animals.

In the scenario **'with existing measures' (WEM)**, national total emissions are expected to decrease to 57.6 kt by 2030 (-8.1% compared to 2005). For the period between 2021 and 2030, NH_3 emissions show a 12.5% reduction.

Declining animal numbers and existing measures such as the increased use of low-emission manure spreading techniques in the agricultural sector are the main reasons for decreased emissions in 2030. National forecasts for agricultural production in Austria (WIFO & BOKU, 2023) show that cattle numbers will fall by 13% between 2021 and 2030. Pig numbers will decrease at a much higher rate because the output price and input cost ratio is less favourable. Poultry numbers will decline at a rate similar to the number of pigs until 2030. In accordance with Austria's CAP-SP, the share of low-emission spreading techniques will be increased significantly in the coming years.

Figure 60: Historical (1990–2021) and projected NH_3 emissions for WEM and WAM (2022–2030) based on fuel sold.



Source: Umweltbundesamt

In the scenario **'with additional measures' (WAM)**, national total emissions are expected to decrease to 51.1 kt by 2030 (-18% compared to 2005).

For the period between 2021 and 2030, national total NH_3 emissions will decrease by 22.3%.

The main reason for the emission reductions is the projected decline in livestock numbers. In the WAM scenario, cattle numbers are projected to fall by 15% between 2021 and 2030 (WIFO & BOKU, 2023). Pig and poultry numbers are expected to decrease as well, by 18% and 21%, respectively.

Additional measures listed in the Austrian NAPCP and NECP as well as the obligatory measures regulated by Austria's Ammonia Reduction Ordinance (*Ammoniakreduktionsverordnung*) are responsible for the falling trend. The analyses at sub-sector level show that the lower livestock numbers and additional measures in animal feeding, animal husbandry and slurry storage will reduce emissions by 21% (i.e. -6.53 kt) in the sub-sector NFR 3.B Manure Management between 2021 and 2030. Emissions in the sub-sector NFR 3.D Agricultural Soils are expected to decrease by 26% (i.e. -8.00 kt) by 2030, mainly due to lower emissions from manure spreading as a result of the lower livestock numbers and an increased use of low-emission manure application techniques. Furthermore, according to the Austrian NECP and NAPCP, there will be a reduced need for mineral N fertilisers due to improved nitrogen management.

Table 349: Austrian national NH_3 emissions in kt and trend based on 'fuel sold' (Source: Umweltbundesamt).

NFR	Description	Emission Inventory 2023* [kt]					Scenario [kt]		Type of Scenario
		1990	2005	2010	2020	2021	2025	2030	
	Total	69.27	62.70	65.15	65.53	65.85	62.27	57.62	WEM
		69.27	62.70	65.15	65.53	65.85	58.46	51.13	WAM
1.A.1	Energy Industries	0.20	0.31	0.46	0.43	0.44	0.44	0.44	WEM
		0.20	0.31	0.46	0.43	0.44	0.44	0.44	WAM
1.A.2	Manufacturing Industries and Construction	0.33	0.43	0.42	0.39	0.40	0.40	0.40	WEM
		0.33	0.43	0.42	0.39	0.40	0.40	0.40	WAM
1.A.3.a, c, d, e	Off-Road Transport	0.01	0.01	0.01	0.01	0.01	0.01	0.01	WEM
		0.01	0.01	0.01	0.01	0.01	0.01	0.01	WAM
1.A.3.b	Road Transport	0.80	2.58	1.85	0.89	0.94	1.02	0.95	WEM
		0.80	2.58	1.85	0.89	0.94	0.99	0.92	WAM
1.A.4	Other Sectors	0.63	0.67	0.68	0.60	0.68	0.55	0.55	WEM
		0.63	0.67	0.68	0.60	0.68	0.54	0.52	WAM
1.A.5	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	WEM
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	WAM
1.B	Fugitive Emissions	IE	0.00	0.00	0.00	0.00	0.00	0.00	WEM
		IE	0.00	0.00	0.00	0.00	0.00	0.00	WAM
2.A,B,C, H,I,J,K,L	Industrial Processes	0.27	0.07	0.09	0.10	0.09	0.09	0.09	WEM
		0.27	0.07	0.09	0.10	0.09	0.09	0.09	WAM
2.D, 2.G	Solvent and Other Product Use	0.07	0.06	0.06	0.06	0.06	0.05	0.05	WEM
		0.07	0.06	0.06	0.06	0.06	0.05	0.05	WAM
3.B	Manure Management	29.66	28.29	29.79	31.26	31.56	30.41	28.07	WEM
		29.66	28.29	29.79	31.26	31.56	29.15	25.03	WAM
3.D	Agricultural Soils	36.91	29.16	30.59	30.56	30.40	28.05	25.79	WEM
		36.91	29.16	30.59	30.56	30.40	25.52	22.40	WAM
3.F, I	Field Burning and Other Agriculture	0.03	0.02	0.02	0.00	0.00	0.00	0.00	WEM
		0.03	0.02	0.02	0.00	0.00	0.00	0.00	WAM
5	Waste	0.37	1.09	1.17	1.24	1.27	1.26	1.27	WEM
		0.37	1.09	1.17	1.24	1.27	1.26	1.27	WAM

* *Data source: Austrian Emission Inventory 2023*

IE: included elsewhere; NA: not applicable; NO: not occurring

8.5 Fine Particulate Matter ($PM_{2.5}$)

Since 1990, $PM_{2.5}$ emissions have decreased by 48.9%. The decline since 2005 is estimated at 38.7%.

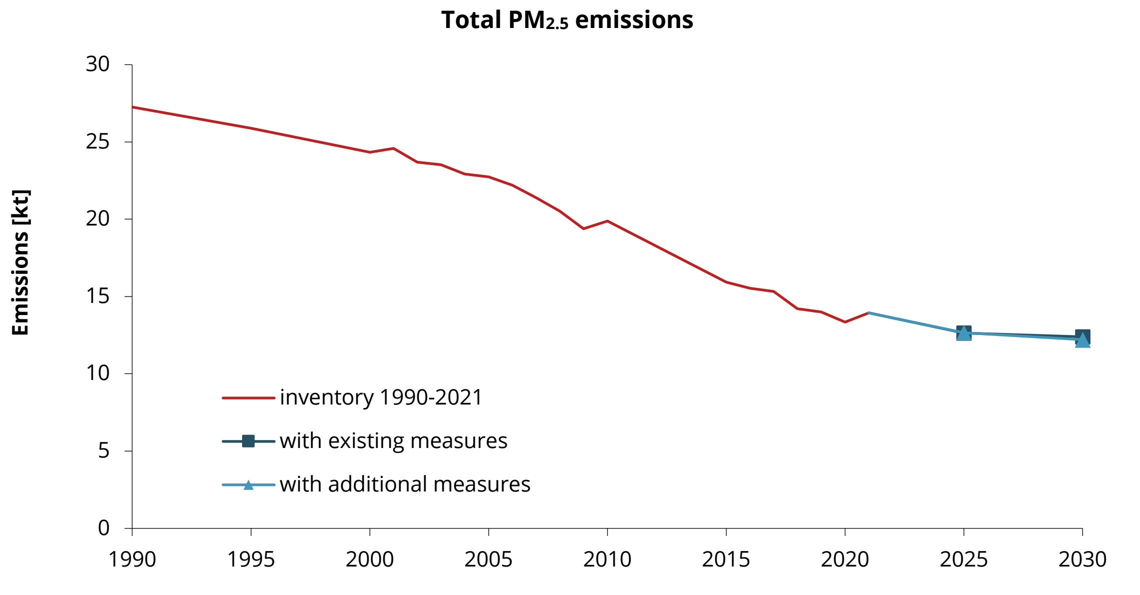
The largest falls were achieved through reduced coal consumption in households (NFR 1.A.4.b.1) and improved vehicle exhaust after-treatment technologies in road transport (NFR 1.A.3.b).

From 2020 to 2021, $PM_{2.5}$ emissions increased by 0.6 kt (+4.5%) due to higher biomass consumption from residential heating (NFR 1.A.4.b.1) because of the colder weather and the higher demand for heating.

With a share of about 45.1%, the residential stationary sector (NFR 1.A.4.b.1) was the main source of total $PM_{2.5}$ emissions in 2021. The change in emissions between 2020 and 2021 by +9.4% was due to the increased volume of biomass used for heating because of the colder weather in 2021. To some extent, the overall decreasing trend of NFR 1.A.4.b.1 Residential Stationary Heating since 2005 can also be explained by efficiency improvements through thermal renovation and a switch to modern biomass boilers and stoves (improvements in fuel combustion technologies).

In the scenario **'with existing measures' (WEM)**, the national total emissions are expected to decrease to 12.4 kt by 2030 (-45.5% compared to 2005).

Figure 61: Historical (1990–2021) and projected $PM_{2.5}$ emissions for WEM and WAM (2022–2030) based on fuel sold.



Source: Umweltbundesamt

In the WEM scenario, $PM_{2.5}$ emissions of NFR 1.A.4 Other Sectors are expected to decrease by 21.8% (i.e -1.6 kt) in 2030 compared to 2021. $PM_{2.5}$ emission reductions are mainly due to a trend away from manually fed fuel wood boilers and wood stoves. Furthermore, biomass heating systems will be used in gradually more energy-efficient buildings. Thus, a declining energy demand for fuel wood (and coal) is responsible for $PM_{2.5}$ reductions. This is also supported by the impact of eco-design provisions for the installation of new heating systems.

Total $PM_{2.5}$ emissions from the road transport sector (NFR 1.A.3.b) are expected to decrease by about 19.3% (i.e. -0.4 kt) compared to 2021. Whereas exhaust emissions from cars and trucks are expected to fall by 2030 (due to a higher penetration of vehicles fitted with filters and an increased share of BEVs), emissions from automobile road abrasion and vehicles (tyres, brake wear) are set to increase slightly because of an increase in total vehicle kilometres driven.

In the energy industries sector (NFR 1.A.1), an increase in $PM_{2.5}$ emissions has been noted for 2030 compared to 2021 (+31.5%; +0.3 kt), generally due to a rise in biomass usage for electricity and heat generation.

Emissions from NFR 1.A.2 Manufacturing Industries and Construction decreased by 65.7% between 2005 and 2021 due to the installation of electrostatic precipitators and bag filters. By 2030, more of these devices will be in use, but the effect will be offset by an increase in emissions due to economic growth.

In the scenario **'with additional measures' (WAM)**, national total emissions are expected to decrease to 12.3 kt by 2030 (-46.1% compared to 2005).

$PM_{2.5}$ emissions from NFR 1.A.4 Other Sectors are expected to fall by 22.7% (i.e. -1.69 kt) by 2030 compared to 2021. Total $PM_{2.5}$ emissions from the road transport sector (including 'fuel exports') are expected to decrease by about 25.0% (i.e. -0.49 kt) compared to 2021.

Due to higher inputs of biomass in energy consumption, $PM_{2.5}$ emissions in the NFR 1.A.2 and NFR 2 sectors are slightly higher than in the WEM scenario.

Table 350: Austrian national $PM_{2.5}$ emissions in kt and trend based on 'fuel sold' (Source: Umweltbundesamt).

NFR	Description	Emission Inventory 2023* [kt]					Scenario [kt]		Type of Scenario
		1990	2005	2010	2020	2021	2025	2030	
	Total	27.26	22.75	19.89	13.35	13.94	12.64	12.39	WEM
		27.26	22.75	19.89	13.35	13.94	12.65	12.21	WAM
1.A.1	Energy Industries	0.85	0.80	1.10	0.96	1.00	1.19	1.32	WEM
		0.85	0.80	1.10	0.96	1.00	1.27	1.35	WAM
1.A.2	Manufacturing Industries and Construction	1.88	1.85	1.52	0.70	0.63	0.72	0.75	WEM
		1.88	1.85	1.52	0.70	0.63	0.70	0.70	WAM
1.A.3.a, c, d, e	Off-Road Transport	0.70	0.66	0.52	0.29	0.31	0.37	0.38	WEM
		0.70	0.66	0.52	0.29	0.31	0.36	0.37	WAM
1.A.3.b	Road Transport	5.70	7.21	4.89	2.01	1.96	1.73	1.58	WEM
		5.70	7.21	4.89	2.01	1.96	1.66	1.47	WAM
1.A.4	Other Sectors	13.31	9.02	9.15	6.88	7.45	6.09	5.82	WEM
		13.31	9.02	9.15	6.88	7.45	6.06	5.76	WAM
1.A.5	Other	0.02	0.02	0.02	0.01	0.01	0.01	0.01	WEM
		0.02	0.02	0.02	0.01	0.01	0.01	0.01	WAM
1.B	Fugitive Emissions	0.11	0.09	0.07	0.05	0.05	0.05	0.05	WEM
		0.11	0.09	0.07	0.05	0.05	0.05	0.04	WAM
2.A,B,C, H,I,J,K,L	Industrial Processes	3.56	2.07	1.52	1.46	1.53	1.53	1.53	WEM
		3.56	2.07	1.52	1.46	1.53	1.56	1.57	WAM
2.D, 2.G	Solvent and Other Product Use	0.53	0.49	0.50	0.40	0.40	0.40	0.38	WEM
		0.53	0.49	0.50	0.40	0.40	0.40	0.38	WAM

NFR	Description	Emission Inventory 2023* [kt]					Scenario [kt]		Type of Scenario
		1990	2005	2010	2020	2021	2025	2030	
3.B	Manure Management	0.13	0.11	0.11	0.11	0.11	0.11	0.09	WEM
		0.13	0.11	0.11	0.11	0.11	0.11	0.09	WAM
3.D	Agricultural Soils	0.14	0.15	0.14	0.14	0.14	0.13	0.13	WEM
		0.14	0.15	0.14	0.14	0.14	0.13	0.13	WAM
3.F, I	Field Burning and Other Agriculture	0.07	0.06	0.05	0.00	0.00	0.00	0.00	WEM
		0.07	0.06	0.05	0.00	0.00	0.00	0.00	WAM
5	Waste	0.25	0.23	0.31	0.34	0.34	0.33	0.34	WEM
		0.25	0.23	0.31	0.34	0.34	0.33	0.34	WAM

** Data source: Austrian Emission Inventory 2023*

IE: included elsewhere; NA: not applicable; NO: not occurring

8.6 Planned improvements

For the next projections reporting cycle in 2025, it is planned to implement the recommendations from the NACP Review 2023 (please refer to Table 343).

9 REPORTING OF GRIDDED EMISSIONS AND LPS

According to the UNECE Convention on Long-Range Transboundary Air Pollution as well as under the NEC Directive parties are obligated to report gridded emissions and large point sources (LPS). Being in line with the 2023 CLRTAP Reporting Guidelines both datasets shall be reported every four years from 2017 onwards for the year x-2.

In submission 2021 Austria reported data on gridded emissions based on fuel sold and on fuel used for the reporting year 2019 as well as recalculated data for the years 2000, 2005, 2010 and 2015. The data sets of 2000, 2005 and 2010 have been adjusted to the new “EMEP grid” referring to a 0.1° × 0.1° latitude-longitude projection. LPS data were reported for 2019. Data sets for 2010 and 2015 have been recalculated. The data for the years 1990 and 1995, for gridded emissions as well as LPS, were latest reported in submission 2012[158].

This chapter includes descriptions on input data, methodology and results of the Austrian gridded emissions for 2000, 2005, 2010, 2015 and 2019 as well as on large point sources (LPS) for 2010, 2015 and 2019.

9.1 Gridded Emissions

9.1.1 Background Information

At the 36th session of the EMEP Steering Body it was suggested to increase the spatial resolution of the EMEP grid from 50 km x 50 km to 0.1° x 0.1° in order to improve quality of monitoring. In the 2023 CLRTAP Reporting Guidelines the “EMEP grid” refers to a 0.1° × 0.1° latitude-longitude projection in the geographic coordinate World Geodetic System (WGS) latest revision, WGS 84. Therefore, the spatial allocation of the latest Austrian Air Emission Inventory (submission 2021) is reported accordingly. In submission 2021 there was a need to adjust the base data and the statistical background to latest databases and updated GIS data.

The mandatory reporting of gridded emissions includes the following pollutants: SO_x, NO_x, NH_3, NMVOC, CO, PM_{10}, $PM_{2.5}$, Pb, Cd, Hg, PCDD/F, PAHs, HCB and PCBs.

The applied method is based on (Orthofer et al., 2002 and Orthofer, 2007) but had to be adapted accordingly due to the improved resolution. So the number of grid cells for Austria increased from about 60 (50 km x 50 km) to 1 144 (0.1° × 0.1°).

9.1.2 Emissions according to the GNFR-Code

In Table 351 the NFR sectors are listed which were used for reporting of gridded emission data based on the Austrian Air Emission Inventory. This is in line with the EMEP/EEA GB 2019 (EEA, 2019).

[158] https://cdr.eionet.europa.eu/at/un/CLRTAP_AT/envt2haba/

Table 351: GNFR categories, corresponding NFR categories and Tier methods used for spatial distribution.

GNFR ID	GNFR Name	NFR categories	Tier methods used
A_PublicPower	Public Power	1.A.1.a	3
B_Industry	Industry	1.A.1.b, 1.A.1.c, 1.A.2.a, 1.A.2.b, 1.A.2.c, 1.A.2.d, 1.A.2.e, 1.A.2.f.i, 1.A.2.g.viii, 2.A., 2.B, 2.C, 2.D.3.b, 2.D.3.c, 2.H, 2.I, 2.J, 2.K, 2.L	2 and higher
C_OtherStationary Comb	Other stationary combustion	1.A.4.a.i, 1.A.4.b.i, 1.A.4.c.i, 1.A.5.a	3
D_Fugitive	Fugitive Emissions	1.B.1, 1.B.2	1
E_Solvents	Solvents	2.D.3.a, 2.D.3.d, 2.D.3.e, 2.D.3.f, 2.D.3.g, 2.D.3.h, 2.D.3.i, 2.G	1
F_RoadTransport	Road Transport	1.A.3.b	3
G_Shipping	Shipping	1.A.3.d.i(ii), 1.A.3.d.ii	1
H_Aviation	Aviation	1.A.3.a.i(i), 1.A.3.a.ii(i)	3
I_Offroad	Offroad	1.A.2.f.ii, 1.A.2.g.vii, 1.A.3.c, 1.A.3.e.i, 1.A.3.e.ii, 1.A.4.a.ii, 1.A.4.b.ii, 1.A.4.c.ii, 1.A.4.c.iii, 1.A.5.b	2
J_Waste	Waste	5	1 and higher
K_AgriLivestock	Agriculture – Livestock	3.B	3
L_AgriOther	Agriculture – Other	3.D, 3.F, 3.I	2
M_Other	Other emission sources	-	Not occurring

9.1.3 Allocation of emissions

The following chapter describes the GIS based method and the proxy data, which was used for the allocation of national emissions to the EMEP Grid. The same method was applied for data based on fuel sold and fuel used. The data was intersected with the EMEP Grid and weighted within ArcGIS 10.8. In a second step the emissions were distributed via database calculations.

Austria is located in central Europe and has a heterogeneous topography. The main part is influenced by alpine climate with more balanced temperatures and precipitation, whereas the eastern part of the country is characterized by continental climate. So it was considered necessary to take into account the regional heterogeneity in case of source categories with a broad spatial distribution.

9.1.3.1 Applied data sources for gridded emission

Information about the main proxy data is listed in Table 352 and is also described in more detail below. These data are the basis for the disaggregation of the national emissions, which was carried out on NFR level. In a final step the results were aggregated to the GNFR sectors as it is required in the CLRTAP reporting template for the gridded emissions (Annex V).

Due to lack of data availability, the proxy data set for the entire time series 2000 to 2019 is not always fully homogeneous. Various datasets and sources were used with the aim of compiling the most accurate and high-resolution data as possible. Therefore, an interdisciplinary approach has been chosen within the expert group to ensure that the proxy data matched the data sources and their timeliness.

Compared to the reporting of earlier years, the access to data has become easier. Austria has well-developed metadata portals for Open data[159] as well as within the INSPIRE service infrastructure[160]. Therefore, it was possible to find contact persons and to clarify licensing issues.

Table 352: Overview of proxy data.

Data set	Data description	Data source	Year	Resolution/data specification
Topographic map	Administrative units, territorial boarders according to the needed database	Federal Office for Metrology and Surveying (BEV)[161]	2002–2019	Cadaster
River network	Danube, Shipping area	BMLRT[162]	2019	Vector data
Employees in the manufacturing industries sector	Economic activities on municipal level (NACE classification), register census 2011	Statistik Austria[163]	2011, 2015, 2018	Municipal level; cadaster, federal state level
Population	Population per municipality	Statistik Austria	2000–2019	Municipal level
Permanent settlement area	Statistical processed data according to Corine Landcover	Statistik Austria	2000, 2006, 2012, 2018	25 m raster
Corine Land cover	Raster data on land cover	Environment Agency Austria[164]	2000, 2006, 2012, 2018	25 x 25 m raster
Commuters	Amount of commuters leaving place of residence	Statistik Austria	2014	Municipal level
Road and railway network	Vector data for classified road and railway network	Graph Integration Platform (GIP) Austria[165] /ÖBB[166]	2016/2019	Vector data
Traffic census points	Geo-referenced information on traffic census on motorways	ASFINAG[167]	2015 (2001–2019)	Points, coordinates, (census data)
Register of buildings and dwellings	Geo-referenced information on dwellings and buildings	Statistik Austria	2019	Address data Dwellings an buildings stock data
Rural- urban typology	Statistical processed data	Statistik Austria	2015	Municipal level
Animal livestock numbers	INVEKOS data base (Integrated Administration and Control) System (IACS)	Agrarmarkt Austria (AMA)[168]	2015, 2019	Points coordinates

[159] Austrian Open data Portal https://www.data.gv.at/ (23.4.2021)

[160] https://geometadatensuche.inspire.gv.at/metadatensuche/srv/ger/catalog.search#/home (23.4.2021)

[161] https://www.bev.gv.at/ (23.4.2021)

[162] Federal Ministry of Agriculture, Regions and Tourism https://www.bmlrt.gv.at/ (23.4.2021)

[163] https://www.statistik.at/web_de/statistiken/index.html (23.4.2021)

[164] https://www.umweltbundesamt.at/ (23.4.2021)

[165] http://www.gip.gv.at/ (23.4.2021)

[166] Austrian federal railways (ÖBB)

[167] http://www.asfinag.at/home-en (23.4.2021)

[168] https://www.ama.at/Intro (23.4.2021)

Data set	Data description	Data source	Year	Resolution/data specification
Animal livestock numbers	Agricultural structure survey	Statistik Austria	2010	Municipal level
Large Point Sources (LPS)	Geo-referenced information on power plants, large industrial plants	Official data submissions 2017 under Regulation (EC) No 166/2006 and Directive 2010/75/EU	2019	Address data
Waste treatment	Geo-referenced information on large point plants in the waste sector (LPS); correlation with population numbers	Official data submissions 2017 under Regulation (EC) No 166/2006 and Directive 2010/75/EU, Statistik Austria	2019	Municipal level
Airports	Terminal controlled area TMA	Austro Control[169]	2020	Polygon

Economic activities

There is a strong correlation between the NACE classification (ÖNACE 2008 classification) and the NFR sectors of manufacturing industries. The amount of employees in the different NACE sectors within the manufacturing industry sector at the municipal level was taken as basis to generate the proxy for the respective NFR sectors. These proxies were finally combined to the aggregated GNFR sector *B_Industry*.

With regard to the whole time series, the definitions of the NACE codes before 2008 (ÖNACE, 2003) do not correspond directly to the current ones. Thus, these categories had to be transferred.

Population and permanent settlement data

Population data is available at the municipality level for the entire period 2000 to 2019. However, the geometry data (boundaries) only go back to 2002. In Austria, there were several municipal area reforms in recent years. These changes had to be taken into account for all data based on district codes (LAU2 Codes).

The permanent settlement area combines Corine Landcover data and economic statistics and is a data set compiled by Statistik Austria.

As described before, the topographical heterogeneity within Austria had to be considered. So, the population data on municipal level and the permanent settlement area was combined for sectors and categories with a wide spatial distribution spectrum. As an example for this approach the NFR sector Solvent Use can be mentioned. The proxy data used for *C_OtherStationaryComb* is described as follow:

- For NFR *1.A.4.a.i* PM_{10} and $PM_{2.5}$ emissions from bonfire and open fire pits of the Austrian Air Emission Inventory on federal level (BLI) were allocated with the proportion of the rural population (municipalities with less than 30 000 inhabitants).
- For NFR *1.A.4.b.i* PM_{10} and $PM_{2.5}$ emissions from barbecue of the Austrian Air Emission Inventory on federal level (BLI) were allocated with the proportion of the total population.

[169] https://www.austrocontrol.at/ (23.4.2021)

- For NFR *1.A.4.b.ii* SO_2, NO_x, NH_3, NMVOC, CO, PM_{10} and $PM_{2.5}$ emissions from mobile sources of the Austrian Air Emission Inventory on national level (OLI) were allocated with the proportion of the rural population (municipalities with less than 30 000 inhabitants).
- For NFR *1.A.4.b.ii* Pb, Cd, Hg, PCDD/F, PAH, Benzo_a, Benzo_b, Benzo_k, Indeno, HCB and PCB emissions from mobile sources of the Austrian Air Emission Inventory on federal level (BLI) were allocated with the proportion of the rural population (municipalities with less than 30 000 inhabitants).

Land use statistics

Land use statistics were taken from the Corine Land cover statistics as basis for soil related emissions, which are included in GNFR sector L_AgriOther. The Corine Land cover also provides the base for calculations of the permanent settlement areas, which is described above. In addition, the data relevant for fertiliser and nitrogen are based on the results of a national study on nitrogen balances (BMLRT, 2020b).

Traffic network and traffic census data

The river network as well as the road network builds the proxy of line based emission data. These vector data is intersected with the EMEP Grid. All shipping emissions are allocated to the Danube River.

The traffic network is taken from a national harmonized street and railway dataset. The preparation of these proxies required a few steps. First the traffic network was divided in motorways, streets in built-up areas and rural traffic net. In a second step the different street levels were weighted in three different ways. The motorways were combined with traffic census data from measuring points. The main routes with intense traffic were weighted with a higher level than less frequented sections. The built-up areas were weighted with commuters in a working distance of 1–4 km and local stationary inhabitants. For rural traffic commuters within a distance between 5 and 50 km the street segments were taken for assessment. It was assumed that these commuters leave their place of residence and travel all days. These weighted databases were finally combined with the national CLRTAP emission data according to the NFR subsectors. In a last step the NFR sectors were aggregated to the respective GNFR sectors. These calculations were done for all pollutants separately.

Energy demand model for space heating

The final energy demand by energy carrier and by fuel technology for NFR categories 1.A.4.a.i and 1.A.4.b.i of the energy demand model for space heating 1990–2018 (see IIR 2020) was extrapolated with its successor, which covers the timespan from 1990–2019 (see chapter 3.1.9) to calculate local emissions 1990–2019 at the municipal level. The municipalities' final energy demand share of the federal state total per category is the allocation key for the emissions of the Austrian Air Emission Inventory on federal level (BLI). Further distribution to the EMEP Grid cell uses register data of buildings and dwellings.

Register of buildings and dwellings

Geo-referenced information on dwellings and buildings (e.g. heating systems, age of buildings, useful floor area etc.) are the proxy data for emissions from stationary fuel combustion in buildings and in agriculture, forestry, fishing and fishing industries (NFR categories 1.A.4.a.i, 1.A.4.b.i and 1.A.4.c.i). Due to the information in the register of buildings and dwellings an index was created to distribute the emissions of the Austrian Air Emission Inventory on federal level (BLI) combined with the usage of heating systems and type of buildings. These indices distinguish between all pollutants.

- For NFR categories *1.A.4.a.i* and *1.A.4.b.i* the final energy demand by energy carrier group was calculated using the method from the energy demand model for space heating based on data of the register of buildings and dwellings for the building stock of the year 2019. Intermediate results were summed up starting from construction period '1919 and before' up to the latest construction year of the respective estimated former year (1990–2018). The final energy demand by energy carrier group and municipality in the EMEP Grid cells' share of the municipality total per category is the allocation key for the emissions of the respective year in the associated municipality.
- For NFR category *1.A.4.c.i* the usable floor area for agricultural use of the register of buildings and dwellings of the year 2019 was evaluated. Intermediate results were summed up starting from construction period '1919 and before' up to the latest construction year of the respective estimated earlier year (1990–2018). The usable floor area for agricultural use in the EMEP Grid cells' share of the federal state total per category is the allocation key for the emissions of the Austrian Air Emission Inventory on federal level (BLI) in the respective year.

Rural- urban typology

Rural- urban typology is a statistical data base which defines the main regional centres and the urban areas trough population density, infrastructures, commuter traffic and reachability. This proxy was taken to calculate the transport emissions from GNFR sector *I_Offroad*.

Animal livestock numbers

For the GNFR sector *K_AgriLivestock* the animal livestock numbers taken from the Integrated Administration and Control System (IACS) data base (INVEKOS), available as point data, were used as proxy. For the timeseries 2000 to 2010 data of agricultural structure survey were in use. The respective animal categories are consistent with those included in the Austrian Air Emission Inventory on NFR level. Another approach (as used in Orthofer, 2002) could have been the amount of employees within the farming business. However, the animal livestock numbers represent the reported emissions of manure management better than the employees as they are not relevant for emissions. So, the usage of livestock data is fully in line with the calculation of agricultural emissions from NFR sector Manure Management.

Large Point Sources

The large point emission sources were directly allocated to their grid cells considering two classes of emission levels (emission high above and below 100 m). LPS data are reported by Austrian plants

- according to Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) (Large Combustion Plants – LCP) → stack heights
- as well as under Regulation (EC) No 166/2006 on the establishment of a European Pollutant Release and Transfer Register → emissions

The required information on emission values, coordinates, stack heights etc. was matched for each relevant NFR sector and aggregated to the respective GNFR sectors to be in line with the CLRTAP reporting obligation (see reporting template Annex VI). For further information please refer to Chapter 9.2.

Waste treatment

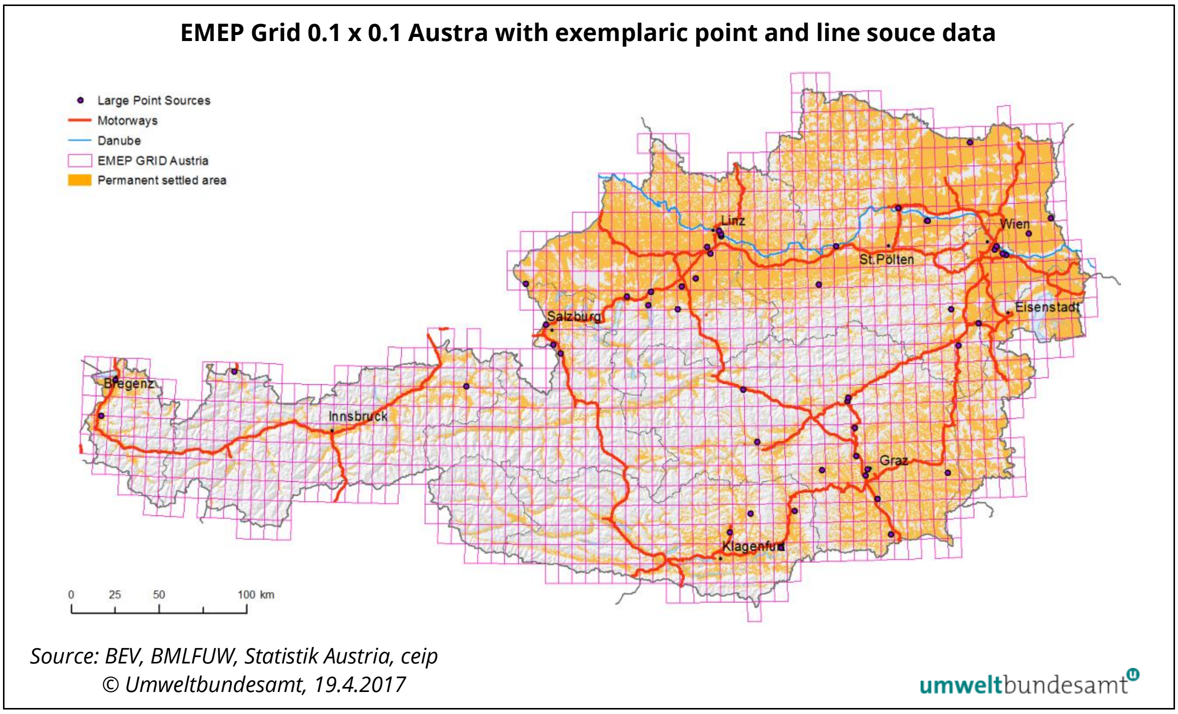
Two different data bases have been taken as proxy for GNFR sector *J_Waste*. On the one hand the respective large point sources with activities in the waste sector have been used as proxy data for waste treatment. On the other hand the population in permanent settlement areas was applied for disaggregating the emissions from waste.

9.1.3.2 Austria's allocation of emissions for the EMEP Grid

Method of allocation

Emissions from point sources were directly allocated to the coordinates of the individual emitters. Line based emissions and emissions from area sources were disaggregated from the national total emissions to the described proxy data (see Table 352). In some cases, the set of proxy data could be used as one pure proxy. However, in several cases (e.g. traffic network) a combination and weighted proxy, respectively, was necessary.

Figure 62: EMEP Grid Austria – example for allocation of the motorway network and waterways (Danube).



A short and simple example of the allocation of the motorway network and waterways (Danube) is illustrated in Figure 62 to point out the method. The length of the segments within the grid cell is multiplied with the national emission divided by the total emissions.

9.1.4 Results of gridded data

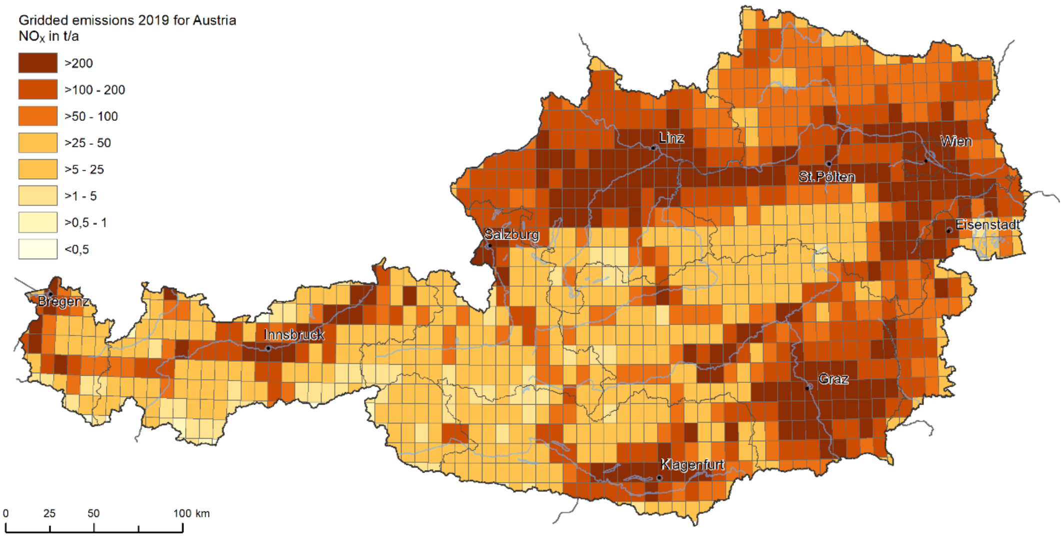
In this chapter the EMEP grid results for the main pollutants NO_x, SO_2, NMVOC and NH_3 as well as for $PM_{2.5}$ based on fuel sold are presented. In the case of NO_x there is a significant difference between results for fuel sold and fuel used, therefore maps have been generated for both.

Emissions of grid cells exceeding the national border have been adjusted proportionally. This methodology is only applied for the purpose of illustrating the results in the following maps.

9.1.4.1 Spatial distribution of NO_x emissions in 2019

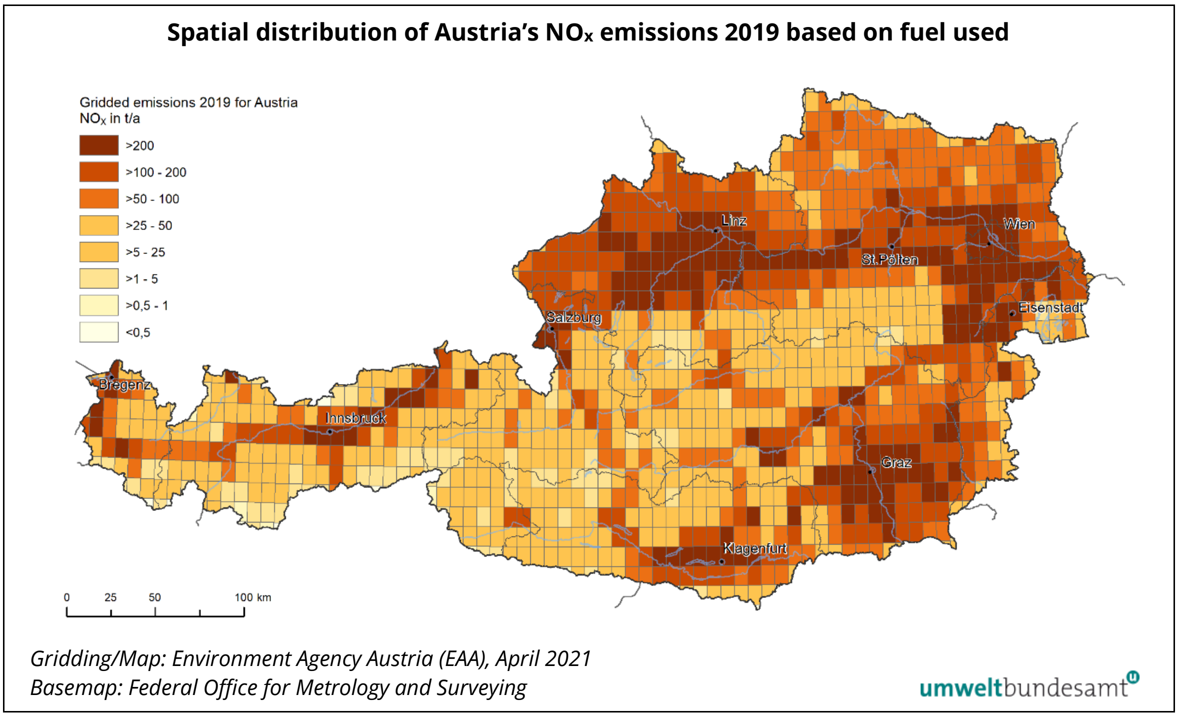
Figure 63: Spatial distribution of Austria´s NO_x emissions 2019 based on fuel sold.

Spatial distribution of Austria's NO_x emissions 2019 based on fuel sold



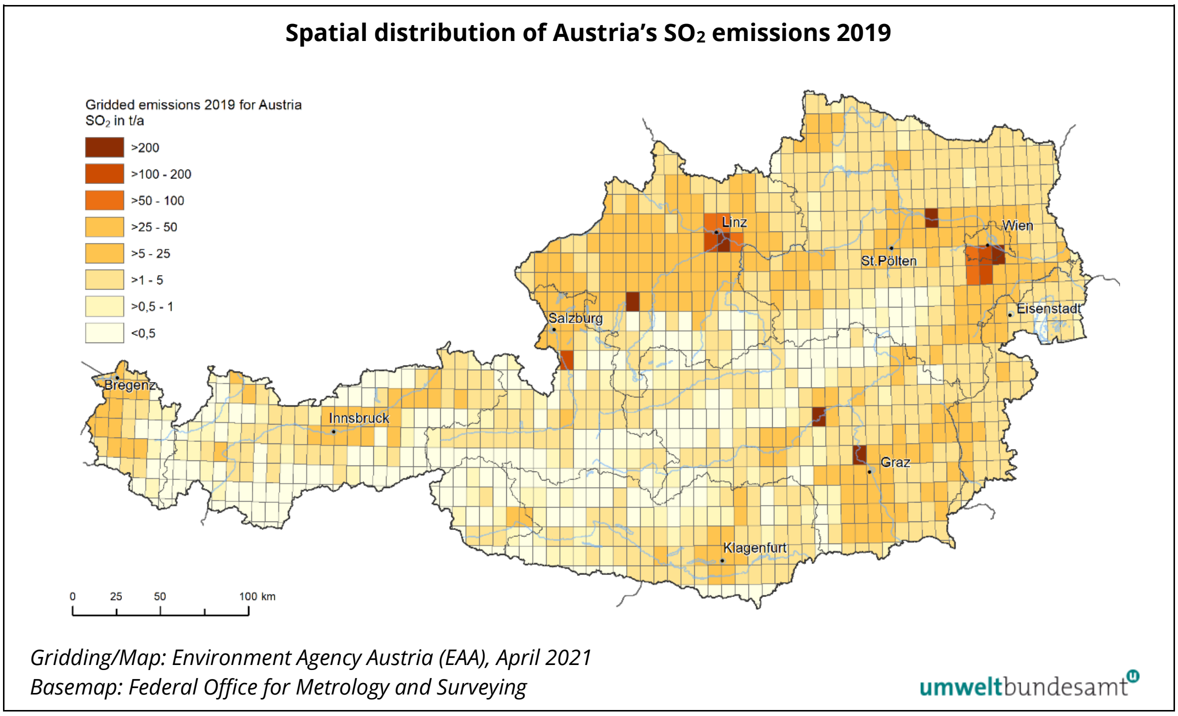
Gridding/Map: Environment Agency Austria (EAA), April 2021
Basemap: Federal Office for Metrology and Surveying

Figure 64: Spatial distribution of Austria´s NO_x emissions 2019 based on fuel used.



9.1.4.2 Spatial distribution of SO_2 emissions in 2019

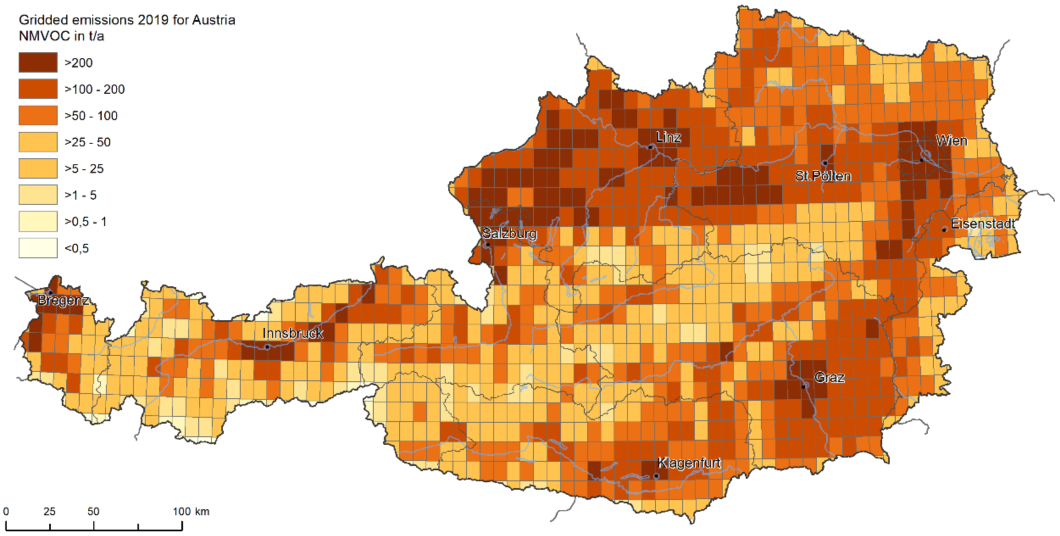
Figure 65: Spatial distribution of Austria´s SO_2 emissions 2019 based on fuel sold.



9.1.4.3 Spatial distribution of NMVOC emissions in 2019

Figure 66: Spatial distribution of Austria´s NMVOC emissions 2019 based on fuel sold.

Spatial distribution of Austria's NMVOC emissions 2019



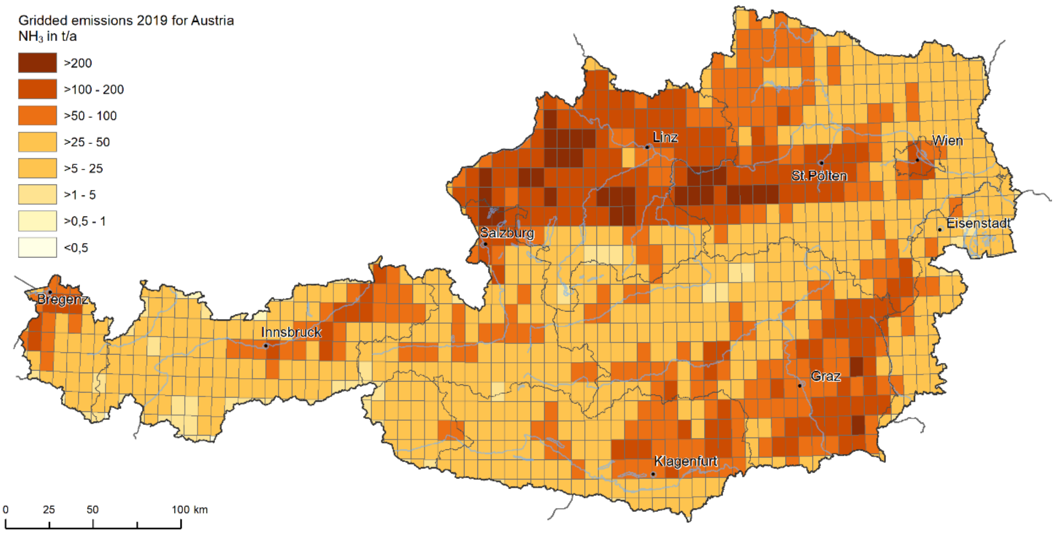
Gridding/Map: Environment Agency Austria (EAA), April 2021
Basemap: Federal Office for Metrology and Surveying

umweltbundesamt

9.1.4.4 Spatial distribution of NH_3 emissions in 2019

Figure 67: Spatial distribution of Austria´s NH_3 emissions 2019 based on fuel sold.

Spatial distribution of Austria's NH_3 emissions 2019



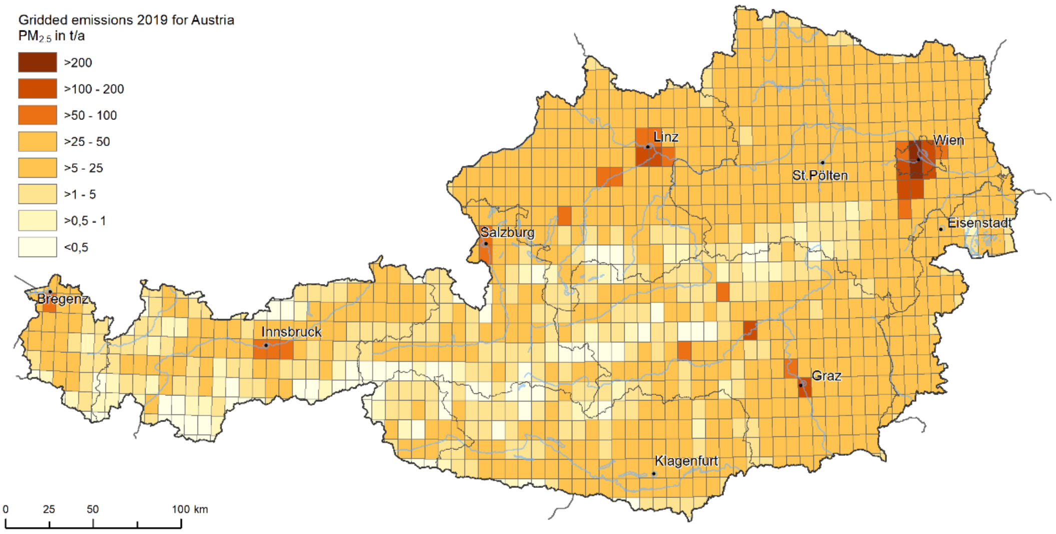
Gridding/Map: Environment Agency Austria (EAA), April 2021
Basemap: Federal Office for Metrology and Surveying

umweltbundesamt

9.1.4.5 Spatial distribution of $PM_{2.5}$ emissions in 2019

Figure 68: Spatial distribution of Austria´s $PM_{2.5}$ emissions 2019 based on fuel sold.

Spatial distribution of Austria's $PM_{2,5}$ emissions 2019



Gridding/Map: Environment Agency Austria (EAA), April 2021
Basemap: Federal Office for Metrology and Surveying

umweltbundesamt

9.2 Large Point Sources (LPS)

"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 of the revised 2014 CLRTAP Reporting Guidelines.

9.2.1 Activity Data

In the following table an overview of the required information and the respective data source is presented.

Table 353: Overview of data sources for LPS (required in ANNEX VI).

Activity data	Data source
LPS	Facility name, owner and (if necessary for distinguishability) parts of the address according to E-PRTR reporting (regulation (EC) No 166/2006 on the establishment of a European Pollutant Release and Transfer Register)
GNFR	Expert judgement
PRTR Facility ID	E-PRTR reporting

Activity data	Data source
Height Class (1-5)	LCP[170] reporting according to directive 2010/75/EU on industrial emissions (integrated pollution prevention and control). If there were more than one height classes available, the upper value was taken
Longitude/latitude	E-PRTR reporting
Emissions for 2000 and 2005	CLRTAP submission 2012. For further details please refer to Austria´s IIR 2012[171]
Emissions for 2010, 2015 and 2019	E-PRTR reporting

9.2.2 Methodological Issues

The applied methodology is in accordance with the revised 2014 CLRTAP Reporting Guidelines. The Austrian LPS data is prepared in line with the list of pollutants to be reported if the applicable threshold value is exceeded as demonstrated in Table 1 of the CLRTAP Reporting Guidelines.

PM emissions

$PM_{2.5}$ emissions are not reported under the E-PRTR Regulation. As PM_{10} emissions are submitted under E-PRTR, $PM_{2.5}$ were be calculated based on the sectoral composition of TSP and PM_{10} in line with the Austrian Air Emission Inventory.

9.3 Recalculations

For the years 2000 and 2005 no recalculations have been carried out for the LPS. Data for 2010 and 2015 have been recalculated based on the updated E-PRTR reports.

For the gridded data, the years 2000, 2005 and 2010 have been adjusted to the new “EMEP grid” referring to a 0.1° × 0.1° latitude-longitude projection. Furthermore, these data sets were improved by using more suitable proxy data.

9.4 Planned Improvements

It is planned to implement the recommendations from the NEC Review 2021 (EC, 2021a) regarding gridded data and LPS data for the next reporting cycle (submission 2025).

[170] Large Combustion Plants

[171] https://cdr.eionet.europa.eu/at/un/CLRTAP_AT/envt2haba/

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11 ABBREVIATIONS

AMA.................................. Agrarmarkt Austria

ASFINAG .... Autobahnen- und Schnellstraßen-Finanzierungs-Aktiengesellschaft

BAWP .... Bundes-Abfallwirtschaftsplan (Federal Waste Management Plan)

BLI .... Austrian Air Emission Inventory on federal level ("Bundesländer Luftschadstoffinventur")

BMDW............................... Bundesministerium für Digitalisierung und Wirtschaftsstandort (Federal Ministry for Digital and Economic Affairs)

BMK.................................. Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation & Technologie; (Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology) (formerly BMNT)

BML .... Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft; (Federal Ministry of Agriculture, Forestry, Regions and Water Management), since 2022

BMLFUW........................... Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (Federal Ministry for Agriculture, Forestry, Environment and Water Management), until 2017

BMLRT............................... Bundesministerium für Landwirtschaft, Regionen und Tourismus (Federal Ministry of Agriculture, Regions and Tourism), formerly BMNT

BMNT .... Bundesministerium für Nachhaltigkeit und Tourismus (Federal Ministry of Sustainability and Tourism), formerly BMLFUW

BMUJF .... Bundesministerium für Umwelt, Jugend und Familie (Federal Ministry for Environment, Youth and Family (before 2000)

BUWAL.............................. Bundesamt für Umwelt, Wald und Landschaft. Bern (The Swiss Agency for the Environment, Forests and Landscape (SAEFL), Bern)

CAN .... Calcium Ammonium Nitrate (Fertilizer)

CORINAIR .... Core Inventory Air

CORINE .... Coordination d´information Environmentale

CRF .... Common Reporting Format

DKDB................................ Dampfkesseldatenbank (Austrian annual steam boiler inventory)

EC .... European Community

EDM.................................. Electronic Data Management

EEA .... European Environment Agency

EIONET.............................. European Environment Information and Observation NETwork

EMEP .... Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe

ETS .... Emission Trading System

EPER .... European Pollutant Emission Register

E-PRTR .... European Pollutant Release and Transfer Register

FC .... Fuel consumption

GDP .... Gross Domestic Product

GEORG .... Grazer Emissionsmodell für Off-Road Geräte

GPG .... Good Practice Guidance (of the IPCC)

HBEFA .... "Handbook of Emission Factors"

HDV .... Heavy Duty Vehicle

HM .... Heavy Metals

IEA .... International Energy Agency

IEF .... Implied emission factor

IFR .... Instrument Flight Rules

IIR .... Informative Inventory Report

IPCC .... Intergovernmental Panel on Climate Change

LTO .... Landing/Take-Off cycle

MCF .... Methane Conversion Factor

MEET .... MEET – Methodology for calculating transport emissions and energy consumption

MMS .... Manure Management System

NACE .... Nomenclature des activites economiques de la Communaute Europeenne

NAPFUE .... Nomenclature for Air Pollution Fuels

NEC .... National Emissions Ceiling (Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants – NEC Directive)

NEMO .... Network Emission Model

NFR .... Nomenclature for Reporting (Format of Reporting under the UNECE/LRTAP Convention)

NIR .... National Inventory Report (Submission under the United Nations Framework Convention on Climate Change)

NISA .... National Inventory System Austria

NPK..................... .... Nitrogen (N) Phosphorus (P) and Potassium (K) (Fertilizer)

OECD................................ Organisation for Economic Co-operation and Development

ODS .... Ozone depleting substances

OLI .... Österreichische Luftschadstoff Inventur (Austrian Air Emission Inventory)

PC .... Passenger Car

PM .... Particulate Matter

POPs .... Persistent Organic Pollutants

PRTR................................. Pollutant Release and Transfer Register

QA/QC............................... Quality Assurance/Quality Control

QMS .... Quality Management System

RT .... Road Truck

RWA.................................. Raiffeisen Ware Austria (see www.rwa.at)

SNAP .... Selected Nomenclature on Air Pollutants

SOP .... Standard Operation Procedure

TAN .... Total ammoniacal nitrogen

Umweltbundesamt.. .... Environment Agency Austria

UNECE/LRTAP .... United Nations Economic Commission for Europe.Convention on Long-range Transboundary Air Pollution

UNFCCC............................ United Nations Framework Convention on Climate Change

VFR .... Visual Flight Rules

VRF .... Variable Refrigerant Flow

VMOe .... Verkehrs-Mengenmodell-Oesterreich

WIFO .... Wirtschaftsforschungsinstitut (Austrian Institute for Economic Research)

Chemical Symbols

SymbolName

Greenhouse gases

CH_4 .... Methane
CO_2 .... Carbon Dioxide
N_2O.......... Nitrous Oxide
HFCs........ Hydroflurocarbons
PFCs .... Perfluorocarbons
SF_6 .... Sulphur hexafluoride
NF_3........... Nitrogen Trifluoride

Further chemical compounds

CO .... Carbon Monoxide
Cd .... Cadmium
NH_3.......... Ammonia
Hg............ Mercury
NO_x.......... Nitrogen Oxides (NO plus NO_2)
NO_2.......... Nitrogen Dioxide
NMVOC... Non-Methane Volatile Organic Compounds
PAH .... Polycyclic Aromatic Hydrocarbons
Pb .... Lead
POP .... Persistent Organic Pollutants
SO_2 .... Sulfur Dioxide
SO_x........... Sulfur Oxides

Units and Metric Symbols

UNIT	Name	Unit for
g	gram	mass
t	ton	mass
W	watt	power
J	joule	calorific value
m	meter	length

Mass Unit Conversion		
1g		
1kg	= 1 000 g	
1t	= 1 000 kg	= 1 Mg
1kt	= 1 000 t	= 1 Gg
1Mt	= 1 Mio t	= 1 Tg

Metric Symbol	Prefix	Factor
P	peta	10^{15}
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
h	hecto	10^{2}
da	deca	10^{1}
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
µ	micro	10^{-6}
n	nano	10^{-9}

12 APPENDIX

12.1 Emission Trends per Sector – Submission under UNECE/LRTAP

Table A-1: Emission trends for SO_2 [kt] 1990–2022 – Submission under UNECE/LRTAP.

SO_2	NFR Sectors								
	1	1.A	1.B	2	3	5	6		
	ENERGY	FUEL COMBUSTION ACTIVITIES	FUGITIVE EMISSIONS FROM FUELS	INDUSTRIAL PROCESSES and PRODUCT USE	AGRICULTURE	WASTE	OTHER EMISSION SOURCES	NATIONAL TOTAL	International Bunkers
1990	71.69	69.69	2.00	1.93	0.00	0.07	NO	**73.70**	0.25
1995	46.18	44.65	1.53	1.07	0.00	0.05	NO	**47.31**	0.38
2000	30.68	30.63	0.04	0.78	0.00	0.06	NO	**31.52**	0.48
2005	25.11	25.07	0.04	0.72	0.00	0.06	NO	**25.89**	0.55
2010	15.26	15.21	0.05	0.70	0.00	0.01	NO	**15.98**	0.57
2011	14.47	14.43	0.05	0.68	0.00	0.01	NO	**15.17**	0.60
2012	14.12	14.08	0.05	0.65	0.00	0.01	NO	**14.79**	0.57
2013	13.75	13.71	0.04	0.58	0.00	0.01	NO	**14.35**	0.54
2014	13.95	13.91	0.04	0.56	0.00	0.01	NO	**14.52**	0.54
2015	13.53	13.49	0.04	0.55	0.00	0.01	NO	**14.10**	0.58
2016	12.69	12.66	0.02	0.56	0.00	0.01	NO	**13.26**	0.54
2017	12.21	12.17	0.04	0.57	0.00	0.01	NO	**12.79**	0.52
2018	11.01	10.98	0.02	0.56	0.00	0.01	NO	**11.58**	0.59
2019	10.56	10.54	0.02	0.59	0.00	0.01	NO	**11.17**	0.68
2020	9.80	9.78	0.02	0.59	0.00	0.01	NO	**10.41**	0.24
2021	10.27	10.24	0.03	0.59	NA	0.01	NO	**10.88**	0.27
2022	10.17	10.14	0.03	0.59	NA	0.02	NO	**10.78**	0.45

Table A-2: Emission trends for NO_x [kt] 1990–2022 – Submission under UNECE/LRTAP.

NO_x	NFR Sectors								
	1	1.A	1.B	2	3	5	6		
	ENERGY	FUEL COMBUSTION ACTIVITIES	FUGITIVE EMISSIONS FROM FUELS	INDUSTRIAL PROCESSES and PRODUCT USE	AGRICULTURE	WASTE	OTHER EMISSION SOURCES	NATIONAL TOTAL	International Bun-kers
1990	200.87	200.87	IE	1.53	13.66	0.12	NO	**216.19**	2.48
1995	185.65	185.65	IE	0.90	12.78	0.07	NO	**199.39**	3.85
2000	199.81	199.81	IE	0.83	11.93	0.07	NO	**212.65**	6.44
2005	236.29	236.29	IE	0.70	10.78	0.06	NO	**247.83**	6.99
2010	195.05	195.05	IE	0.55	10.38	0.02	NO	**206.00**	7.60
2011	186.62	186.62	IE	0.52	10.93	0.02	NO	**198.08**	7.98
2012	181.72	181.72	IE	0.55	11.03	0.02	NO	**193.32**	7.68
2013	182.37	182.37	IE	0.45	10.90	0.02	NO	**193.75**	7.46
2014	175.02	175.02	IE	0.46	11.19	0.02	NO	**186.70**	7.49
2015	171.91	171.91	IE	0.52	11.58	0.02	NO	**184.03**	8.18
2016	164.04	164.04	IE	0.52	11.83	0.02	NO	**176.41**	10.28
2017	155.17	155.17	IE	0.47	11.60	0.02	NO	**167.27**	10.06
2018	143.24	143.24	IE	0.41	11.32	0.02	NO	**155.00**	11.54
2019	134.42	134.42	IE	0.50	10.85	0.02	NO	**145.81**	13.47
2020	113.05	113.05	IE	0.48	10.86	0.03	NO	**124.41**	4.54
2021	111.69	111.69	IE	0.46	11.03	0.03	NO	**123.21**	5.35
2022	103.42	103.42	IE	0.40	10.59	0.03	NO	**114.44**	8.91

Table A-3: Emission trends for NMVOC [kt] 1990–2022 – Submission under UNECE/LRTAP.

NMVOC	**NFR Sectors**								
	1	**1.A**	**1.B**	**2**	**3**	**5**	**6**		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	164.98	149.38	15.59	118.97	44.66	0.17	NO	**328.77**	0.18
1995	116.83	107.22	9.60	85.75	41.66	0.15	NO	**244.38**	0.26
2000	76.80	71.00	5.80	62.61	37.70	0.13	NO	**177.23**	0.42
2005	61.75	58.28	3.46	57.19	35.01	0.12	NO	**154.07**	0.47
2010	51.14	48.57	2.57	48.71	34.81	0.09	NO	**134.75**	0.49
2011	46.92	44.39	2.54	48.79	34.20	0.09	NO	**130.01**	0.51
2012	46.47	43.94	2.53	47.36	33.82	0.08	NO	**127.74**	0.49
2013	45.66	43.22	2.44	42.36	33.88	0.08	NO	**121.98**	0.46
2014	40.73	38.16	2.57	40.60	33.95	0.07	NO	**115.35**	0.46
2015	40.87	38.39	2.48	36.84	33.90	0.07	NO	**111.68**	0.50
2016	40.18	37.75	2.43	36.14	33.91	0.07	NO	**110.31**	0.23
2017	39.63	37.17	2.45	37.01	33.99	0.07	NO	**110.70**	0.20
2018	36.36	34.02	2.34	37.07	33.45	0.06	NO	**106.94**	0.22
2019	36.19	33.79	2.41	37.47	32.97	0.06	NO	**106.69**	0.24
2020	34.35	32.32	2.03	40.86	32.66	0.06	NO	**107.93**	0.10
2021	38.35	36.34	2.02	37.08	32.55	0.06	NO	**108.05**	0.12
2022	32.15	30.28	1.86	35.34	32.50	0.06	NO	**100.04**	0.19

Table A-4: Emission trends for NH_3 [kt] 1990–2022 – Submission under UNECE/LRTAP.

NH_3	**NFR Sectors**								
	1	**1.A**	**1.B**	**2**	**3**	**5**	**6**		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	1.96	1.96	IE	0.34	71.42	0.37	NO	**74.09**	0.00
1995	3.22	3.22	IE	0.17	68.11	0.61	NO	**72.10**	0.00
2000	3.74	3.74	IE	0.17	63.40	0.74	NO	**68.05**	0.00
2005	4.01	4.00	0.00	0.13	60.79	1.09	NO	**66.01**	0.00
2010	3.43	3.42	0.00	0.15	63.68	1.17	NO	**68.43**	0.00
2011	3.13	3.12	0.00	0.16	63.69	1.17	NO	**68.14**	0.00
2012	3.00	3.00	0.00	0.15	64.13	1.18	NO	**68.45**	0.00
2013	2.82	2.82	0.00	0.16	64.22	1.11	NO	**68.31**	0.00
2014	2.60	2.60	0.00	0.15	65.26	1.15	NO	**69.16**	0.00
2015	2.65	2.65	0.00	0.14	66.16	1.17	NO	**70.12**	0.00
2016	2.56	2.56	0.00	0.15	67.23	1.22	NO	**71.15**	0.00
2017	2.59	2.59	0.00	0.17	67.74	1.20	NO	**71.70**	0.00
2018	2.55	2.55	0.00	0.14	66.55	1.19	NO	**70.42**	0.00
2019	2.57	2.57	0.00	0.16	65.20	1.20	NO	**69.13**	0.01
2020	2.31	2.31	0.00	0.16	65.02	1.24	NO	**68.73**	0.00
2021	2.50	2.50	0.00	0.14	65.22	1.28	NO	**69.15**	0.00
2022	2.40	2.40	0.00	0.13	64.23	1.23	NO	**67.99**	0.00

Table A-5: Emission trends for CO [kt] 1990–2022 – Submission under UNECE/LRTAP.

CO	**NFR Sectors**								
	1	**1.A**	**1.B**	**2**	**3**	**5**	**6**		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	1 199.50	1 199.50	IE	37.19	0.95	10.59	NO	**1 248.24**	0.40
1995	927.59	927.59	IE	34.72	0.91	9.72	NO	**972.94**	0.56
2000	700.39	700.39	IE	18.69	0.81	7.76	NO	**727.65**	0.80
2005	602.68	602.68	IE	14.54	0.75	7.03	NO	**625.00**	0.91
2010	559.32	559.32	IE	14.31	0.58	5.15	NO	**579.35**	0.87
2011	542.92	542.92	IE	14.33	0.37	4.82	NO	**562.44**	0.86
2012	543.08	543.08	IE	14.18	0.21	4.52	NO	**562.00**	0.83
2013	547.08	547.08	IE	14.33	0.17	4.21	NO	**565.80**	0.74
2014	512.24	512.24	IE	14.23	0.23	3.90	NO	**530.60**	0.74
2015	523.30	523.30	IE	14.22	0.16	3.65	NO	**541.34**	0.78
2016	518.07	518.07	IE	14.17	0.16	3.40	NO	**535.80**	1.49
2017	508.46	508.46	IE	14.19	0.11	3.20	NO	**525.96**	1.46
2018	467.02	467.02	IE	14.26	0.09	3.02	NO	**484.39**	1.73
2019	480.12	480.12	IE	14.14	0.08	2.86	NO	**497.21**	1.89
2020	456.10	456.10	IE	13.90	0.00	2.72	NO	**472.72**	0.91
2021	520.74	520.74	IE	14.07	NA	2.58	NO	**537.39**	1.07
2022	464.15	464.15	IE	14.03	NA	2.43	NO	**480.62**	1.52

Table A-6: Emission trends for Cd [kg] 1990–2022 – Submission under UNECE/LRTAP.

Cd	NFR Sectors								
	1	1.A	1.B	2	3	5	6		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	1 054.1	1054.1	NA	634.1	7.7	60.6	NO	**1 756.5**	0.2
1995	760.9	760.9	NA	337.3	7.9	3.5	NO	**1 109.6**	0.3
2000	668.1	668.1	NA	349.3	7.3	3.2	NO	**1 028.0**	0.4
2005	702.3	702.3	NA	381.1	6.9	2.9	NO	**1 093.3**	0.5
2010	811.7	811.7	NA	140.1	5.6	2.5	NO	**960.0**	0.5
2011	796.4	796.4	NA	137.8	3.6	2.4	NO	**940.3**	0.5
2012	819.8	819.8	NA	136.2	2.1	2.4	NO	**960.5**	0.5
2013	832.8	832.8	NA	139.6	1.7	2.2	NO	**976.3**	0.5
2014	765.9	765.9	NA	137.8	2.3	2.4	NO	**908.3**	0.5
2015	805.1	805.1	NA	133.9	1.6	2.3	NO	**942.9**	0.5
2016	788.4	788.4	NA	132.5	1.6	2.2	NO	**924.6**	0.6
2017	800.7	800.7	NA	136.5	1.1	2.2	NO	**940.5**	0.5
2018	771.0	771.0	NA	126.0	0.8	1.9	NO	**899.8**	0.6
2019	771.4	771.4	NA	108.0	0.8	2.1	NO	**882.2**	0.7
2020	755.5	755.5	NA	106.5	0.0	2.2	NO	**864.2**	0.2
2021	825.6	825.6	NA	115.2	NA	2.3	NO	**943.1**	0.3
2022	762.3	762.3	NA	128.9	NA	2.4	NO	**893.6**	0.5

Table A-7: Emission trends for Hg [kg] 1990–2022 – Submission under UNECE/LRTAP.

Hg	NFR Sectors								
	1	1.A	1.B	2	3	5	6		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	1 582.4	1 582.4	NA	876.6	1.5	54.9	NO	**2 515.4**	0.1
1995	730.3	730.3	NA	832.1	1.5	28.1	NO	**1 592.0**	0.1
2000	654.5	654.5	NA	723.7	1.4	18.2	NO	**1 397.7**	0.1
2005	675.1	674.1	1.0	912.7	1.3	21.7	NO	**1 610.8**	0.2
2010	708.3	707.7	0.6	370.3	1.0	27.6	NO	**1 107.3**	0.2
2011	693.0	692.6	0.5	380.7	0.6	28.4	NO	**1 102.7**	0.2
2012	708.5	708.2	0.3	375.0	0.4	30.6	NO	**1 114.5**	0.2
2013	735.3	735.2	0.1	398.5	0.3	31.6	NO	**1 165.6**	0.2
2014	695.6	695.4	0.2	389.3	0.4	32.5	NO	**1 117.7**	0.2
2015	685.0	684.9	0.0	387.1	0.3	32.2	NO	**1 104.6**	0.2
2016	637.1	637.1	0.0	370.7	0.3	31.6	NO	**1 039.6**	0.2
2017	674.5	674.5	0.0	359.1	0.2	32.9	NO	**1 066.7**	0.2
2018	660.5	660.4	0.1	339.5	0.1	33.2	NO	**1 033.3**	0.2
2019	658.9	658.8	0.1	358.5	0.1	33.4	NO	**1 050.9**	0.2
2020	652.0	651.9	0.0	377.1	0.0	36.9	NO	**1 066.0**	0.1
2021	676.8	676.8	0.0	332.2	NA	38.2	NO	**1 047.2**	0.1
2022	614.5	614.5	0.0	337.2	NA	39.9	NO	**991.6**	0.2

Table A-8: Emission trends for Pb [kg] 1990–2022 – Submission under UNECE/LRTAP.

Pb	**NFR Sectors**								
	1	**1.A**	**1.B**	**2**	**3**	**5**	**6**		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	194 445.0	194 445.0	NA	37 420.0	0.8	1 019.2	NO	**232 885.0**	0.2
1995	11 485.6	11 485.6	NA	14 559.4	0.9	12.6	NO	**26 058.4**	0.3
2000	9 077.3	9 077.3	NA	14 206.1	0.8	12.1	NO	**23 296.3**	0.4
2005	10 847.2	10 847.2	NA	16 375.7	0.8	11.0	NO	**27 234.7**	0.5
2010	12 242.2	12 242.2	NA	3 646.3	0.7	3.5	NO	**15 892.6**	0.5
2011	11 999.4	11 999.4	NA	3 864.5	0.4	3.4	NO	**15 867.8**	0.5
2012	12 212.6	12 212.6	NA	3 633.3	0.2	3.4	NO	**15 849.5**	0.5
2013	12 484.9	12 484.9	NA	3 671.6	0.2	3.2	NO	**16 159.9**	0.5
2014	11 800.4	11 800.4	NA	3 611.6	0.3	3.3	NO	**15 415.5**	0.5
2015	12 265.4	12 265.4	NA	2 923.2	0.2	3.3	NO	**15 192.1**	0.5
2016	12 257.0	12 257.0	NA	3 333.5	0.2	3.2	NO	**15 593.9**	0.6
2017	12 460.4	12 460.4	NA	3 252.0	0.1	3.2	NO	**15 715.7**	0.5
2018	12 303.4	12 303.4	NA	2 952.3	0.1	3.0	NO	**15 258.9**	0.6
2019	12 194.8	12 194.8	NA	2 638.7	0.1	3.1	NO	**14 836.7**	0.7
2020	11 403.5	11 403.5	NA	1 557.9	0.0	3.1	NO	**12 964.6**	0.2
2021	12 153.5	12 153.5	NA	1 607.6	NA	3.2	NO	**13 764.3**	0.3
2022	11 376.4	11 376.4	NA	2 294.6	NA	3.2	NO	**13 674.2**	0.5

Table A-9: Emission trends for PAH total [kg] 1990–2022 – Submission under UNECE/LRTAP.

PAH	NFR Sectors								
	1	1.A	1.B	2	3	5	6		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	11 430.4	11 430.4	NA	6 960.1	35.9	46.2	NO	**18 472.6**	NE
1995	10 689.0	10 689.0	NA	217.8	33.9	43.8	NO	**10 984.5**	NE
2000	8 612.3	8 612.3	NA	110.7	30.0	39.6	NO	**8 792.7**	NE
2005	6 947.3	6 947.3	NA	108.4	27.5	26.0	NO	**7 109.3**	NE
2010	7 709.0	7 709.0	NA	107.8	21.3	12.0	NO	**7 850.0**	NE
2011	7 067.0	7 067.0	NA	106.0	13.6	12.0	NO	**7 198.6**	NE
2012	7 383.7	7 383.7	NA	119.8	7.8	12.0	NO	**7 523.3**	NE
2013	7 568.6	7 568.6	NA	104.8	6.3	12.0	NO	**7 691.7**	NE
2014	6 688.5	6 688.5	NA	101.6	8.3	11.9	NO	**6 810.3**	NE
2015	6 952.9	6 952.9	NA	96.7	5.9	11.9	NO	**7 067.5**	NE
2016	7 059.2	7 059.2	NA	93.9	5.9	12.0	NO	**7 171.0**	NE
2017	7 080.0	7 080.0	NA	98.4	4.2	12.0	NO	**7 194.6**	NE
2018	6 607.0	6 607.0	NA	108.7	3.1	12.1	NO	**6 730.9**	NE
2019	6 760.6	6 760.6	NA	109.2	2.9	12.1	NO	**6 884.7**	NE
2020	6 413.5	6 413.5	NA	110.3	0.1	12.1	NO	**6 536.0**	NE
2021	7 080.4	7 080.4	NA	111.6	NA	12.1	NO	**7 204.1**	NE
2022	5 554.5	5 554.5	NA	114.3	NA	12.1	NO	**5 681.0**	NE

Table A-10: Emission trends for Benzo(a)pyrene [kg] 1990–2022 – Submission under UNECE/LRTAP.

Benzo (a)-pyrene	**NFR Sectors**								
	1	**1.A**	**1.B**	**2**	**3**	**5**	**6**		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	3 784.9	3 784.9	NA	2 257.4	6.5	12.3	NO	**6 061.1**	NE
1995	3 532.9	3 532.9	NA	75.9	6.1	11.7	NO	**3 626.6**	NE
2000	2 815.6	2 815.6	NA	36.7	5.4	10.6	NO	**2 868.2**	NE
2005	2 221.1	2 221.1	NA	35.8	4.9	6.9	NO	**2 268.8**	NE
2010	2 474.8	2 474.8	NA	35.5	3.8	3.2	NO	**2 517.3**	NE
2011	2 259.7	2 259.7	NA	34.9	2.4	3.2	NO	**2 300.2**	NE
2012	2 367.0	2 367.0	NA	39.4	1.4	3.2	NO	**2 411.0**	NE
2013	2 423.1	2 423.1	NA	34.6	1.1	3.2	NO	**2 462.0**	NE
2014	2 129.7	2 129.7	NA	33.5	1.5	3.2	NO	**2 167.9**	NE
2015	2 218.0	2 218.0	NA	32.0	1.1	3.2	NO	**2 254.2**	NE
2016	2 252.8	2 252.8	NA	31.0	1.1	3.2	NO	**2 288.0**	NE
2017	2 258.6	2 258.6	NA	32.4	0.7	3.2	NO	**2 294.9**	NE
2018	2 098.4	2 098.4	NA	35.7	0.6	3.2	NO	**2 137.8**	NE
2019	2 144.2	2 144.2	NA	35.8	0.5	3.2	NO	**2 183.7**	NE
2020	2 037.6	2 037.6	NA	36.1	0.0	3.2	NO	**2 076.9**	NE
2021	2 255.7	2 255.7	NA	36.9	NA	3.2	NO	**2 295.8**	NE
2022	1 752.7	1 752.7	NA	37.3	NA	3.2	NO	**1 793.2**	NE

Table A-11: Emission trends for Benzo(b)flouranthene [kg] 1990–2022 – Submission under UNECE/LRTAP.

Benzo (b)-flouran thene	**NFR Sectors**								
	1	**1.A**	**1.B**	**2**	**3**	**5**	**6**		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	4 000.0	4 000.0	NA	2 212.5	19.2	27.2	NO	**6 258.9**	NE
1995	3 707.7	3 707.7	NA	65.5	17.9	25.9	NO	**3 817.0**	NE
2000	2 986.9	2 986.9	NA	35.5	15.8	23.4	NO	**3 061.6**	NE
2005	2 442.1	2 442.1	NA	34.9	14.4	15.4	NO	**2 506.7**	NE
2010	2 729.4	2 729.4	NA	34.6	11.1	7.1	NO	**2 782.1**	NE
2011	2 505.0	2 505.0	NA	34.1	7.1	7.1	NO	**2 553.2**	NE
2012	2 619.6	2 619.6	NA	38.5	4.0	7.1	NO	**2 669.2**	NE
2013	2 690.7	2 690.7	NA	33.7	3.2	7.1	NO	**2 734.7**	NE
2014	2 378.9	2 378.9	NA	32.7	4.3	7.0	NO	**2 423.0**	NE
2015	2 476.9	2 476.9	NA	31.1	3.1	7.0	NO	**2 518.1**	NE
2016	2 513.2	2 513.2	NA	30.2	3.1	7.1	NO	**2 553.5**	NE
2017	2 523.3	2 523.3	NA	31.7	2.2	7.1	NO	**2 564.3**	NE
2018	2 355.7	2 355.7	NA	35.0	1.6	7.1	NO	**2 399.4**	NE
2019	2 413.6	2 413.6	NA	35.1	1.5	7.1	NO	**2 457.4**	NE
2020	2 285.5	2 285.5	NA	35.3	0.0	7.2	NO	**2 327.9**	NE
2021	2 519.1	2 519.1	NA	36.1	NA	7.2	NO	**2 562.4**	NE
2022	1 969.9	1 969.9	NA	36.5	NA	7.2	NO	**2 013.6**	NE

Table A-12: Emission trends for Benzo(k)flouranthene [kg] 1990–2022 – Submission under UNECE/LRTAP.

Benzo (k)-flouranthene	NFR Sectors								
	1	1.A	1.B	2	3	5	6		
	ENERGY	FUEL COMBUSTION ACTIVITIES	FUGITIVE EMISSIONS FROM FUELS	INDUSTRIAL PROCESSES and PRODUCT USE	AGRICULTURE	WASTE	OTHER EMISSION SOURCES	NATIONAL TOTAL	International Bunkers
1990	1 544.1	1 544.1	NA	2 078.3	6.3	6.6	NO	**3 635.3**	NE
1995	1 454.3	1 454.3	NA	33.6	6.0	6.3	NO	**1 500.1**	NE
2000	1 196.2	1 196.2	NA	17.6	5.4	5.7	NO	**1 224.9**	NE
2005	995.5	995.5	NA	17.2	5.0	3.7	NO	**1 021.5**	NE
2010	1 087.4	1 087.4	NA	17.1	3.9	1.7	NO	**1 110.0**	NE
2011	1 002.8	1 002.8	NA	16.7	2.5	1.7	NO	**1 023.8**	NE
2012	1 041.3	1 041.3	NA	19.2	1.4	1.7	NO	**1 063.6**	NE
2013	1 069.6	1 069.6	NA	16.6	1.2	1.7	NO	**1 089.0**	NE
2014	957.4	957.4	NA	16.0	1.5	1.7	NO	**976.6**	NE
2015	987.9	987.9	NA	15.1	1.1	1.7	NO	**1 005.8**	NE
2016	1 001.4	1 001.4	NA	14.6	1.1	1.7	NO	**1 018.8**	NE
2017	1 005.0	1 005.0	NA	15.4	0.8	1.7	NO	**1 022.9**	NE
2018	948.2	948.2	NA	17.3	0.6	1.7	NO	**967.8**	NE
2019	972.9	972.9	NA	17.3	0.5	1.7	NO	**992.4**	NE
2020	920.6	920.6	NA	17.7	0.0	1.7	NO	**940.0**	NE
2021	1 009.1	1 009.1	NA	17.5	NA	1.7	NO	**1 028.3**	NE
2022	811.5	811.5	NA	18.5	NA	1.7	NO	**831.7**	NE

Table A-13: Emission trends for Indeno(1,2,3-c,d)pyrene [kg] 1990–2022 – Submission under UNECE/LRTAP.

Indeno (1,2,3-c,d)-pyrene	**NFR Sectors**								
	1	**1.A**	**1.B**	**2**	**3**	**5**	**6**		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	2 101.33	2 101.33	NA	411.60	3.89	0.06	NO	**2 516.88**	NE
1995	1 994.20	1 994.20	NA	42.45	3.81	0.01	NO	**2 040.46**	NE
2000	1 613.56	1 613.56	NA	20.61	3.46	0.01	NO	**1 637.64**	NE
2005	1 288.56	1 288.56	NA	20.19	3.21	0.01	NO	**1 311.97**	NE
2010	1 417.40	1 417.40	NA	20.03	2.54	0.00	NO	**1 439.98**	NE
2011	1 299.52	1 299.52	NA	19.70	1.64	0.00	NO	**1 320.86**	NE
2012	1 355.83	1 355.83	NA	22.16	0.94	0.00	NO	**1 378.93**	NE
2013	1 385.21	1 385.21	NA	19.53	0.76	0.00	NO	**1 405.51**	NE
2014	1 222.42	1 222.42	NA	18.94	1.01	0.00	NO	**1 242.38**	NE
2015	1 270.10	1 270.10	NA	18.07	0.71	0.00	NO	**1 288.88**	NE
2016	1 291.86	1 291.86	NA	17.55	0.72	0.00	NO	**1 310.13**	NE
2017	1 293.16	1 293.16	NA	18.34	0.50	0.00	NO	**1 312.01**	NE
2018	1 204.75	1 204.75	NA	20.25	0.37	0.00	NO	**1 225.38**	NE
2019	1 229.94	1 229.94	NA	20.24	0.35	0.00	NO	**1 250.53**	NE
2020	1 169.87	1 169.87	NA	20.64	0.01	0.00	NO	**1 190.52**	NE
2021	1 296.48	1 296.48	NA	20.45	NA	0.00	NO	**1 316.93**	NE
2022	1 020.48	1 020.48	NA	21.41	NA	0.00	NO	**1 041.90**	NE

Table A-14: Emission trends for Dioxin/Furan (PCDD/F) [g] 1990–2022 – Submission under UNECE/LRTAP.

DIOX	NFR Sectors								
	1	1.A	1.B	2	3	5	6		
	ENERGY	FUEL COMBUSTION ACTIVITIES	FUGITIVE EMISSIONS FROM FUELS	INDUSTRIAL PROCESSES and PRODUCT USE	AGRICULTURE	WASTE	OTHER EMISSION SOURCES	NATIONAL TOTAL	International Bunkers
1990	60.58	60.58	NA	40.63	0.13	20.34	NO	**121.68**	NE
1995	41.62	41.62	NA	13.74	0.13	2.32	NO	**57.80**	NE
2000	33.39	33.39	NA	14.91	0.13	2.35	NO	**50.78**	NE
2005	28.35	28.35	NA	4.55	0.11	2.07	NO	**35.09**	NE
2010	31.55	31.55	NA	5.96	0.09	2.90	NO	**40.50**	NE
2011	29.02	29.02	NA	5.78	0.05	2.82	NO	**37.67**	NE
2012	29.95	29.95	NA	5.91	0.03	2.89	NO	**38.77**	NE
2013	30.43	30.43	NA	5.79	0.02	2.53	NO	**38.78**	NE
2014	26.89	26.89	NA	6.01	0.03	2.91	NO	**35.85**	NE
2015	27.67	27.67	NA	6.11	0.02	2.90	NO	**36.70**	NE
2016	27.31	27.31	NA	6.14	0.02	2.73	NO	**36.20**	NE
2017	27.58	27.58	NA	6.32	0.02	2.75	NO	**36.67**	NE
2018	25.35	25.35	NA	5.72	0.01	2.34	NO	**33.42**	NE
2019	25.10	25.10	NA	6.08	0.01	2.67	NO	**33.86**	NE
2020	24.30	24.30	NA	6.02	0.00	2.83	NO	**33.15**	NE
2021	27.27	27.27	NA	6.97	NA	3.05	NO	**37.29**	NE
2022	22.93	22.93	NA	5.55	NA	3.23	NO	**31.72**	NE

Table A-15: Emission trends for HCB [kg] 1990–2022 – Submission under UNECE/LRTAP.

HCB	NFR Sectors								
	1	1.A	1.B	2	3	5	6		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	51.04	51.04	NA	20.07	10.14	0.40	NO	**81.66**	NA
1995	33.62	33.62	NA	3.60	5.58	0.03	NO	**42.83**	NA
2000	15.95	15.95	NA	3.76	0.52	0.04	NO	**20.26**	NA
2005	12.21	12.21	NA	1.22	0.16	0.04	NO	**13.64**	NA
2010	12.40	12.40	NA	1.95	0.82	0.05	NO	**15.22**	NA
2011	11.01	11.01	NA	1.93	0.61	0.05	NO	**13.60**	NA
2012	35.49	35.49	NA	1.96	0.52	0.05	NO	**38.02**	NA
2013	113.71	113.71	NA	1.99	0.70	0.05	NO	**116.45**	NA
2014	117.72	117.72	NA	2.07	0.73	0.05	NO	**120.58**	NA
2015	10.05	10.05	NA	2.18	0.17	0.06	NO	**12.45**	NA
2016	9.99	9.99	NA	2.18	0.93	0.06	NO	**13.17**	NA
2017	10.09	10.09	NA	2.29	1.80	0.06	NO	**14.24**	NA
2018	9.17	9.17	NA	2.02	1.51	0.07	NO	**12.76**	NA
2019	9.08	9.08	NA	2.12	2.36	0.07	NO	**13.63**	NA
2020	8.76	8.76	NA	2.09	0.23	0.08	NO	**11.16**	NA
2021	10.02	10.02	NA	2.55	0.01	0.08	NO	**12.66**	NA
2022	8.24	8.24	NA	2.06	0.02	0.08	NO	**10.40**	NA

Table A-16: Emission trends for PCB [kg] 1990–2022 – Submission under UNECE/LRTAP.

PCB	NFR Sectors								
	1	1.A	1.B	2	3	5	6		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	8.73	8.73	NA	27.68	NA	0.00	NO	**36.41**	NA
1995	6.95	6.95	NA	3.48	NA	0.01	NO	**10.44**	NA
2000	5.07	5.07	NA	4.11	NA	0.01	NO	**9.18**	NA
2005	3.70	3.70	NA	2.16	NA	0.01	NO	**5.87**	NA
2010	2.40	2.40	NA	2.04	NA	0.01	NO	**4.45**	NA
2011	2.04	2.04	NA	2.11	NA	0.01	NO	**4.16**	NA
2012	1.89	1.89	NA	2.10	NA	0.01	NO	**4.01**	NA
2013	1.94	1.94	NA	2.10	NA	0.01	NO	**4.05**	NA
2014	1.95	1.95	NA	2.18	NA	0.01	NO	**4.14**	NA
2015	2.02	2.02	NA	2.02	NA	0.01	NO	**4.05**	NA
2016	2.07	2.07	NA	2.03	NA	0.01	NO	**4.12**	NA
2017	2.09	2.09	NA	2.13	NA	0.01	NO	**4.23**	NA
2018	1.58	1.58	NA	2.10	NA	0.02	NO	**3.69**	NA
2019	1.43	1.43	NA	2.07	NA	0.02	NO	**3.52**	NA
2020	1.23	1.23	NA	1.99	NA	0.02	NO	**3.24**	NA
2021	1.04	1.04	NA	2.01	NA	0.02	NO	**3.08**	NA
2022	0.96	0.96	NA	1.79	NA	0.02	NO	**2.77**	NA

Table A-17: Emission trends for TSP [kt] 1990–2022 – Submission under UNECE/LRTAP.

TSP	NFR Sectors								
	1	**1.A**	**1.B**	**2**	**3**	**5**	**6**		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	28.64	27.79	0.85	28.72	4.96	0.37	NO	**62.69**	0.27
1995	27.37	26.72	0.65	28.76	4.93	0.39	NO	**61.45**	0.41
2000	25.68	25.02	0.66	28.68	4.82	0.32	NO	**59.50**	0.52
2005	27.13	26.53	0.61	26.96	4.79	0.39	NO	**59.27**	0.59
2010	25.15	24.68	0.47	22.34	4.69	0.46	NO	**52.64**	0.62
2011	23.58	23.10	0.48	22.19	4.64	0.48	NO	**50.91**	0.65
2012	23.10	22.66	0.44	21.67	4.61	0.54	NO	**49.93**	0.62
2013	22.42	21.96	0.45	21.63	4.59	0.51	NO	**49.15**	0.59
2014	20.58	20.17	0.41	22.59	4.58	0.63	NO	**48.38**	0.59
2015	20.83	20.38	0.45	22.28	4.57	0.72	NO	**48.40**	0.63
2016	20.64	20.22	0.42	22.27	4.55	0.73	NO	**48.20**	0.70
2017	20.71	20.28	0.44	23.11	4.55	0.74	NO	**49.11**	0.67
2018	19.79	19.41	0.38	22.82	4.53	0.71	NO	**47.86**	0.76
2019	19.43	19.04	0.39	23.61	4.52	0.83	NO	**48.39**	0.88
2020	17.06	16.72	0.34	22.89	4.50	0.77	NO	**45.22**	0.31
2021	18.68	18.33	0.35	24.37	4.49	0.78	NO	**48.33**	0.37
2022	17.22	16.90	0.32	22.70	4.46	0.79	NO	**45.16**	0.59

Table A-18: Emission trends for PM_{10} [kt] 1990–2022 – Submission under UNECE/LRTAP.

PM_{10}	NFR Sectors								
	1	1.A	1.B	2	3	5	6		
	ENERGY	FUEL COMBUSTION ACTIVITIES	FUGITIVE EMISSIONS FROM FUELS	INDUSTRIAL PROCESSES and PRODUCT USE	AGRICULTURE	WASTE	OTHER EMISSION SOURCES	NATIONAL TOTAL	International Bunkers
1990	25.19	24.79	0.40	13.63	4.23	0.30	NO	**43.35**	0.27
1995	24.12	23.82	0.31	13.22	4.23	0.31	NO	**41.88**	0.41
2000	22.57	22.26	0.31	13.04	4.18	0.27	NO	**40.06**	0.52
2005	23.13	22.84	0.29	11.52	4.16	0.29	NO	**39.10**	0.59
2010	20.99	20.77	0.22	9.55	4.04	0.36	NO	**34.95**	0.62
2011	19.67	19.44	0.23	9.55	4.01	0.37	NO	**33.59**	0.65
2012	19.22	19.01	0.21	9.28	3.98	0.40	NO	**32.88**	0.62
2013	18.58	18.36	0.21	9.31	3.95	0.36	NO	**32.20**	0.59
2014	16.85	16.65	0.19	9.63	3.94	0.44	NO	**30.86**	0.59
2015	16.92	16.71	0.21	9.47	3.92	0.48	NO	**30.79**	0.63
2016	16.64	16.45	0.20	9.48	3.91	0.48	NO	**30.50**	0.70
2017	16.58	16.38	0.21	9.78	3.89	0.48	NO	**30.73**	0.67
2018	15.64	15.47	0.18	9.58	3.88	0.45	NO	**29.54**	0.76
2019	15.30	15.11	0.19	9.75	3.86	0.52	NO	**29.43**	0.88
2020	13.66	13.50	0.16	9.45	3.84	0.50	NO	**27.45**	0.31
2021	14.94	14.77	0.17	10.08	3.83	0.52	NO	**29.36**	0.37
2022	13.53	13.38	0.15	9.50	3.81	0.53	NO	**27.37**	0.59

Table A-19: Emission trends for $PM_{2.5}$ [kt] 1990–2022– Submission under UNECE/LRTAP.

$PM_{2.5}$	**NFR Sectors**								
	1	**1.A**	**1.B**	**2**	**3**	**5**	**6**		
	ENERGY	**FUEL COMBUSTION ACTIVITIES**	**FUGITIVE EMISSIONS FROM FUELS**	**INDUSTRIAL PROCESSES and PRODUCT USE**	**AGRICULTURE**	**WASTE**	**OTHER EMISSION SOURCES**	**NATIONAL TOTAL**	**International Bunkers**
1990	22.67	22.56	0.11	4.07	0.34	0.25	NO	**27.33**	0.27
1995	21.88	21.80	0.09	3.46	0.34	0.25	NO	**25.94**	0.41
2000	20.44	20.35	0.09	3.22	0.32	0.24	NO	**24.22**	0.52
2005	20.34	20.25	0.09	2.54	0.31	0.22	NO	**23.42**	0.59
2010	18.07	18.00	0.07	2.02	0.30	0.30	NO	**20.68**	0.62
2011	16.86	16.78	0.07	2.07	0.28	0.29	NO	**19.50**	0.65
2012	16.43	16.36	0.07	1.97	0.27	0.31	NO	**18.97**	0.62
2013	15.83	15.77	0.07	1.98	0.26	0.27	NO	**18.35**	0.59
2014	14.22	14.16	0.06	1.97	0.27	0.32	NO	**16.78**	0.59
2015	14.15	14.09	0.07	1.93	0.26	0.33	NO	**16.68**	0.63
2016	13.83	13.77	0.06	1.96	0.26	0.32	NO	**16.38**	0.70
2017	13.67	13.61	0.07	1.97	0.26	0.32	NO	**16.22**	0.67
2018	12.74	12.68	0.06	1.92	0.26	0.28	NO	**15.20**	0.76
2019	12.42	12.36	0.06	1.94	0.26	0.33	NO	**14.94**	0.88
2020	11.28	11.23	0.05	1.84	0.25	0.33	NO	**13.70**	0.31
2021	12.32	12.27	0.05	1.96	0.25	0.35	NO	**14.88**	0.37
2022	10.98	10.93	0.05	1.86	0.25	0.36	NO	**13.45**	0.59

12.2 Austria´s emissions based on fuel used (without ‘fuel exports’)

The national emissions without fuel exports were used to assess compliance with the emission ceilings under the NEC Directive for the years 2010 to 2019 (Directive 2001/81/EG on national emission ceilings for certain atmospheric pollutants, Annex I).

But from 2020 onwards the emissions based on fuels sold (i.e. including fuel exports) are used for assessing the compliance with the relevant national emission reduction commitments.

The following tables show the Austrian emissions of the pollutants SO_2, NO_x, NH_3, NMVOC and $PM_{2.5}$ without emissions from fuel exports. They are determined on the basis of the fuel used.

Table A-20: Emission trends for SO_x [kt] 1990–2022 on the basis of fuel used.

SO_x	NFR Sectors								
	1	1.A	1.B	2	3	5	6		
	ENERGY	FUEL COMBUSTION ACTIVITIES	FUGITIVE EMISSIONS FROM FUELS	INDUSTRIAL PROCESSES and PRODUCT USE	AGRICULTURE	WASTE	OTHER	NATIONAL TOTAL	International Bun-kers
	kt								
1990	70.93	68.93	2.00	1.93	0.00	0.07	NO	**72.94**	0.25
1995	45.26	43.73	1.53	1.07	0.00	0.05	NO	**46.38**	0.38
2000	30.15	30.11	0.04	0.78	0.00	0.06	NO	**31.00**	0.48
2005	25.05	25.01	0.04	0.72	0.00	0.06	NO	**25.84**	0.55
2010	15.22	15.18	0.05	0.70	0.00	0.01	NO	**15.94**	0.57
2011	14.44	14.40	0.05	0.68	0.00	0.01	NO	**15.13**	0.60
2012	14.09	14.05	0.05	0.65	0.00	0.01	NO	**14.76**	0.57
2013	13.71	13.67	0.04	0.58	0.00	0.01	NO	**14.31**	0.54
2014	13.91	13.87	0.04	0.56	0.00	0.01	NO	**14.48**	0.54
2015	13.49	13.46	0.04	0.55	0.00	0.01	NO	**14.06**	0.58
2016	12.65	12.63	0.02	0.56	0.00	0.01	NO	**13.22**	0.54
2017	12.17	12.14	0.04	0.57	0.00	0.01	NO	**12.75**	0.52
2018	10.97	10.94	0.02	0.56	0.00	0.01	NO	**11.54**	0.59
2019	10.52	10.50	0.02	0.59	0.00	0.01	NO	**11.13**	0.68
2020	9.78	9.75	0.02	0.59	0.00	0.01	NO	**10.38**	0.24
2021	10.24	10.21	0.03	0.59	NA	0.01	NO	**10.84**	0.27
2022	10.15	10.11	0.03	0.59	NA	0.02	NO	**10.76**	0.45

Table A-21: Emission trends for NO_x [kt] 1990–2022 on the basis of fuel used.

NO_x	NFR Sectors								
	1	1.A	1.B	2	4	6	7		
	ENERGY	FUEL COMBUSTION ACTIVITIES	FUGITIVE EMISSIONS FROM FUELS	INDUSTRIAL PROCESSES and PRODUCT USE	AGRICULTURE	WASTE	OTHER	NATIONAL TOTAL	International Bunkers
	kt								
1990	184.43	184.43	IE	1.53	13.66	0.12	NO	**199.75**	2.48
1995	168.62	168.62	IE	0.90	12.78	0.07	NO	**182.37**	3.85
2000	168.25	168.25	IE	0.83	11.93	0.07	NO	**181.08**	6.44
2005	179.34	179.34	IE	0.70	10.78	0.06	NO	**190.89**	6.99
2010	158.95	158.95	IE	0.55	10.38	0.02	NO	**169.91**	7.60
2011	157.60	157.60	IE	0.52	10.93	0.02	NO	**169.06**	7.98
2012	153.76	153.76	IE	0.55	11.03	0.02	NO	**165.35**	7.68
2013	150.98	150.98	IE	0.45	10.90	0.02	NO	**162.35**	7.46
2014	147.63	147.63	IE	0.46	11.19	0.02	NO	**159.31**	7.49
2015	145.72	145.72	IE	0.52	11.58	0.02	NO	**157.84**	8.18
2016	141.45	141.45	IE	0.52	11.83	0.02	NO	**153.82**	10.28
2017	134.91	134.91	IE	0.47	11.60	0.02	NO	**147.02**	10.06
2018	124.55	124.55	IE	0.41	11.32	0.02	NO	**136.31**	11.54
2019	117.42	117.42	IE	0.50	10.85	0.02	NO	**128.81**	13.47
2020	104.18	104.18	IE	0.48	10.86	0.03	NO	**115.54**	4.54
2021	102.57	102.57	IE	0.46	11.03	0.03	NO	**114.09**	5.35
2022	96.28	96.28	IE	0.40	10.59	0.03	NO	**107.30**	8.91

Table A-22: Emission trends for NMVOC [kt] 1990–2022 on the basis of fuel used.

NMVOC	NFR Sectors								
	1	1.A	1.B	2	4	6	7		
	ENERGY	FUEL COMBUSTION ACTIVITIES*	FUGITIVE EMISSIONS FROM FUELS	INDUSTRIAL PROCESSES	AGRICULTURE	WASTE	OTHER	NATIONAL TOTAL	International Bunkers
	kt								
1990	159.38	143.79	15.59	118.97	44.66	0.17	NO	**323.18**	0.18
1995	115.25	105.65	9.60	85.75	41.66	0.15	NO	**242.81**	0.26
2000	76.74	70.94	5.80	62.61	37.70	0.13	NO	**177.17**	0.42
2005	56.79	53.33	3.46	57.19	35.01	0.12	NO	**149.11**	0.47
2010	49.01	46.44	2.57	48.71	34.81	0.09	NO	**132.61**	0.49
2011	45.28	42.74	2.54	48.79	34.20	0.09	NO	**128.36**	0.51
2012	45.05	42.52	2.53	47.36	33.82	0.08	NO	**126.31**	0.49
2013	44.36	41.92	2.44	42.36	33.88	0.08	NO	**120.68**	0.46
2014	39.66	37.09	2.57	40.60	33.95	0.07	NO	**114.28**	0.46
2015	39.83	37.34	2.48	36.84	33.90	0.07	NO	**110.64**	0.50
2016	39.23	36.80	2.43	36.14	33.91	0.07	NO	**109.36**	0.23
2017	38.78	36.33	2.45	37.01	33.99	0.07	NO	**109.85**	0.20
2018	35.54	33.20	2.34	37.07	33.45	0.06	NO	**106.13**	0.22
2019	35.46	33.05	2.41	37.47	32.97	0.06	NO	**105.96**	0.24
2020	33.97	31.94	2.03	40.86	32.66	0.06	NO	**107.55**	0.10
2021	37.91	35.89	2.02	37.08	32.55	0.06	NO	**107.60**	0.12
2022	31.75	29.88	1.86	35.34	32.50	0.06	NO	**99.64**	0.19

** exhaust and non-exhaust emissions (gasoline evaporation) from 1.A.3.b Road Transport calculated on the basis of 'fuel used'*

Table A-23: Emission trends for NH_3 [kt] 1990–2022 on the basis of fuel used.

NH_3	NFR Sectors								
	1	1.A	1.B	2	4	6	7		
	ENERGY	FUEL COMBUSTION ACTIVITIES	FUGITIVE EMISSIONS FROM FUELS	INDUSTRIAL PROCESSES	AGRICULTURE	WASTE	OTHER	NATIONAL TOTAL	International Bunkers
	kt								
1990	1.91	1.91	IE	0.34	71.42	0.37	NO	**74.04**	0.00
1995	3.18	3.18	IE	0.17	68.11	0.61	NO	**72.07**	0.00
2000	3.88	3.88	IE	0.17	63.40	0.74	NO	**68.19**	0.00
2005	3.38	3.37	0.00	0.13	60.79	1.09	NO	**65.39**	0.00
2010	2.94	2.94	0.00	0.15	63.68	1.17	NO	**67.94**	0.00
2011	2.73	2.72	0.00	0.16	63.69	1.17	NO	**67.74**	0.00
2012	2.64	2.64	0.00	0.15	64.13	1.18	NO	**68.10**	0.00
2013	2.50	2.50	0.00	0.16	64.22	1.11	NO	**67.99**	0.00
2014	2.32	2.32	0.00	0.15	65.26	1.15	NO	**68.88**	0.00
2015	2.36	2.36	0.00	0.14	66.16	1.17	NO	**69.83**	0.00
2016	2.27	2.27	0.00	0.15	67.23	1.22	NO	**70.86**	0.00
2017	2.32	2.32	0.00	0.17	67.74	1.20	NO	**71.42**	0.00
2018	2.25	2.25	0.00	0.14	66.55	1.19	NO	**70.12**	0.00
2019	2.27	2.27	0.00	0.16	65.20	1.20	NO	**68.84**	0.01
2020	2.16	2.16	0.00	0.16	65.02	1.24	NO	**68.58**	0.00
2021	2.31	2.31	0.00	0.14	65.22	1.28	NO	**68.96**	0.00
2022	2.22	2.22	0.00	0.13	64.23	1.23	NO	**67.81**	0.00

Table A-24: Emission trends for $PM_{2.5}$ [kt] 1990–2022 on the basis of fuel used.

$PM_{2.5}$	NFR Sectors								
	1	1.A	1.B	2	4	6	7		
	ENERGY	FUEL COMBUSTION ACTIVITIES*	FUGITIVE EMISSIONS FROM FUELS	INDUSTRIAL PROCESSES	AGRICULTURE	WASTE	OTHER	NATIONAL TOTAL	International Bunkers
	kt								
1990	22.06	21.95	0.11	4.07	0.34	0.25	NO	**26.72**	0.27
1995	21.18	21.09	0.09	3.46	0.34	0.25	NO	**25.24**	0.41
2000	19.77	19.68	0.09	3.22	0.32	0.24	NO	**23.56**	0.52
2005	18.03	17.95	0.09	2.54	0.31	0.22	NO	**21.11**	0.59
2010	16.39	16.32	0.07	2.02	0.30	0.30	NO	**19.01**	0.62
2011	15.44	15.37	0.07	2.07	0.28	0.29	NO	**18.09**	0.65
2012	15.12	15.05	0.07	1.97	0.27	0.31	NO	**17.66**	0.62
2013	14.58	14.51	0.07	1.98	0.26	0.27	NO	**17.10**	0.59
2014	13.09	13.02	0.06	1.97	0.27	0.32	NO	**15.65**	0.59
2015	12.96	12.90	0.07	1.93	0.26	0.33	NO	**15.49**	0.63
2016	12.64	12.58	0.06	1.96	0.26	0.32	NO	**15.19**	0.70
2017	12.48	12.41	0.07	1.97	0.26	0.32	NO	**15.03**	0.67
2018	11.53	11.47	0.06	1.92	0.26	0.28	NO	**13.99**	0.76
2019	11.26	11.20	0.06	1.94	0.26	0.33	NO	**13.78**	0.88
2020	10.76	10.71	0.05	1.84	0.25	0.33	NO	**13.18**	0.31
2021	11.66	11.61	0.05	1.96	0.25	0.35	NO	**14.22**	0.37
2022	10.34	10.30	0.05	1.86	0.25	0.36	NO	**12.81**	0.59

* *exhaust and non-exhaust emissions (tyre and break wear, road abrasion) from 1.A.3.b Road Transport calculated on the basis of 'fuel used'*

12.3 Information on PM emission factors (include/exclude the condensable component)

Table A-25: PM emission factors per source category and information on condensable component.

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
1.A.1.a	Public electricity and heat production	Partially (large plants)	Small biomass plants w/o secondary filtering (ESP, fabric)	Large plants: Continuous Stack measurements. Small biomass plants: national study based on flue gas concentrations of funded plants.
1.A.1.b	Petroleum refining	X		Continuous Stack measurements.
1.A.1.c	Manufacture of solid fuels and other energy industries	X	Charcoal production: unknown	Natural gas only. National study.
1.A.2.a	Stationary combustion in manufacturing industries and construction: Iron and steel	X		National studies, based on stack measurements.
1.A.2.b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	X		National studies, based on stack measurements.
1.A.2.c	Stationary combustion in manufacturing industries and construction: Chemicals	X		National studies, based on stack measurements.
1.A.2.d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	X		National studies, based on stack measurements.
1.A.2.e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	X		National studies, based on stack measurements.
1.A.2.f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	X		National studies, based on stack measurements.
1.A.2.g.vii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	X		TU GRAZ (Graz University of Technology)
1.A.2.g.viii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	X		National studies, based on stack measurements.
1.A.3.a.i(i)	International aviation LTO (civil)	No information available.		Kalivoda & Kudrna, 2002
1.A.3.a.ii(i)	Domestic aviation LTO (civil)			
1.A.3.b.i	Road transport: Passenger cars	X		TU GRAZ (Graz University of Technology)
1.A.3.b.ii	Road transport: Light duty vehicles	X		
1.A.3.b.iii	Road transport: Heavy duty vehicles and buses	X		
1.A.3.b.iv	Road transport: Mopeds & motorcycles	X		
1.A.3.b.v	Road transport: Gasoline evaporation	NA		
1.A.3.b.vi	Road transport: Automobile tyre and brake wear	No information in the EMEP/EEA GB, 2019		EMEP/EEA GB, 2019
1.A.3.b.vii	Road transport: Automobile road abrasion	No information in the EMEP/EEA GB, 2019		EMEP/EEA GB, 2019
1.A.3.c	Railways	No information in the EMEP/EEA GB, 2019		EMEP/EEA GB, 2019

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
1.A.3.d.i(ii)	International inland waterways	No information in the EMEP/EEA GB, 2019		EMEP/EEA GB, 2019
1.A.3.d.ii	National navigation (shipping)			EMEP/EEA GB, 2019
1.A.3.e.i	Pipeline transport	X		Natural gas only.
1.A.3.e.ii	Other (please specify in the IIR)	X		TU GRAZ (Graz University of Technology)
1.A.4.a.i	Commercial/institutional: Stationary	X	X	In general, there is a lack of information. Only a few emission factors include the condensable fraction, see Table 178: NFR 1.A.4. PM emission factors with information on coverage of condensables and combustion cycle for the year 2021. (EEA, 2023a), (Winiwarter et al., 2001), (Winiwarter et al., 2007), (FOEN, 2015), (German Environment Agency, 2008), (Naturvårdsverket, undated).
1.A.4.a.ii	Commercial/institutional: Mobile	IE		
1.A.4.b.i	Residential: Stationary	X	X	In general, there is a lack of information. Only a few emission factors include the condensable fraction, see Table 178: NFR 1.A.4. PM emission factors with information on coverage of condensables and combustion cycle for the year 2021. (EEA, 2023a), (Winiwarter et al., 2001), (Winiwarter et al., 2007), (FOEN, 2015), (German Environment Agency, 2008), (Naturvårdsverket, undated).
1.A.4.b.ii	Residential: Household and gardening (mobile)	X		TU GRAZ (Graz University of Technology)

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
1.A.4.c.i	Agriculture/Forestry/Fishing: Stationary	X	X	In general, there is a lack of information. Only a few emission factors include the condensable fraction, see Table 178: NFR 1.A.4. PM emission factors with information on coverage of condensables and combustion cycle for the year 2022. (EEA, 2023a), (Winiwarter et al., 2001), (Winiwarter et al., 2007), (FOEN, 2015), (German Environment Agency, 2008), (Naturvårdsverket, undated).
1.A.4.c.ii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	X		TU GRAZ (Graz University of Technology)
1.A.4.c.iii	Agriculture/Forestry/Fishing: National fishing	NO		
1.A.5.a	Other stationary (including military)	NO		
1.A.5.b	Other, Mobile (including military, land based and recreational boats)	X		TU GRAZ (Graz University of Technology)
1.B.1.a	Fugitive emission from solid fuels: Coal mining and handling	X		EMEP/EEA GB, 2019 (open cast mining), Winiwarter et al, 2001 (storage of solid fuels)
1.B.1.b	Fugitive emission from solid fuels: Solid fuel transformation	IE		
1.B.1.c	Other fugitive emissions from solid fuels	NO		
1.B.2.a.i	Fugitive emissions oil: Exploration, production, transport	NA		
1.B.2.a.iv	Fugitive emissions oil: Refining / storage	NA		
1.B.2.a.v	Distribution of oil products	NA		
1.B.2.b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	NA		
1.B.2.c	Venting and flaring (oil, gas, combined oil and gas)	NA		
1.B.2.d	Other fugitive emissions from energy production	NA		
2.A.1	Cement production		X	Mauschitz, 2011
2.A.2	Lime production	X		(diffuse) Winiwarter et al., 2007
2.A.3	Glass production		X	PS-EFs based on TSP measurements
2.A.5.a	Quarrying and mining of minerals other than coal	X		(diffuse) Winiwarter et al., 2007
2.A.5.b	Construction and demolition	X		(diffuse) EMEP/EEA GB, 2019
2.A.5.c	Storage, handling and transport of mineral products	NO		

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
2.A.6	Other mineral products (please specify in the IIR)	NO		
2.B.1	Ammonia production	NA		
2.B.2	Nitric acid production	NA		
2.B.3	Adipic acid production	NO		
2.B.5	Carbide production	NE		
2.B.6	Titanium dioxide production	NO		
2.B.7	Soda ash production	NO		
2.B.10.a	Chemical industry: Other (please specify in the IIR)		X	PS-EFs based on TSP measurements Winiwarter et al., 2007
2.B.10.b	Storage, handling and transport of chemical products (please specify in the IIR)	NO		
2.C.1	Iron and steel production		X	PS-EFs based on TSP measurements
2.C.2	Ferroalloys production		X	EMEP/EEA GB, 2019
2.C.3	Aluminium production		X	EMEP/EEA GB, 2019
2.C.4	Magnesium production	NO		
2.C.5	Lead production		X	EMEP/EEA GB, 2019
2.C.6	Zinc production	NO		
2.C.7.a	Copper production		X	EMEP/EEA GB, 2019
2.C.7.b	Nickel production	NO		
2.C.7.c	Other metal production (please specify in the IIR)	NE		
2.C.7.d	"Storage, handling and transport of metal products	NO		
2.D.3.a	Domestic solvent use including fungicides	NA		
2.D.3.b	Road paving with asphalt	X		EMEP/EEA GB, 2019
2.D.3.c	Asphalt roofing		X	PS-EFs based on TSP measurements
2.D.3.d	Coating applications	NA		
2.D.3.e	Degreasing	NA		
2.D.3.f	Dry cleaning	NA		
2.D.3.g	Chemical products	NA		
2.D.3.h	Printing	NA		
2.D.3.i	Other solvent use (please specify in the IIR)	NA		
2.G	Other product use (please specify in the IIR)	X (for fireworks)		EMEP/EEA GB, 2019/Keller&Schragen 2021
2.H.1	Pulp and paper industry	NA		
2.H.2	Food and beverages industry	X		(diffuse) Winiwarter et al., 2007
2.H.3	Other industrial processes (please specify in the IIR)	NO		
2.I	Wood processing	X		(diffuse) Winiwarter et al., 2007
2.J	Production of POPs	NO		
2.K	"Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)"	NO		

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
2.L	Other production, consumption, storage, transportation or handling of bulk products (please specify in the IIR)	NO		
3.B.1.a	Manure management – Dairy cattle	No information available		Lükewille et al., 2001 Winiwarter et al., 2007
3.B.1.b	Manure management – Non-dairy cattle	No information available		Lükewille et al., 2001 Winiwarter et al., 2007
3.B.2	Manure management – Sheep	No information available		Lükewille et al., 2001 Winiwarter et al., 2007
3.B.3	Manure management – Swine	No information available		Lükewille et al., 2001 Winiwarter et al., 2007
3.B.4.a	Manure management – Buffalo	NO		
3.B.4.d	Manure management – Goats	No information available		Lükewille et al., 2001 Winiwarter et al., 2007
3.B.4.e	Manure management – Horses	No information available		Lükewille et al., 2001 Winiwarter et al., 2007
3.B.4.f	Manure management – Mules and asses	IE		
3.B.4.g.i	Manure mangement – Laying hens	No information available		Lükewille et al., 2001 Winiwarter et al., 2007
3.B.4.g.ii	Manure mangement – Broilers	No information available		Lükewille et al., 2001 Winiwarter et al., 2007
3.B.4.g.iii	Manure mangement – Turkeys	No information available		Lükewille et al., 2001 Winiwarter et al., 2007
3.B.4.g.iv	Manure management – Other poultry	No information available		Lükewille et al., 2001 Winiwarter et al., 2007
3.B.4.h	Manure management – Other animals (please specify in IIR)	No information available		Lükewille et al., 2001 Winiwarter et al., 2007
3.D.a.1	Inorganic N-fertilizers (includes also urea application)	NA		
3.D.a.2.a	Animal manure applied to soils	NA		
3.D.a.2.b	Sewage sludge applied to soils	NA		
3.D.a.2.c	"Other organic fertilizers applied to soils (including compost)"	NA		
3.D.a.3	Urine and dung deposited by grazing animals	NA		
3.D.a.4	Crop residues applied to soils	NA		
3.D.b	Indirect emissions from managed soils	NO		
3.D.c	Farm-level agricultural operations including storage, handling and transport of agricultural products		X	EMEP/EEA GB, 2023
3.D.d	Off-farm storage, handling and transport of bulk agricultural products	NA		(diffuse) Winiwarter et al., 2007
3.D.e	Cultivated crops	NA		
3.D.f	Use of pesticides	NA		
3.F	Field burning of agricultural residues	No information in the EMEP/EEA GB 2023		EMEP/EEA GB, 2023
3.I	Agriculture other (please specify in the IIR)	NO		
5.A	Biological treatment of waste – Solid waste disposal on land	NA		(diffuse) Winiwarter et al., 2007
5.B.1	Biological treatment of waste – Composting	NA		

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
5.B.2	Biological treatment of waste - Anaerobic digestion at biogas facilities	NA		
5.C.1.a	Municipal waste incineration	IE, NO		
5.C.1.b.i	Industrial waste incineration	No information available		National studies
5.C.1.b.ii	Hazardous waste incineration	NO		
5.C.1.b.iii	Clinical waste incineration	No information available		National studies
5.C.1.b.iv	Sewage sludge incineration	NO		
5.C.1.b.v	Cremation	No information available		National studies
5.C.1.b.vi	Other waste incineration (please specify in the IIR)	NO		
5.C.2	Open burning of waste	No information in the EMEP/EEA GB 2023		EMEP/EEA GB, 2023
5.D.1	Domestic wastewater handling	NA		
5.D.2	Industrial wastewater handling	NA		
5.D.3	Other wastewater handling	NO		
5.E	Other waste (please specify in IIR)	No information in the EMEP/EEA GB 2019		EMEP/EEA GB 2019
6.A	Other (included in national total for entire territory) (please specify in IIR)	NO		

NA: as emissions occur at ambient temperature level, it is unlikely that substantial quantities of condensable particulate material are included

umweltbundesamt

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The Informative Inventory Report (IIR) 2024 presents a comprehensive and detailed description of emission trends and the methodologies applied in the Austrian Air Emission Inventory for the air pollutants

- sulphur dioxide (SO_2), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs), ammonia (NH_3)
- carbon monoxide (CO) and
- particulate matter (TSP, PM_{10}, $PM_{2.5}$)

as well as the air pollutant groups such as

- heavy metals: cadmium (Cd), mercury (Hg), lead (Pb) and
- persistent organic pollutants (POPs): polycyclic aromatic hydrocarbons (PAHs), dioxins and furans (PCDD/Fs), hexachlorobenzene (HCB) as well as polychlorinated biphenyls (PCB).

With the IIR 2024, Austria complies with its reporting obligations under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP) and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants.

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