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ENVIRONMENT AGENCY AUSTRIA

Austria's Informative Inventory Report (IIR) 2021

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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REPORT
REP-0762

Vienna 2021

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), 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 information covered refers to the following accreditation scope of the IBE: EMEP 2019 (www.bmdw.gv.at/akkreditierung).

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This report is compiled and published as an inspection report in accordance with the Accreditation Law and the international standard ISO/IEC 17020, in fulfilment of and in compliance with the EMEP/EEA air pollutant emission inventory guidebook (scope of accreditation regarding air pollutants) as well as the Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants (NEC Directive). It replaces the one designated as DRAFT submitted on March 15th 2021 and has undergone a complete and final quality control and layout/typesetting.

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PREFACE

The report "Austria's Informative Inventory Report (IIR) 2021" 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 2021 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 2014 the Reporting Guidelines were revised (ECE/EB.AIR.125)[3] and were adopted for application in 2015 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 (**N**omenclature **f**or **R**eporting – 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 2021 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" (revised in 2018). 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 2021a).

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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/1_reporting_guidelines2014/ece.eb.air.125_advance_version_reporting_guidelines_2014.pdf

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

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

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.

Elisabeth Rigler in her function as head of the Department *Climate Change Mitigation & Emission Inventories* of the *Umweltbundesamt* is responsible for the preparation and review of Austria's 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* and Katja Pazdernik in her function as deputy are responsible for the content of this report and for the quality management system of the Austrian Air Emission Inventory.

The preparation and review of Austria's National Air Emission Inventory are the responsibility of the Department "Climate Change Mitigation & Emission Inventories" of the Umweltbundesamt.

Project leader for the preparation of the Austrian Air Emission Inventory is Stephan Poupa.

Specific responsibilities for the preparation of the Austrian Air Emission Inventory are:

- Data Management .... Stephan Poupa
- Fuel combustion stationary .... Stephan Poupa ('Sector Lead')
- Fuel combustion mobile .... Barbara Schodl ('Sector Lead')
- Fugitive emissions .... Marion Pinterits ('Sector Lead')
- Industrial processes .... Michaela Titz ('Sector Lead')
- Solvent Use .... Maria Purzner ('Sector Lead')
- Agriculture .... Michael Anderl ('Sector Lead')
- Waste .... Christoph Lampert ('Sector Lead')
- Key Category Analysis .... Andreas Zechmeister
- Uncertainty Analysis .... Andreas Zechmeister

Project leader for the preparation of the IIR 2021 is Simone Haider.

Specific responsibilities for the IIR 2021 have been as follows:

- Executive Summary .... Simone Haider
- Chapter 1 Introduction .... Simone Haider, Günther Schmidt
- Chapter 2 Trends .... Marion Gangl, Simone Haider, Michaela Titz
- Chapter 3 Energy .... Stephan Poupa, Günther Schmidt, Wolfgang Schieder
- Chapter 3 Transport .... Barbara Schodl, Günther Schmidt
- Chapter 3 Fugitive emission .... Marion Pinterits, Traute Köther
- Chapter 4 Industrial Processes and Product Use……………………………….. ..... Maria Purzner, Michaela Titz, Manuela Wieser
- Chapter 5 Agriculture .... Michael Anderl, Simone Haider, Nicole Mandl
- Chapter 6 Waste .... Christoph Lampert, Katja Pazdernik
- Chapter 7 Recalculations & Improvements…. .... Michaela Titz, Simone Haider
- Chapter 8 Projections .... Michaela Titz
- Chapter 9 Reporting of gridded emissions and LPS…………………………… Christine Brendle, Günther Schmidt, Robert Wankmüller
- Appendix .... Simone Haider, Marion Gangl

CONTENT

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 under 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 2019 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.

The emission data presented in this report were compiled according to the revised 2014 Reporting Guidelines (ECE/EB.AIR.125) that were approved by the Executive Body for the UNECE/LRTAP Convention at its 36th 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.

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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/

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 $PM_{2.5}$. Austria uses the national emission totals calculated on the basis of *fuel used* (thus excluding emissions from fuel exports in the vehicle tank) for assessing compliance with the 2010 emission ceilings under the NEC Directive.

The annual greenhouse gas reporting under the UNFCCC and the Kyoto Protocoll 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 2019, 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 economic crisis in 2009 caused a decrease in emissions, followed by an increase due to the recovery of the economy. From 2018 to 2019 emissions decreased by 5.9%, mainly because of lower coal consumption in power plants and lower emissions of oil refinery.

In 1990, national total NO_x emissions amounted to 217 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 2019, NO_x emissions amounted to 144 kt and were about 34% lower than in 1990. From 2018 to 2019 emissions decreased by 4.8%. This was caused by a decline in road traffic, especially passenger cars and heavy duty vehicles. In 2019 52% of the total nitrogen oxides emissions originate from road transport (including fuel exports). Austria is a landlocked country and fuel prices vary between neighbouring countries. So Austria has experienced a considerable amount of 'fuel export' in the last decades and the share of NO_x emissions caused by fuel sold in Austria but used abroad is notable. Emissions for 2019 based on fuel used amount to 131 kt and are about 14 kt lower than based on fuel sold; the decrease between 1990 and 2019 is slightly stronger (-35%).

In 1990, national total NMVOC emissions amounted to 336 kt. Emissions have decreased steadily since then and in the year 2019 emissions were reduced by 68% to 109 kt compared to 1990. The largest reductions since 1990 have been achieved in the road transport sector due to an increased use of catalytic converters and diesel cars. Reductions in the solvent sector were due to various regulations (Solvent Ordinance, Cogeneration Act, VOC Emissions Ordinance). From 2018 to 2019 emissions decreased by 0.4%.

In 1990, national total NH_3 emissions amounted to 62 kt; emissions have increased over the period from 1990 to 2019. In 2019, emissions were 3.2% above 1990 levels and amounted to 64 kt. NH_3 in Austria is almost exclusively emitted in the agricultural sector. The higher NH_3 emissions can be explained by an increased number of cattle kept in loose house systems (for reasons of animal welfare and stipulated by EU law), an increase in the number of cows with higher milk yields and an increased use of urea as nitrogen fertilizer (cost-saving, but less efficient than other types of mineral fertilizer). Compared to the previous year, emissions in 2019 decreased by 1.6%. The main reasons for this short-term decrease are on the one hand a significantly lower consumption of mineral fertilizers and on the other hand a smaller number of cattle.

In 1990, national total CO emissions amounted to 1 254 kt. Emissions considerably decreased from 1990 to 2019. In 2019, emissions were 60% below 1990 levels and amounted to 498 kt. This reduction was mainly due to decreasing emissions from road transport (catalytic converters). The emissions increased between 2018 and 2019 by 2.9%, mainly due to sector iron and steel.

Particulate Matter

Particulate matter emissions in Austria mainly arise from industrial processes, road transport, agriculture and small heating installations.

Particulate matter (PM) emissions show a decreasing trend over the period 1990 to 2019: TSP emissions decreased by 28%, PM_{10} emissions were about 35% below the level of 1990, and $PM_{2.5}$ emissions dropped by about 48%. Between 2018 and 2019 PM_{10} and $PM_{2.5}$ emissions decreased by 0.1% (PM_{10}) and 1.2% ($PM_{2.5}$). TSP emissions increased by 0.4%. The short-term decrease of PM_{10} and $PM_{2.5}$ was mainly due to lower emissions from *1.A.3 Road transport* (passenger cars). In the transport sector PM emissions show a general decrease since several years as a result of improved technology. TSP emissions increased slightly compared to the previous year because of rising emissions from *2.A Mineral Products* and *2.B Chemical Industry*.

Heavy Metals

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

The overall Cd emissions reduction of 34% from 1990 to 2019 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. In the last years emissions remained quite stable, the increased emission level 2017 was due to higher emissions from iron and steel production and from industrial processes.

The overall reduction of Hg of about 54% for the period 1990 to 2019 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 sub-sectors and in the agriculture sector led to the sharp fall of total Hg emission in Austria by the year 2000. Between 2018 and 2019 emissions increased by 2.7% because of larger emissions from NFR *2.C.1 Iron and Steel Production.*

The overall reduction trend of Pb emissions was minus 91% for the period 1990 to 2019, 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 Pb emissions show an increase of 5.9% mainly as a result of rising emissions from *Iron and Steel Production (NFR 2.C.1)* and *Other product manufacture and use (NFR 2.G).*

Persistent Organic Pollutants (POPs)

Emissions of all POPs decreased remarkably from 1990 to 2019 (HCB -79%, PAH -66%, PCDD/F -73% and PCBs -26%), where the highest achievement was made until 1995. 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 2019 PCDD/F emissions increased by 0.3% compared to the previous year 2018, PAH emissions increased by 0.8% and HCB emissions by 7.6% in the same time. This increase of HCB emissions was mainly due to higher emissions from sectors *3.D.f Use of pesticides* and 2.*C.1 Iron and Steel Production*. PAH emissions and PCDD/F emissions rose because of higher emissions from sectors *2 Industrial Processes* and *1.A.4 Other Sectors (only PAH).*

In 2019 PCB emissions increased by 8.5% compared to the previous year 2018, due to increased emissions from *sector 2.C.1 Iron and Steel Production*.

The most important source for 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 and PCB 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 2019.

Name of key category	No of occurrences as key category
1.A.4.b.1 – Residential: stationary	25 times (SO_2, NO_x, NMVOC, CO, Cd, Pb, Hg, PAH, DIOX, HCB, TSP, PM_{10}, $PM_{2.5}$)
2.C.1 – Iron and Steel Production	13 times (Cd, Pb, Hg, DIOX, HCB, PCB, TSP, PM_{10}, $PM_{2.5}$)
1.A.3.b.1 – R.T., Passenger cars	12 times (NO_x, NMVOC, CO, Pb, TSP, PM_{10}, $PM_{2.5}$)
1.A.1.a – Public Electricity and Heat Production	14 times (SO_2, NO_x, Cd, Pb, Hg, DIOX, TSP, PM_{10}, $PM_{2.5}$)
1.A.3.b.3 – R.T., Heavy duty vehicles	7 times (SO_2, NO_x, 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. Natural gas gross inland consumption has been revised for 1999–2004. In addition, natural gas consumption has been shifted from 'energy sector use' to 'final energy consumption' for the years 1994–1996 and 1999–2018. Final energy consumption has also been shifted to different sectors. For liquid fuels, gross inland consumption has been revised for the year 2018 for motor gasoline only. Furthermore, considerable amounts of LPG fuel consumed in the period 1990–2018 have been removed from category 1.A.1.a and included in 'oil refinery' instead (use of energy sector). For solid fuels, gross inland consumption has been revised for the years 2017 and 2018. Gross inland consumption for solid biomass fuels has been revised for 2005–2018.

The recalculations of the $PM_{2.5}$ emissions in the category *Coal Mining and Handling (1.B.1.a)* for the years 2014, 2016, 2017 and 2018 are also due to a revision of the energy balance.

In NFR sector ***1.A.3 Transport***, the mileage model for the vehicle categories had to be recalibrated as a result of the update of the energy data (LPG, biogas) in accordance with the energy balance. This has led to minor changes in the activity data and emissions for each vehicle category over the entire time series. According to the bottom-up/top-down methodology applied for the calculation of domestic fuel consumption and fuel exports, an increased use of domestic fuels always results in a reduction of exported fuel quantities, and vice versa.

Recalculations in category *Domestic navigation (1.A.3.d)* result from slightly updated domestic fuel consumption data on the basis of a new study on Austria's off-road emissions with focus on shipping, especially passenger ships.

In NFR sector ***2 Industrial Processes and Product Use*** recalculations have been carried out mainly in subcategory *Solvent Use (2.D.3)*: The changes in the emission estimates result from improved allocations of activity data to the different categories, combined with higher/lower IEFs leading to an increase in the emissions.

In the categories Quarrying and mining of minerals other than coal (2.A.5.a), Construction and demolition (2.A.5.b) and Aluminium production (2.C.3) recalculations have been carried out due to changes of activity data.

Due to recalculations of the energy balances, the activity data in category Wood processing (2.I) had to be updated. Thus, particulate matter emissions since 2005 have changed.

The main reasons for revised emissions in NFR sector ***3 Agriculture*** are due to the availability of new information on input materials for Austria's biogas plants as well as revised emissions from inorganic N fertilizers due to the implementation of a new EF for N-stabilised fertilizers. Furthermore, grassland and cropland areas have been adjusted.

In NFR sector ***5 Waste****,* revisions werde made in categories Waste disposal on land (5.A), Biological treatment of waste (5.B) and Wastewater (5.D): The method for extrapolating the amount of collected landfill gas was improved, which led to reduced landfill gas amounts and subsequent downward revisions of NMVOC in category *5.A*. Revisions in category *5.B* are due to new information available on input materials for Austria's biogas plants (see also sector *3 Agriculture*). For NMVOC from category *5.D.1 domestic wastewater* a recalculation for 2018 was carried out as new data on wastewater volumes became available and new data on the level of connection of the with sewer systems in 2018.

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 330. The next Stage 3 review is currently not scheduled, but is expected within the next five years.

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 2020 (EC 2020) for Austria are summarized and commented in Table 331.

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.

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

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8 https://www.unece.org/env/lrtap/welcome.html

9 http://www.unece.org

10 http://unfccc.int/2860.php

11 http://ec.europa.eu/index_en.htm

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

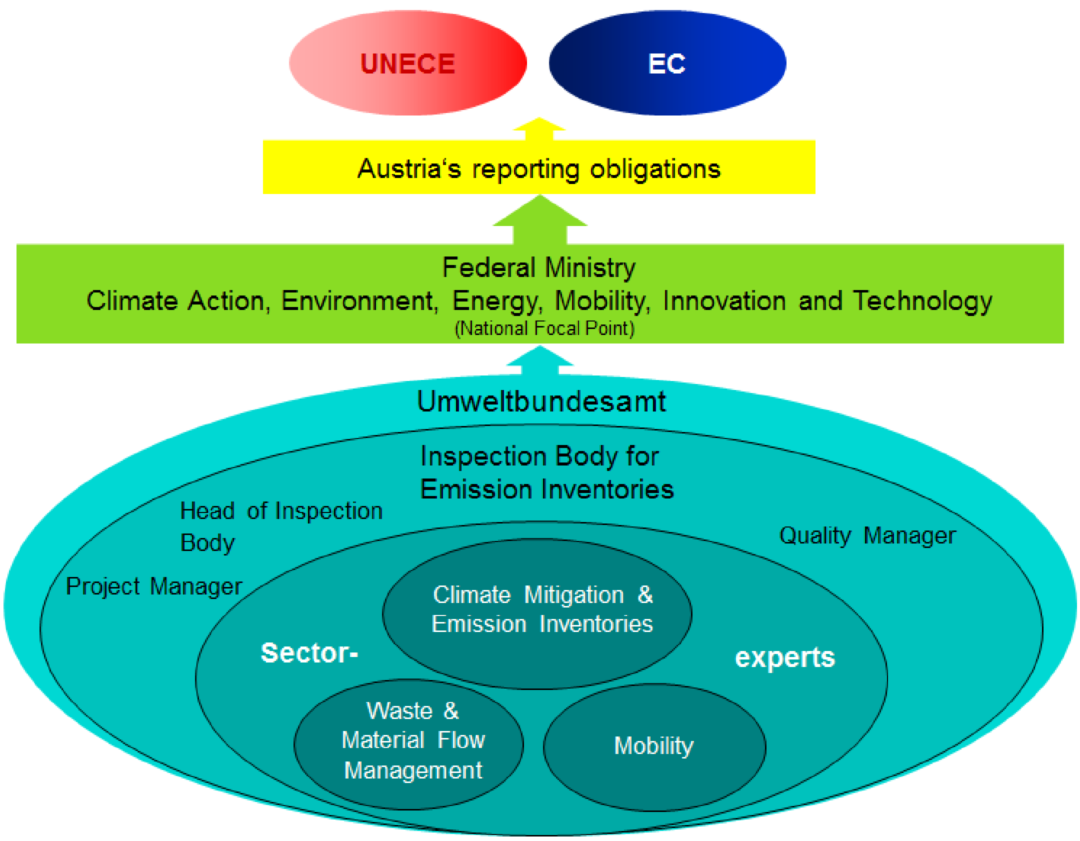
13 „Umweltkontrollgesetz" – Bundesgesetz über die Umweltkontrolle und die Einrichtung einer Umweltbundesamt Gesellschaft mit beschränkter Haftung; Federal Law Gazette I 152/1998

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 and the Kyoto Protocol, the EC Monitoring Mechanism as well as the UNECE and NEC Directive (see Chapter 1.6).

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. No technical instructions from outside the IBE are given for the preparation of emission inventories (see Figure 1).

Responsibilities within the Austrian National Inventory System



Source: Umweltbundesamt

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

The quality system 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.

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

There are 8 sectors defined (Energy, Transport, Fugitive Emissions, Industrial Processes, Product Use, Agriculture, LULUCF[15] and Waste). At least two experts form a sector team and one of them is nominated team leader ('Sector Lead'). 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 as a party of the Kyoto Protocol.

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 EU Monitoring Mechanism 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 (formerly referred to as BMNT) 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 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 declara-

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[15] 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

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

tions. 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 are – 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'). Responsible for data collection and analysis is the BMK. The necessary data is requested by the Umweltbundesamt for the purpose of inventory preparation.
- Since 2004 there is 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 to be adapted to different obligations which are 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]
- 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.

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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/

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/ACC).

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

26 http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php

- 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.
- 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.

For more details on NISA, see the report "NISA – NATIONAL INVENTORY SYSTEM AUSTRIA – Implementation Report"[27] which presents an overview of NISA and evaluates its compliance with the guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol as specified under the Marrakesh Accord (decision 20/CP.7).[28]

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[29] 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 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 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 – generally more stringent – standards for national emission inventories under the UNFCCC and the Kyoto Protocol and also meets all the requirements of the LRTAP Convention and other reporting obligations 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: timeliness, transparency, accuracy, consistency, comparability, and completeness (TACCC).

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.

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27 http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0004.pdf

28 http://unfccc.int/resource/docs/cop7/13a03.pdf#page=2

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

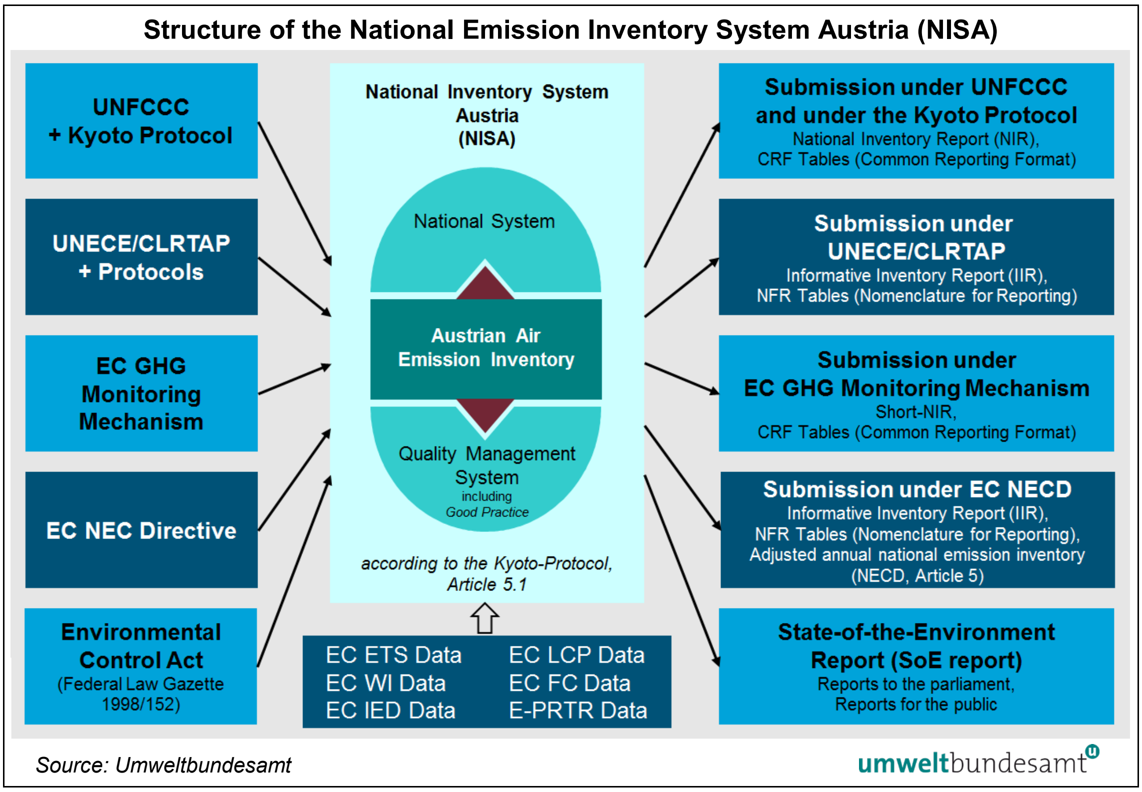

Figure 2: Structure of the National Emission Inventory System Austria (NISA).

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[30] 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[31] transposes the NEC Directive into Austrian national legislation.
- „United Nations Framework Convention on Climate Change" (UNFCCC) (1992)[32] and the Kyoto Protocol (1997).[33]

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

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

32 http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php

33 http://unfccc.int/files/essential_background/kyoto_protocol/application/pdf/kpstats.pdf

- European Council Decision 525/2013/EC[34] "Monitoring Mechanism Regulation" on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change.
- Austrian "ambient air quality act"[35] 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[36] which requires the reporting of air emissions from various industrial activities.
- E-PRTR Regulation (EC) No 166/2006[37] 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.

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	34	29.12.2003	24.06.1998 (s) 17.12.2003 (r)
1998	Aarhus Protocol on Persistent Organic Pollutants (POPs)	33	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	28	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

[34] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:165:0013:0040:EN:PDF (repealing Decision 280/2004/EC)

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

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

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

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 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)[38/39] 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 (ECE/EB.AIR.125)[40] and were adopted for application in 2015 and subsequent years.

The data presented in this report were compiled according to the Reporting Guidelines for estimating and reporting emission data, which also define the new reporting format (**N**omenclature **f**or **R**eporting – NFR (latest version of the templates 'NFR19'[41] 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)**	**Years** [(1)]
A. National total emissions		
1. Main pollutants	SO_x, NO_x, NH_3, NMVOC, CO	from 1990 to 2019
2. Particulate matter	$PM_{2.5}$, PM_{10}, (*TSP, BC*)	for 1990, 1995, and for 2000 to 2019
3. Heavy metals	Pb, Cd, Hg, (*As, Cr, Cu, Ni, Se, Zn)*	from 1990 to 2019
4. POPs	PCDD/PCDF, PAHs[(2)], HCB, PCBs	from 1990 to 2019
B. Emissions by NFR source category		
1. Main pollutants	SO_x, NO_x, NH_3, NMVOC, CO	from 1990 to 2019
2. Particulate matter	$PM_{2.5}$, PM_{10}, (*TSP, BC*)	for 1990, 1995, and for 2000 to 2019
3. Heavy metals	Pb, Cd, Hg, (*As, Cr, Cu, Ni, Se, Zn)*	from 1990 to 2019
4. POPs	PCDD/PCDF, PAHs [(2)], HCB, PCBs	from 1990 to 2019
C. Activity data by source category		**from 1990 to 2019**

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

39 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.

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

41 https://www.ceip.at/reporting-instructions/reporting-programme

Element(s)	Pollutant(s)	Years (1)
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	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 and every 4 years
LPS emissions		
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	2020, 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	2020, 2025, 2030, and where available also for 2040 and 2050
3. Projected activity data by NFR19		2020, 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}*

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 used* (thus excluding emissions from fuel exports in the vehicle tank) for compliance assessment under the NEC Directive.

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 2019 was compiled according to the recommendations for inventories as set out by the UNECE Executive Body[42] and in the guidelines mentioned above.

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

42 http://www.ceip.at/ms/ceip_home1/ceip_home/reporting_instructions/

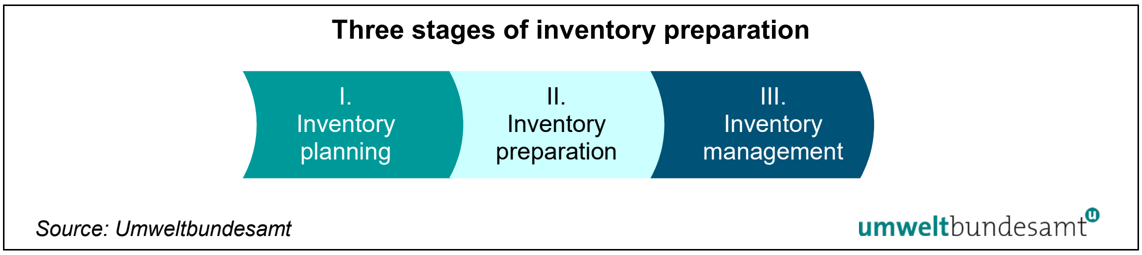

Figure 3: Three stages of inventory preparation.

I 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, also 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.

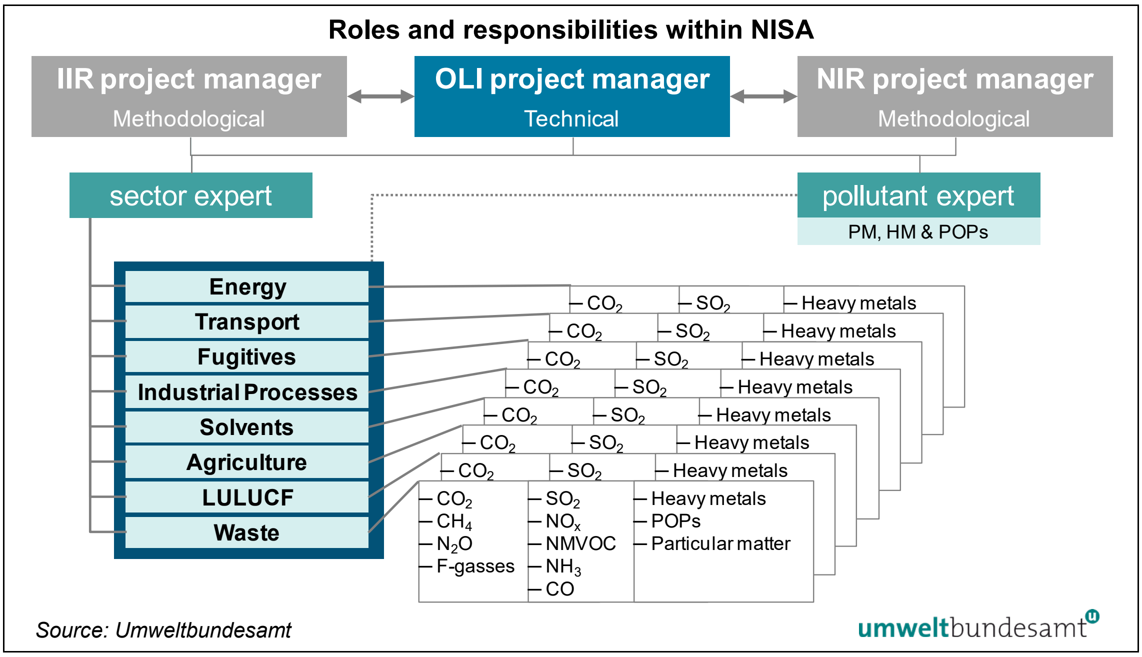

Figure 4: Roles and responsibilities within the National Emission Inventory System Austria (NISA).

Emissions of air pollutants are estimated together with greenhouse gases in a single data base based on the CORINAIR[43] scheme, which was formerly also used as reporting format under the

[43] 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)

UNECE. This nomenclature was designed by the ETC/ACC[44] to estimate emissions of all kind of air pollutants as well as greenhouse gases.

The CORINAIR system's nomenclature is called SNAP,[45] 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.

II 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 methodological choices and for contracting studies, if needed.

As the source of emission factors and/or the methodology of emission estimation for HM, POPs and PM is different compared to the "main" pollutants for a lot of source categories, emission inventories for these pollutants were prepared in studies that were contracted out; however, the incorporation into the inventory system and the update of emission calculations for subsequent years is the responsibility of the sector experts.

All data collected together with emission estimates are fed into a database (see below), where data sources are documented for future reconstruction 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[46] format.

In addition to actual emission data, background tables of the NFR are filled in by the sector experts, and finally QA/QC procedures as defined in the inventory planning process are carried out before the data is submitted under the UNECE/EC.

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

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 (sector experts, deputies, project-/quality- and data managers of the inventory); 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 data base and generating NFR data files	December 23
Quality checks	Tier 1 and Tier 2 QA/QC activities	December

44 European Topic Centre on Air Emissions

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

46 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

Task	Description	Deadline
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 ot the Informative Inventory Report to the EC (NEC Directive) and UNECE	March 15

III 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 continuously 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 databases 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[47].
- 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.

[47] „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.

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 growth rates of transport performance on Austrian roads from Federal Ministry of Climate Action, Environment, Energy, Mobility, In-novation and Technology (BMK) • ZBD: Zentrale Beguchtachtungsdatenbank (periodically updated specific mileage) • Flight movements from AustroControl
IPPU	• National production statistics • Import/export statistics • EU-ETS • Direct information from industry or associations of industry • Short term statistics for trade and services • Austrian foreign trade statistics • Structural business statistics • Surveys at companies and associations
Agriculture	• National studies • National agricultural statistics obtained from Statistik Austria • National fertilizer statistics obtained from Agrarmarkt Austria (AMA) • Distributing company (sales data)
Waste	• Federal Waste Management Plan (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) • Death statistics

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

In cases where the IBE's capabilities or resources are exceeded, some of its inventory activities are subcontracted, in some cases routinely (e.g. the emission inventory for road transport), in other cases as required (e.g. revision of methodologies for a complex emission source). Such subcontracts have so far been concluded with:

- Technical University Graz (road and off-road transport)
- Technical University of Natural Resources and Applied Life Sciences, Research Center Seibersdorf (Agriculture)
- Institute for Industrial Ecology (Product Use)
- Amon and Hörtenhuber 2019 (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 2019 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[48]
- EMEP/EEA air pollutant emission inventory guidebook – 2009. Technical report No 9/2009[49]
- EMEP/EEA air pollutant emission inventory guidebook – 2013. Technical report No. 12/2013[50]
- EMEP/EEA air pollutant emission inventory guidebook – 2016. Technical report No. 21/2016[51]
- EMEP/EEA air pollutant emission inventory guidebook – 2019. Technical report No. 21/2019[52]
- Handbook emission factors for road transport (HBEFA), Version 4.1

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[1] and amended by Directive 2009/29/EC[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 2013–2020 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.

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48 http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm

49 http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009

50 http://www.eea.europa.eu/publications/emep-eea-guidebook-2013

51 http://www.eea.europa.eu/publications/emep-eea-guidebook-2016

52 https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

[1] 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 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the emission allowance trading scheme of the Community, OJ L 140/63

Greenhouse gases covered under the EU ETS are CO_2 (since 2005), N_2O (since 2010) and PFC (since 2013)[2]. About one third of total Austrian GHG emissions currently result from installations under the EU-ETS (~29,6 Mt CO_2 in 2019).

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, runs from 2013 to 2020. 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 601/2012[54]. In Austria, Member State specific regulations are defined in the Austrian Emissions Allowance Trading Act[55] and the Austrian Monitoring, Reporting and Verification Ordinance[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 (NFR Sector 1) and 4 Industrial Processes and Product Use (NFR 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 is in charge of granting the licence to independent verifiers. In addition, the Ministry 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.

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

[2] 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.

54 Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

55 Emissionszertifikategesetz 2011, Federal Law Gazette I No. 118/2011, as amended

56 Überwachungs-, Berichterstattungs- und Prüfungs-Verordnung, Federal Law Gazette II No. 339/2007, as amended

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).

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

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 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. (1999): Entwicklung der Schwermetallemissionen – Abschätzung der Emissionen von Blei, Cadmium und Quecksilber für die Jahre 1985, 1990 und 1995 gemäß der CORINAIR-Systematik. Institut für Industrielle Ökologie und Österreichisches Forschungszentrum Seibersdorf. Wien. (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. (2001): Österreichische Emissionsinventur für POPs 1985–1999. FTU – Forschungsgesellschaft Technischer Umweltschutz GmbH. Werkvertrag des Umweltbundesamt, IB-650. Wien. (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.; HÖFLINGER, W. (2001): Österreichische Emissionsinventur für Staub. Österreichisches Forschungszentrum Seibersdorf. Wien.

  Austrian emission inventory for PM. Austrian Research Centers Seibersdorf. Vienna.

- WINIWARTER, W.; SCHMID-STEJSKAL, H. & WINDSPERGER, A. (2007): Aktualisierung und Verbesserung der österreischen Luftschadstoffinventur für Schwebstaub. Systems research – Austrian Research Centers & Institut für Industrielle Ökologie. Wien.

  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.

[58] ORTHOFER, R. (1996); HÜBNER, C. (1996); HÜBNER, C. & WURST, F. (1997); HÜBNER, C. (2000)

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 & Motorcycles	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	Other transportation	D	PS/CS	CS	CS	CS	D	D	D	D	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	CS	CS	CS	CS	D/CS	D/CS	D/CS	L/CS	L/CS	CS	D/CS	CS	CS	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	CS	CS
2.A	MINERAL PRODUCTS													CS	CS	CS
2.B	CHEMICAL INDUSTRY	CS	CS	CS	PS	CS	CS	CS	CS					CS	CS	CS
2.C	METAL PRODUCTION	CS	CS	CS		CS	CS	CS	CS	CS	CS	CS	D	CS	CS	CS
2.D	NON ENERGY PRODUCTS FROM FUELS AND SOLVENT USE			CS		CS	PS		CS							
2.G	Other product manufacture and use	D	D	D	D	D	D	D	D	D	D			D	D	D
2.H	Other Processes		CS	L		CS				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

NFR	Description	SO_2	NO_x	NMVOC	NH_3	CO	Cd	Hg	Pb	PAH	DIOX	HCB	PCB	TSP	PM_{10}	$PM_{2.5}$
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
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			CS/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 2019" (EEA 2019)".

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 2019).

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 2019 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 2021 to the UNECE/LRTAP and the European Commission. For all gases a level assessment for all years 1990 (base year) and 2019 (last year), as well as a trend assessment for 1990 to 2019 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.5.a	Other, Stationary (including Military)
1.A.4.b.2	Residential: Household and gardening (mobile)	1.A.5.b	Other, Mobile (including Military)
1.A.4.c.1	Agriculture/Forestry/Fishing: Stationary		
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 procecces 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
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.D	Wastewater Treatment
5.B.1	Composting	5.E	Other Waste
5.C.1	Waste Incineration		

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 2019 – 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 % contri-butions	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	17	6	4							11	7	9		14	15			4	11					3		4		6		**118**	**4**
1.A.1.b	Petroleum refining				4							12																				**16**	**25**
1.A.2.a	Iron and Steel	42	3							31	8																					**84**	**6**
1.A.2.d	Pulp, Paper and Print	5	6		3							13				9											3		4		4	**46**	**13**
1.A.2.f	Non-metallic Minerals	7		4	5								10			17	38															**82**	**7**
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	9																		4												**13**	**27**
1.A.3.b.1	R.T., Passenger cars			35	10		28			9	55				73											2	3	3	4	5	6	**234**	**3**
1.A.3.b.2	R.T., Light duty vehicles			6																							3		3		4	**16**	**24**
1.A.3.b.3	R.T., Heavy duty vehicles		4	10	40																						8		11	2	15	**89**	**5**
1.A.3.b.5	R.T., Gasoline evaporation						8																									**8**	**31**

NFR Code	NFR Category	% Contributions to pollutant totals for key categories (cumulative 80%)																														Sum of KC % contri-butions	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.6	R.T., Automobile tyre and break wear													24												5	3	6	3	6		**47**	**12**
1.A.3.b.7	R.T., Automobile road abrasion																									4	3	3		3		**13**	**28**
1.A.3.c	Railways																									4		2		1		**8**	**33**
1.A.4.a.1	Commer-cial/Institutional: Stationary		8										5																	2	3	**18**	**22**
1.A.4.b.1	Residential: sta-tionary	12	39	7	6	21	6			42	19	20	12	9		15	17	75	81	48	25	40	73			17	18	24	21	42	26	**715**	**1**
1.A.4.c.1	Agricul-tu-re/Forestry/Fishing: Stationary																	9												3		**12**	**30**
1.A.4.c.2	Agricul-tu-re/Forestry/Fishing: Off-road Vehicles and Other Machin-ery			4	4																						6	2	8	3	10	**37**	**14**
1.B.2.a	Oil						4																									**4**	**40**
1.B.2.b	Natural gas		3																													**3**	**42**
2.A.5	Mining, construc-tion/demolition and handling of prod-ucts																									34	12	24	7	5		**82**	**8**
2.C.1	Iron and Steel Production											20	32	34	11	33				8	36	22		96	35		22		20		12	**379**	**2**

NFR Code	NFR Category	% Contributions to pollutant totals for key categories (cumulative 80%)																														Sum of KC % contri-butions	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.C.3	Aluminium production																			10		9										**19**	**21**
2.C.5	Lead Production												9												47							**57**	**11**
2.D.3.a	Domestic solvent use including fungicides					15																										**15**	**26**
2.D.3.d	Coating applications					8	16																									**24**	**18**
2.D.3.e	Degreasing					3	5																									**7**	**34**
2.D.3.g	Chemical products					2	5																									**7**	**36**
2.D.3.h	Printing						5																									**5**	**39**
2.D.3.i	Other solvent use						5																									**5**	**38**
2.G	Other product manufacture and use											6		6														2		3		**17**	**23**
2.H	Other Processes					2																										**2**	**44**
2.I	Wood processing																									3						**3**	**43**
3.B.1	Cattle					22		28	29																							**79**	**9**
3.B.3	Swine							9	21																							**30**	**15**
3.B.4.e	Horses								8																							**8**	**32**
2.B-10	Handling of products and other chemical industry				5												19															**24**	**19**
3.D.a.1	Inorganic N-fertilizers							7	6																							**12**	**29**
3.D.a.2	Organic fertilizers			4		8		40	12																							**63**	**10**

NFR Code	NFR Category	% Contributions to pollutant totals for key categories (cumulative 80%)																														Sum of KC % contri-butions	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		
3.D.c	On-farm storage, handling and transport of agri-cultural products																									9		12				**21**	**20**
3.D.f	Use of Pesticides																					14	13									**27**	**16**
5.B.1	Composting								7																							**7**	**35**
5.C.1	Waste incineration												8								18											**27**	**17**
5.E	Other waste han-dling																			6												**6**	**37**

Table 8: Key Categories for SO_2 emissions for the year 2019.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2019) Estimate [kt] $E_{x,t}$**	**Level Assessment $L_{x,t}$**	**Cumulative Total of $L_{x,t}$**
1.A.2.a	Iron and Steel	4.62	42.2%	42.2%
1.A.4.b.1	Residential: stationary	1.26	11.5%	53.8%
1.A.2.g.8	Other Stationary Combustion in Manufacturing In-dustries and Construction	1.00	9.1%	62.9%
1.A.1.a	Public Electricity and Heat Production	0.81	7.5%	70.4%
1.A.2.f	Non-metallic Minerals	0.79	7.2%	77.6%
1.A.2.d	Pulp, Paper and Print	0.52	4.8%	82.4%
	National Total	**10.93**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kt] $E_{x,0}$**	**Latest Year (2019) 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	1.26	0.392	39.1%	39.1%
1.A.1.a	Public Electricity and Heat Production	11.81	0.81	0.175	17.5%	56.5%
1.A.4.a.1	Commercial/Institutional: Stationary	4.95	0.06	0.078	7.8%	64.3%
1.A.2.d	Pulp, Paper and Print	4.30	0.52	0.060	6.0%	70.3%
1.A.3.b.3	R.T., Heavy duty vehicles	2.59	0.05	0.040	4.0%	74.3%
1.A.2.a	Iron and Steel	6.73	4.62	0.034	3.4%	77.6%
1.B.2.b	Natural gas	2.00	0.02	0.031	3.1%	80.8%
	National Total	**73.70**	**10.93**			

Table 9: Key Categories for NO_x emissions for the year 2019.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2019) Estimate [kt] $E_{x,t}$**	**Level Assessment $L_{x,t}$**	**Cumulative Total of $L_{x,t}$**
1.A.3.b.1	R.T., Passenger cars	51.07	35.4%	35.4%
1.A.3.b.3	R.T., Heavy duty vehicles	14.18	9.8%	45.2%
1.A.4.b.1	Residential: stationary	10.49	7.3%	52.5%
1.A.3.b.2	R.T., Light duty vehicles	9.14	6.3%	58.9%
1.A.1.a	Public Electricity and Heat Production	8.50	5.9%	64.8%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	6.34	4.4%	69.2%
3.D.a.2	Organic fertilizers	5.53	3.8%	73.0%
1.A.2.f	Non-metallic Minerals	5.50	3.8%	76.8%
1.A.2.g.7	Mobile Combustion in Manufacturing Industries and Construction	5.37	3.7%	80.5%
	National Total	**144.20**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2019) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
1.A.3.b.3	R.T., Heavy duty vehicles	48.83	14.18	0.474	40.2%	40.2%
1.A.3.b.1	R.T., Passenger cars	59.99	51.07	0.122	10.3%	50.6%
1.A.4.b.1	Residential: stationary	15.43	10.49	0.068	5.7%	56.3%
1.A.2.f	Non-metallic Minerals	9.99	5.50	0.061	5.2%	61.5%
2.B-10	Handling of products and other chemical industry	4.07	0.09	0.054	4.6%	66.1%
1.A.1.a	Public Electricity and Heat Production	12.09	8.50	0.049	4.2%	70.3%
1.A.1.b	Petroleum refining	4.32	1.05	0.045	3.8%	74.1%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	9.42	6.34	0.042	3.6%	77.7%
1.A.2.d	Pulp, Paper and Print	7.17	4.58	0.035	3.0%	80.7%
	National Total	**217.35**	**144.20**			

Table 10: Key Categories for NMVOC emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
3.B.1	Cattle	24.00	22.1%	22.1%
1.A.4.b.1	Residential: stationary	22.72	20.9%	43.0%
2.D.3.a	Domestic solvent use including fungicides	16.73	15.4%	58.4%
2.D.3.d	Coating applications	8.74	8.1%	66.5%
3.D.a.2	Organic fertilizers	8.30	7.6%	74.1%
2.D.3.e	Degreasing	2.79	2.6%	76.7%
2.H	Other Processes	2.71	2.5%	79.2%
2.D.3.g	Chemical products	2.52	2.3%	81.5%
	National Total	**108.59**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2019) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
1.A.3.b.1	R.T., Passenger cars	65.86	2.32	0.280	27.9%	27.9%
2.D.3.d	Coating applications	45.79	8.74	0.163	16.3%	44.2%
1.A.3.b.5	R.T., Gasoline evaporation	19.69	0.39	0.085	8.5%	52.6%
1.A.4.b.1	Residential: stationary	36.33	22.72	0.060	6.0%	58.6%
2.D.3.i	Other solvent use	13.20	0.92	0.054	5.4%	64.0%
2.D.3.h	Printing	12.65	0.66	0.053	5.3%	69.3%
2.D.3.e	Degreasing	13.26	2.79	0.046	4.6%	73.9%
2.D.3.g	Chemical products	12.79	2.52	0.045	4.5%	78.4%
1.B.2.a	Oil	11.44	1.81	0.042	4.2%	82.6%
	National Total	**335.54**	**108.59**			

Table 11: Key Categories for NH_3 emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
3.D.a.2	Organic fertilizers	25.37	39.8%	39.8%
3.B.1	Cattle	17.66	27.7%	67.4%
3.B.3	Swine	5.70	8.9%	76.4%
3.D.a.1	Inorganic N-fertilizers	4.38	6.9%	83.2%
	National Total	**63.82**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2019) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
3.B.1	Cattle	13.89	17.66	1.907	28.8%	28.8%
3.B.3	Swine	8.47	5.70	1.404	21.2%	49.9%
3.D.a.2	Organic fertilizers	26.93	25.37	0.788	11.9%	61.8%
3.B.4.e	Horses	0.65	1.72	0.542	8.2%	70.0%
5.B.1	Composting	0.35	1.28	0.467	7.0%	77.0%
3.D.a.1	Inorganic N-fertilizers	5.12	4.38	0.372	5.6%	82.6%
	National Total	**81.84**	**63.82**			

Table 12: Key Categories for CO emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1.A.4.b.1	Residential: stationary	211.40	42.4%	42.4%
1.A.2.a	Iron and Steel	152.61	30.6%	73.0%
1.A.3.b.1	R.T., Passenger cars	42.51	8.5%	81.6%
	National Total	**498.47**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2019) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
1.A.3.b.1	R.T., Passenger cars	465.39	42.51	0.560	55.2%	55.2%
1.A.4.b.1	Residential: stationary	358.66	211.40	0.195	19.2%	74.5%
1.A.2.a	Iron and Steel	210.72	152.61	0.077	7.6%	82.1%
	National Total	**1 253.89**	**498.47**			

Table 13: Key Categories for Cd emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [t] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1.A.4.b.1	Residential: stationary	0.23	19.8%	19.8%
2.C.1	Iron and Steel Production	0.23	19.7%	39.5%
1.A.2.d	Pulp, Paper and Print	0.15	13.1%	52.6%
1.A.1.b	Petroleum refining	0.14	12.4%	65.0%
1.A.1.a	Public Electricity and Heat Production	0.13	11.2%	76.3%
2.G	Other product manufacture and use	0.07	6.2%	82.5%
	National Total	**1.16**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [t] $E_{x,0}$	Latest Year (2019) Estimate [t] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
2.C.1	Iron and Steel Production	0.46	0.23	0.383	32.0%	32.0%
1.A.4.b.1	Residential: stationary	0.31	0.23	0.138	11.5%	43.5%
1.A.2.f	Non-metallic Minerals	0.10	0.02	0.124	10.4%	53.9%
2.C.5	Lead Production	0.07	0.00	0.111	9.3%	63.2%
5.C.1	Waste incineration	0.06	0.00	0.097	8.1%	71.3%
1.A.1.a	Public Electricity and Heat Production	0.18	0.13	0.083	6.9%	78.2%
1.A.4.a.1	Commercial/Institutional: Stationary	0.06	0.02	0.054	4.5%	82.7%
	National Total	**1.76**	**1.16**			

Table 14: Key Categories for Pb emissions for the year 2019.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2019) Estimate [t] $E_{x,t}$**	**Level Assessment $L_{x,t}$**	**Cumulative Total of $L_{x,t}$**
2.C.1	Iron and Steel Production	6.85	33.5%	33.5%
1.A.3.b.6	R.T., Automobile tyre and break wear	4.87	23.8%	57.4%
1.A.1.a	Public Electricity and Heat Production	1.89	9.2%	66.6%
1.A.4.b.1	Residential: stationary	1.81	8.8%	75.5%
2.G	Other product manufacture and use	1.25	6.1%	81.6%
	National Total	**20.42**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [t] $E_{x,0}$**	**Latest Year (2019) Estimate [t] $E_{x,t}$**	**Trend Assessment $L_{x,t}$**	**Contribution to the trend**	**Cumulative Total of $L_{x,t}$**
1.A.3.b.1	R.T., Passenger cars	161.71	0.01	0.762	73.4%	73.4%
2.C.1	Iron and Steel Production	32.09	6.85	0.119	11.5%	84.9%
	National Total	**232.54**	**20.42**			

Table 15: Key Categories for Hg emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [t] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
2.C.1	Iron and Steel Production	0.32	32.5%	32.5%
1.A.2.f	Non-metallic Minerals	0.17	17.2%	49.7%
1.A.4.b.1	Residential: stationary	0.15	15.1%	64.8%
1.A.1.a	Public Electricity and Heat Production	0.14	13.8%	78.6%
1.A.2.d	Pulp, Paper and Print	0.09	8.8%	87.4%
	National Total	**0.99**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [t] $E_{x,0}$	Latest Year (2019) Estimate [t] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
1.A.2.f	Non-metallic Minerals	0.70	0.17	0.451	38.1%	38.1%
2.B-10	Handling of products and other chemical industry	0.27	0.00	0.229	19.3%	57.4%
1.A.4.b.1	Residential: stationary	0.39	0.15	0.205	17.3%	74.7%
1.A.1.a	Public Electricity and Heat Production	0.34	0.14	0.177	14.9%	89.6%
	National Total	**2.16**	**0.99**			

Table 16: Key Categories for PAH emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [t] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1.A.4.b.1	Residential: stationary	4.83	74.5%	74.5%
1.A.4.c.1	Agriculture/Forestry/Fishing: Stationary	0.61	9.5%	84.0%
	National Total	**6.48**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [t] $E_{x,0}$	Latest Year (2019) Estimate [t] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
1.A.4.b.1	Residential: stationary	10.63	4.83	0.458	80.6%	80.6%
	National Total	**19.13**	**6.48**			

Table 17: Key Categories for PCDD/F/Furan emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [g] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1.A.4.b.1	Residential: stationary	16.24	48.3%	48.3%
2.C.3	Aluminium production	3.23	9.6%	57.8%
2.C.1	Iron and Steel Production	2.66	7.9%	65.7%
5.E	Other waste handling	2.08	6.2%	71.9%
1.A.2.g.8	Other Stationary Combustion in Manufacturing Industries and Construction	1.46	4.3%	76.3%
1.A.1.a	Public Electricity and Heat Production	1.33	4.0%	80.2%
	National Total	**33.66**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [g] $E_{x,0}$	Latest Year (2019) Estimate [g] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
2.C.1	Iron and Steel Production	37.21	2.66	0.377	35.7%	35.7%
1.A.4.b.1	Residential: stationary	40.63	16.24	0.266	25.2%	60.9%
5.C.1	Waste incineration	18.19	0.32	0.195	18.4%	79.3%
1.A.1.a	Public Electricity and Heat Production	12.12	1.33	0.118	11.1%	90.4%
	National Total	**125.24**	**33.66**			

Table 18: Key Categories for HCB emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [kg] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1.A.4.b.1	Residential: stationary	6.89	40.0%	40.0%
2.C.1	Iron and Steel Production	3.86	22.4%	62.5%
3.D.f	Use of pesticides	2.36	13.7%	76.2%
2.C.3	Aluminium production	1.61	9.4%	85.5%
	National Total	**17.22**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kg] $E_{x.0}$	Latest Year (2019) Estimate [kg] $E_{x.t}$	Trend Assessment $L_{x.t}$	Contribution to the trend	Cumulative Total of $L_{x.t}$
1.A.4.b.1	Residential: stationary	48.86	6.89	0.638	72.9%	72.9%
3.D.f	Use of pesticides	10.12	2.36	0.118	13.5%	86.4%
	National Total	**82.95**	**17.22**			

Table 19: Key Categories for PCB emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [kg] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
2.C.1	Iron and Steel Production	33.33	95.7%	95.7%
	National Total	**34.81**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kg] $E_{x.0}$	Latest Year (2019) Estimate [kg] $E_{x.t}$	Trend Assessment $L_{x.t}$	Contribution to the trend	Cumulative Total of $L_{x.t}$
2.C.5	Lead Production	19.16	0.00	1.543	47.4%	47.4%
2.C.1	Iron and Steel Production	19.34	33.33	1.127	34.6%	82.0%
	National Total	**47.23**	**34.81**			

Table 20: Key Categories for TSP emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
2.A.5	Mining, construction/demolition and handling of products	13.10	34.0%	34.0%
1.A.4.b.1	Residential: stationary	6.68	17.4%	51.4%
3.D.c	On-farm storage, handling and transport of agricultural products	3.29	8.5%	59.9%
1.A.3.b.6	R.T., Automobile tyre and break wear	1.96	5.1%	65.0%
1.A.3.b.7	R.T., Automobile road abrasion	1.64	4.3%	69.3%
1.A.3.c	Railways	1.61	4.2%	73.5%
2.I	Wood processing	1.14	3.0%	76.4%
1.A.1.a	Public Electricity and Heat Production	1.06	2.8%	79.2%
1.A.3.b.1	R.T., Passenger cars	0.73	1.9%	81.0%
	National Total	**38.49**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2019) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
2.C.1	Iron and Steel Production	6.43	0.64	0.396	21.8%	21.8%
1.A.4.b.1	Residential: stationary	11.50	6.68	0.329	18.1%	39.9%
2.A.5	Mining, construction/demolition and handling of products	9.97	13.10	0.214	11.7%	51.6%
1.A.3.b.3	R.T., Heavy duty vehicles	2.46	0.23	0.152	8.4%	60.0%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	2.06	0.47	0.108	6.0%	66.0%
1.A.3.b.6	R.T., Automobile tyre and break wear	1.05	1.96	0.062	3.4%	69.4%
1.A.3.b.1	R.T., Passenger cars	1.61	0.73	0.060	3.3%	72.7%
1.A.2.d	Pulp, Paper and Print	1.06	0.24	0.056	3.1%	75.8%
1.A.3.b.7	R.T., Automobile road abrasion	0.89	1.64	0.051	2.8%	78.6%
	National Total	**53.12**	**38.49**			

Table 21: Key Categories for PM_{10} emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1.A.4.b.1	Residential: stationary	6.25	23.7%	23.7%
2.A.5	Mining, construction/demolition and handling of products	6.23	23.7%	47.4%
3.D.c	On-farm storage, handling and transport of agricultural products	3.29	12.5%	59.9%
1.A.3.b.6	R.T., Automobile tyre and break wear	1.48	5.6%	65.5%
1.A.1.a	Public Electricity and Heat Production	0.95	3.6%	69.1%
1.A.3.b.7	R.T., Automobile road abrasion	0.82	3.1%	72.2%
1.A.3.b.1	R.T., Passenger cars	0.73	2.8%	75.0%
1.A.3.c	Railways	0.57	2.2%	77.1%
2.G	Other product manufacture and use	0.51	1.9%	79.1%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	0.47	1.8%	80.9%
	National Total	**26.34**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2019) 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	10.67	6.25	0.305	21.0%	21.0%
2.C.1	Iron and Steel Production	4.56	0.45	0.284	19.6%	40.6%
1.A.3.b.3	R.T., Heavy duty vehicles	2.46	0.23	0.154	10.6%	51.2%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	2.06	0.47	0.109	7.5%	58.8%
2.A.5	Mining, construction/demolition and handling of products	4.73	6.23	0.104	7.2%	65.9%
1.A.3.b.1	R.T., Passenger cars	1.61	0.73	0.061	4.2%	70.1%
1.A.2.d	Pulp, Paper and Print	0.95	0.21	0.051	3.5%	73.6%
1.A.3.b.6	R.T., Automobile tyre and break wear	0.79	1.48	0.047	3.3%	76.9%
1.A.3.b.2	R.T., Light duty vehicles	0.84	0.17	0.046	3.2%	80.1%
	National Total	**40.81**	**26.34**			

Table 22: Key Categories for $PM_{2.5}$ emissions for the year 2019.

Level Assessment

NFR Code	NFR Category	Latest Year (2019) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1.A.4.b.1	Residential: stationary	5.93	42.2%	42.2%
1.A.3.b.6	R.T., Automobile tyre and break wear	0.80	5.7%	47.9%
1.A.1.a	Public Electricity and Heat Production	0.80	5.7%	53.5%
1.A.3.b.1	R.T., Passenger cars	0.73	5.2%	58.7%
2.A.5	Mining, construction/demolition and handling of products	0.71	5.0%	63.7%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	0.47	3.4%	67.1%
1.A.3.b.7	R.T., Automobile road abrasion	0.44	3.1%	70.2%
2.G	Other product manufacture and use	0.43	3.1%	73.3%
1.A.4.c.1	Agriculture/Forestry/Fishing: Stationary	0.37	2.6%	75.9%
1.A.4.a.1	Commercial/Institutional: Stationary	0.33	2.3%	78.2%
1.A.3.b.3	R.T., Heavy duty vehicles	0.23	1.6%	79.9%
1.A.3.c	Railways	0.21	1.5%	81.3%
	National Total	**14.06**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2019) Estimate [kt] $E_{x,t}$	Trend Assess-ment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
1.A.4.b.1	Residential: stationary	9.98	5.93	0.311	26.4%	26.4%
1.A.3.b.3	R.T., Heavy duty vehicles	2.46	0.23	0.171	14.5%	40.9%
2.C.1	Iron and Steel Production	2.07	0.21	0.143	12.1%	53.0%
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	2.06	0.47	0.122	10.3%	63.4%
1.A.3.b.1	R.T., Passenger cars	1.61	0.73	0.068	5.7%	69.1%
1.A.3.b.2	R.T., Light duty vehicles	0.84	0.17	0.052	4.4%	73.5%
1.A.2.d	Pulp, Paper and Print	0.78	0.18	0.047	3.9%	77.5%
1.A.4.a.1	Commercial/Institutional: Stationary	0.77	0.33	0.034	2.9%	80.3%
	National Total	**27.07**	**14.06**			

1.6 Quality Assurance, Quality Control and verification

For fulfilment of the reporting obligations the Expert Team '*Climate Change Mitigation & Emission Inventories'* at the Umweltbundesamt, in particular the *Inspection Body for Emission Inventories*, operates a QMS based on the International Standard EN ISO/IEC 17020 *General Criteria for the operation of various types of bodies performing inspections*.

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 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 so far.

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 ISO compared to the IPCC 2006 GL as well as the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019

The implementation of QA/QC procedures as required by the IPCC 2006 GL and the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 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 2019 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).

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[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 2019[61]	IPCC 2006 GL	ISO 9001[62]	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, under the Kyoto Protocol, climate change mitigation measures and air quality control. To achieve this, the IBE is committed to strict impartiality and quality management. In this context, the term quality means:

1. Fulfilment of requirements for emission inventories.
2. For the fulfilment of these requirements, the IBE undertakes to keep its staff updated on the latest technical expertise, scientific findings and the latest developments. The IBE will therefore encourage the participation of its staff in international technical and political processes and ensure the transfer of knowledge within the IBE.

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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 ISO 9001

64 According to the EMEP Guidebook 2019, it also is good practice to summarize lessons learned from previous inventory preparation cycles in an inventory management report.

3. Compliance with the EN ISO/IEC 17020 standard by ensuring the implementation and continuous improvement of a QMS as described in this manual by the IBE and its personnel. 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-practice example by setting a high quality standard – even higher than specified in the requirements – so as 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.

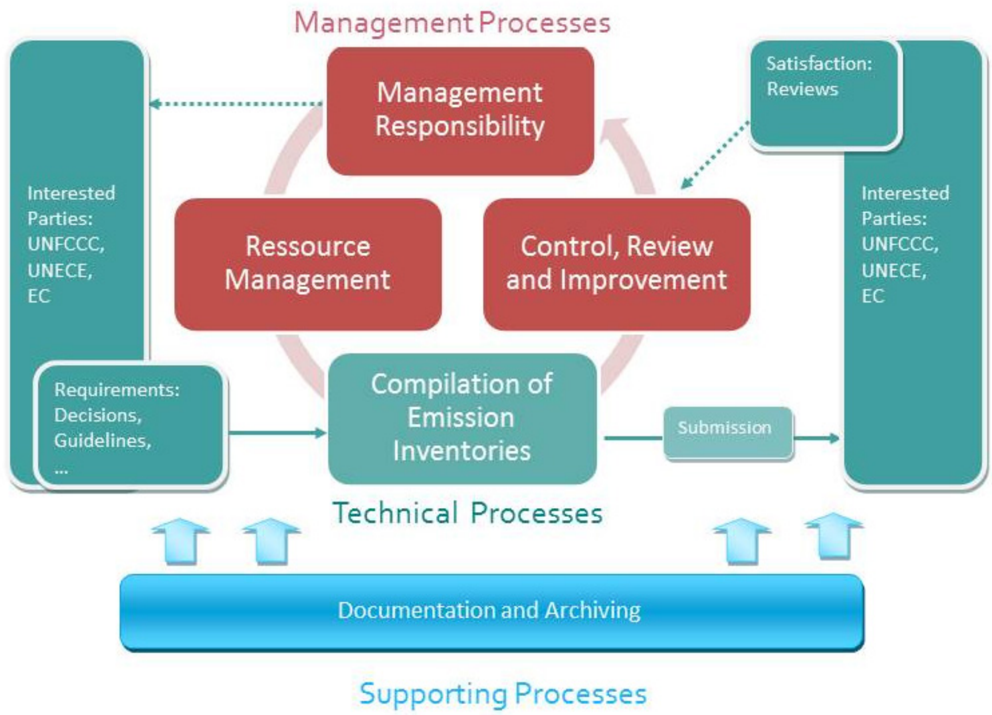
The QMS was primarily developed to meet the requirement of reporting greenhouse gas emissions under the Kyoto Protocol. For this reason the emphasis was originally placed on greenhouse gases, but by now all main air pollutants are covered by the QMS.

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 6).

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

Continual Improvement of the Quality Management System



Source: Umweltbundesamt

Figure 5: Process-based QMS of the IBE.

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 lead, project manager, head of inspection body, inventory support – 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:

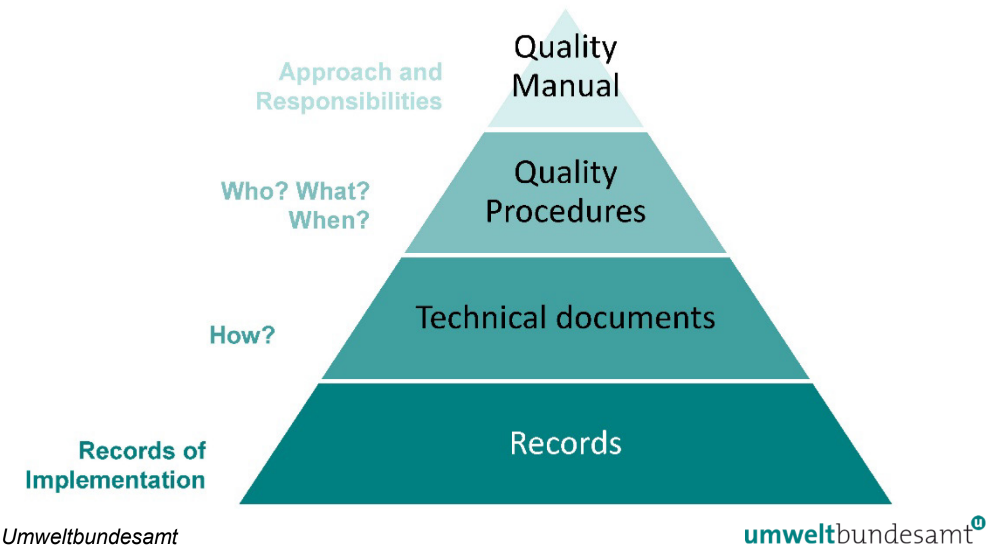
- QC activities
- Procedures for country specific methodologies
- Internal audits (QM specific)
- Procedures for sub-contracting
- Inventory improvement plan
- Documentation and archiving
- Treatment of confidential data
- Annual Management Review

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, ...)

Structure of the Austrian Quality Management System



Source: Umweltbundesamt

Figure 6: Structure of the Austrian Quality Management System (QMS).

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
- ✓ provision of references
- ✓ plausibility of data
- ✓ consistency of data
- ✓ completeness
- ✓ correct transformation/transcription into NFR
- ✓ information on background tables
- ✓ 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 5 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

Before methodologies are applied the methodology is defined as a SOP (standard operating procedure) together with a template for calculating emissions, where needed. The SOP is checked for applicability and completeness of information needed 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 sub-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 ISO/IEC 17020 is regularly monitored. Audits are performed every 20 months on average by the accreditation body (one 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 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.

Audits of data suppliers

Suppliers of annual activity data, that do not have in place a (certified) QMS or whose data are not independently verified, are audited in a so called 'input data audit'. The aim of the audits is to assess:

(1) whether the requirements regarding independence and integrity are fulfilled
(2) the long term availability of the data
(3) the data collection and management process
(4) whether the QC requirements of the data processing are fulfilled

When indicated, recommendations for improvements are made and implementation of these measures is assessed. These input data audits have proven a good basis for the cooperation with the data supplier.

Since 2007 all main data suppliers have been audited:

- 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 Institute for Industrial Ecology in 2016
- the national forest inventory at the Austrian Federal Office and Research Centre for Forests (BFW) in 2016

It is planned to conduct a follow-up audit at these institutions only when substantial changes become apparent.

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/LRTAP Review: The last In-depth review (stage 3) took place in 2017; the findings are summarized in Chapter 7.5, Table 320. 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.
- 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 2020 are summarized in Chapter 7.5, Table 321.
- 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. Information or data is declared as confidential when it could directly or indirectly identify an individual person, business or organisation. For this reason some emissions are reported at a higher, aggregated level so that confidentiality is no longer an issue, e.g. for fluorinated substances. 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[65].
- 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 the CRF/NFR tables) is obligatory for the 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.

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 2020

In 2020 the accreditation of the Inspection Body for Emission Inventories according to EN ISO/IEC 17020 was renewed in a comprehensive audit by the Austrian Accreditation Body. In their final report the authorized experts stated that the QMS of the IBE is actively implemented and fulfils the requirements of the standard in an adequate manner. Furthermore, they attested that the system is well structured. Regarding the personnel of the IBE the feedback from the auditors was that it is not only very competent but also highly committed to their inventory work and they actively support the continuous improvement of the inventory.

Since 2019 each position in the inspection body has been at least double staffed (meanwhile 22 experts are directly or indirectly involved in inventory work).

[65] Federal Act on Federal Statistics (Federal Statistics Act 2000) no. 163/1999

Five of these experts were able to gain experience by taking part in the international review process for greenhouse gases (comprehensive review under the European Effort Sharing Decision).

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 2019 (EEA 2019)".

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 2021a).

Uncertainties of emission factors of the relevant pollutants are based on the qualitative ratings following the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA 2019). 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 2019 (EEA 2019). 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 2019.

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 2019 (EEA 2019). 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				
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		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 burning 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 2019) 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 2019 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 2019	Level uncertainty 2019 [%]	Trend uncertainty 2019 [%]
SO2	[kt]	10.9	6.8	1.2
NO_x	[kt]	144.2	18.4	4.6
NMVOC	[kt]	108.6	36.7	10.1
NH_3	[kt]	63.8	21.4	6.1
CO	[kt]	498.5	68.8	11.5
Cd	[t]	1.2	40.7	9.9
Hg	[t]	1.0	30.2	5.8
Pb	[t]	20.4	48.7	8.1
PAH	[t]	6.5	151.8	16.1
DIOX	[g]	33.7	102.7	14.4
HCB	[kg]	17.2	88.1	9.0
PCB	[kg]	34.8	119.8	80.7
TSP	[kt]	38.5	74.3	23.7
PM_{10}	[kt]	26.3	62.4	17.8
$PM_{2.5}$	[kt]	14.1	31.5	9.0

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 2019.

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	0.8	8.0	20.0	21.54	2.58	-0.01	0.01	-0.25	0.13	0.08
1 A 1 b	SO2	2.3	0.5	1.0	10.0	10.05	0.20	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	4.6	5.0	10.0	11.18	22.30	0.05	0.06	0.49	0.44	0.44
1 A 2 b	SO2	0.2	0.1	5.0	20.0	20.62	0.03	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	0.10	0.00	0.00	0.02	0.02	0.00
1 A 2 d	SO2	4.3	0.5	10.0	20.0	22.36	1.15	0.00	0.01	-0.03	0.10	0.01
1 A 2 e	SO2	1.6	0.1	5.0	20.0	20.62	0.03	0.00	0.00	-0.04	0.01	0.00
1 A 2 f	SO2	2.2	0.8	5.0	20.0	20.62	2.21	0.01	0.01	0.12	0.08	0.02
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	1.0	10.0	20.0	22.36	4.17	0.01	0.01	0.20	0.19	0.07
1 A 3 a	SO2	0.0	0.1	3.0	20.0	20.22	0.04	0.00	0.00	0.03	0.01	0.00
1 A 3 b 1	SO2	1.5	0.1	3.1	20.0	20.24	0.02	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	0.01	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	0.1	5.0	20.0	20.62	0.01	-0.01	0.00	-0.18	0.01	0.03
1 A 4 b	SO2	25.9	1.3	15.0	20.0	25.00	8.34	-0.03	0.02	-0.70	0.36	0.62
1 A 4 c	SO2	1.8	0.1	5.0	20.0	20.62	0.03	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	0.01	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-10	SO2	1.6	0.4	2.0	40.0	40.05	1.79	0.00	0.00	0.07	0.01	0.01
2 C 1	SO2	0.3	0.1	0.5	125.0	125.00	0.33	0.00	0.00	0.02	0.00	0.00
2 C 7	SO2	0.1	0.1	5.0	125.0	125.10	2.91	0.00	0.00	0.22	0.01	0.05
2 G	SO2	0.0	0.0	100.0	125.0	160.08	0.01	0.00	0.00	0.01	0.01	0.00
3 F	SO2	0.0	0.0	100.0	125.0	160.08	0.00	0.00	0.00	0.00	0.00	0.00
5 C	SO2	0.1	0.0	7.0	200.0	200.12	0.06	0.00	0.00	0.01	0.00	0.00
Total		**73.7**	**10.9**				**46.34**					**1.36**
Total Uncertainties						Uncertainty in total inventory %:	**6.81**				Trend uncertainty %:	**1.16**

Table 28: Uncertainty estimation of NO_x emissions 1990 and 2019.

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	8.5	8.0	20.0	21.54	1.61	0.00	0.04	0.04	0.44	0.20
1 A 1 b	NOX	4.3	1.0	1.0	10.0	10.05	0.01	-0.01	0.00	-0.08	0.01	0.01
1 A 1 c	NOX	1.4	0.8	1.0	40.0	40.01	0.05	0.00	0.00	-0.01	0.01	0.00
1 A 2 a	NOX	5.4	3.8	5.0	10.0	11.18	0.09	0.00	0.02	0.01	0.12	0.02
1 A 2 b	NOX	0.3	0.2	5.0	40.0	40.31	0.00	0.00	0.00	0.01	0.01	0.00
1 A 2 c	NOX	1.7	1.4	5.0	40.0	40.31	0.15	0.00	0.01	0.05	0.04	0.00
1 A 2 d	NOX	7.2	4.6	10.0	40.0	41.23	1.72	0.00	0.02	-0.03	0.30	0.09
1 A 2 e	NOX	1.7	0.6	5.0	40.0	40.31	0.03	0.00	0.00	-0.10	0.02	0.01
1 A 2 f	NOX	10.0	5.5	5.0	40.0	40.31	2.36	-0.01	0.03	-0.21	0.18	0.08
1 A 2 g 7	NOX	3.0	5.4	1.0	40.0	40.01	2.22	0.02	0.02	0.62	0.03	0.38
1 A 2 g 8	NOX	3.7	3.2	10.0	40.0	41.23	0.85	0.00	0.01	0.14	0.21	0.06
1 A 3 a	NOX	0.4	1.9	3.0	40.0	40.11	0.27	0.01	0.01	0.30	0.04	0.09
1 A 3 b 1	NOX	60.0	51.1	3.1	40.0	40.12	201.86	0.05	0.23	2.07	1.03	5.34
1 A 3 b 2	NOX	7.3	9.1	3.1	40.0	40.12	6.46	0.02	0.04	0.79	0.18	0.66
1 A 3 b 3	NOX	48.8	14.2	3.1	40.0	40.12	15.56	-0.08	0.07	-3.35	0.29	11.27
1 A 3 b 4	NOX	0.1	0.2	3.1	40.0	40.12	0.00	0.00	0.00	0.03	0.00	0.00
1 A 3 c	NOX	1.8	0.7	3.0	40.0	40.11	0.04	0.00	0.00	-0.09	0.01	0.01
1 A 3 d	NOX	1.1	1.6	3.0	40.0	40.11	0.21	0.00	0.01	0.16	0.03	0.03
1 A 3 e	NOX	0.6	0.3	1.0	10.0	10.05	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	NOX	3.1	1.2	5.0	40.0	40.31	0.12	0.00	0.01	-0.15	0.04	0.02
1 A 4 b	NOX	16.3	10.9	15.0	40.0	42.72	10.37	0.00	0.05	0.01	1.06	1.13
1 A 4 c	NOX	10.5	6.9	5.0	100.0	100.12	22.76	0.00	0.03	-0.04	0.22	0.05
1 A 5 b	NOX	0.1	0.1	1.0	125.0	125.00	0.01	0.00	0.00	0.02	0.00	0.00
2 B 1	NOX	IE	0.2	2.0	40.0	40.05	0.00		0.00		0.00	
2 B 2	NOX	IE	0.1	2.0	40.0	40.05	0.00		0.00		0.00	
2 B-10	NOX	4.1	0.1	2.0	40.0	40.05	0.00	-0.01	0.00	-0.48	0.00	0.23
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	100.0	125.0	160.08	0.00	0.00	0.00	0.00	0.02	0.00
2 H	NOX	NA	NA	10.0	40.0	41.23						
3 B 1	NOX	0.3	0.2	1.0	125.0	125.00	0.04	0.00	0.00	0.00	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	0.05	0.00	0.00	0.08	0.02	0.01
3 D a	NOX	11.4	9.8	5.0	125.0	125.10	71.66	0.01	0.04	1.26	0.32	1.70
3 F	NOX	0.1	0.0	100.0	125.0	160.08	0.00	0.00	0.00	-0.01	0.01	0.00
5 C	NOX	0.1	0.0	7.0	200.0	200.12	0.00	0.00	0.00	-0.05	0.00	0.00
Total		**217.4**	**144.2**				**338.51**					**21.38**
Total Uncertainties						Uncertainty in total inventory %:	**18.40**				Trend uncertainty %:	**4.62**

Table 29: Uncertainty estimation of NMVOC emissions 1990 and 2019.

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	0.31	0.00	0.00	0.12	0.01	0.01
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	0.1	5.0	200.0	200.06	0.07	0.00	0.00	0.07	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	0.00	0.00	0.00	0.02	0.00	0.00
1 A 2 d	NMVOC	0.7	0.3	10.0	200.0	200.25	0.24	0.00	0.00	0.02	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	0.10	0.00	0.00	0.06	0.00	0.00
1 A 2 g 7	NMVOC	0.5	0.3	1.0	40.0	40.01	0.01	0.00	0.00	0.02	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	0.00	0.00
1 A 3 a	NMVOC	0.2	0.2	3.0	40.0	40.11	0.01	0.00	0.00	0.02	0.00	0.00
1 A 3 b 1	NMVOC	65.9	2.3	3.1	125.0	125.04	7.14	-0.06	0.01	-7.06	0.03	49.88
1 A 3 b 2	NMVOC	2.8	0.1	3.1	125.0	125.04	0.01	0.00	0.00	-0.31	0.00	0.09
1 A 3 b 3	NMVOC	5.1	0.3	3.1	125.0	125.04	0.15	0.00	0.00	-0.49	0.00	0.24
1 A 3 b 4	NMVOC	2.9	1.6	3.1	125.0	125.04	3.29	0.00	0.00	0.23	0.02	0.05
1 A 3 b 5	NMVOC	19.7	0.4	3.1	125.0	125.04	0.20	-0.02	0.00	-2.23	0.01	4.97
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	0.6	3.0	40.0	40.11	0.05	0.00	0.00	0.04	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	0.7	5.0	70.0	70.18	0.19	0.00	0.00	0.05	0.01	0.00
1 A 4 b	NMVOC	42.4	23.7	15.0	70.0	71.59	243.32	0.03	0.07	2.07	1.50	6.52
1 A 4 c	NMVOC	5.5	2.6	5.0	100.0	100.12	5.78	0.00	0.01	0.24	0.05	0.06
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	11.4	1.8	0.5	20.0	20.01	0.11	-0.01	0.01	-0.11	0.00	0.01
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-10	NMVOC	1.6	0.3	2.0	20.0	20.10	0.00	0.00	0.00	-0.02	0.00	0.00
2 C 1	NMVOC	0.3	0.3	0.5	125.0	125.00	0.09	0.00	0.00	0.06	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	114.4	32.4	20.0	30.0	36.06	115.88	-0.01	0.10	-0.41	2.73	7.64
2 G	NMVOC	0.1	0.1	100.0	125.0	160.08	0.01	0.00	0.00	0.01	0.03	0.00
2 H	NMVOC	1.9	2.7	10.0	40.0	41.23	1.06	0.01	0.01	0.25	0.11	0.08
3 B 1	NMVOC	32.8	24.0	1.0	125.0	125.00	762.98	0.04	0.07	4.98	0.10	24.84
3 B 2	NMVOC	0.1	0.1	10.0	125.0	125.40	0.02	0.00	0.00	0.04	0.01	0.00
3 B 3	NMVOC	1.5	1.0	4.0	125.0	125.06	1.42	0.00	0.00	0.20	0.02	0.04
3 B 4	NMVOC	1.0	1.4	10.0	125.0	125.40	2.76	0.00	0.00	0.41	0.06	0.17
3 D a	NMVOC	14.9	8.4	5.0	125.0	125.10	92.90	0.01	0.02	1.32	0.18	1.76
3 D e	NMVOC	1.8	1.5	5.0	750.0	750.02	112.29	0.00	0.00	2.15	0.03	4.63
3 F	NMVOC	0.1	0.0	100.0	125.0	160.08	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00
Total		**335.5**	**108.6**				**1 350.44**					**101.02**
Total						Uncertainty in total inventory %:	**36.75**				Trend uncertainty %:	**10.05**

Table 30: Uncertainty estimation of NH_3 emissions 1990 and 2019.

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·F Note C	$J\cdot E\cdot\sqrt{2}$ Note D	K^2+L^2
1 A 1 a	NH3	0.1	0.3	8.0	750.0	750.04	15.63	0.00	0.01	2.69	0.06	7.23
1 A 1 b	NH3	0.1	0.1	1.0	750.0	750.00	0.97	0.00	0.00	0.07	0.00	0.01
1 A 1 c	NH3	0.0	0.0	1.0	750.0	750.00	0.00	0.00	0.00	-0.05	0.00	0.00
1 A 2 a	NH3	0.0	0.0	5.0	750.0	750.02	0.06	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	0.19	0.00	0.00	0.11	0.00	0.01
1 A 2 d	NH3	0.1	0.1	10.0	750.0	750.07	0.63	0.00	0.00	-0.10	0.02	0.01
1 A 2 e	NH3	0.0	0.0	5.0	750.0	750.02	0.03	0.00	0.00	-0.09	0.00	0.01
1 A 2 f	NH3	0.1	0.2	5.0	750.0	750.02	3.84	0.00	0.00	0.27	0.02	0.07
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	0.04	0.00	0.00	0.10	0.02	0.01
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	0.9	3.1	200.0	200.02	8.58	0.00	0.02	0.47	0.07	0.23
1 A 3 b 2	NH3	0.0	0.0	3.1	200.0	200.02	0.01	0.00	0.00	0.02	0.00	0.00
1 A 3 b 3	NH3	0.0	0.1	3.1	200.0	200.02	0.15	0.00	0.00	0.38	0.01	0.14
1 A 3 b 4	NH3	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	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	0.01	0.00	0.00	0.07	0.00	0.00
1 A 4 a	NH3	0.1	0.1	5.0	125.0	125.10	0.01	0.00	0.00	-0.04	0.01	0.00
1 A 4 b	NH3	0.5	0.5	15.0	125.0	125.90	1.04	0.00	0.01	-0.04	0.18	0.03
1 A 4 c	NH3	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	-0.01	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	0.01	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	-0.06	0.00	0.00
2 G	NH3	0.1	0.1	100.0	40.0	107.70	0.01	0.00	0.00	-0.01	0.13	0.02
3 B 1	NH3	13.9	17.7	1.0	20.0	20.02	30.71	0.05	0.29	1.07	0.40	1.31
3 B 2	NH3	0.7	1.0	10.0	40.0	41.23	0.39	0.00	0.02	0.13	0.22	0.07
3 B 3	NH3	8.5	5.7	4.0	20.0	20.40	3.31	-0.05	0.09	-0.98	0.52	1.24
3 B 4	NH3	2.9	4.5	10.0	40.0	41.23	8.64	0.02	0.07	0.98	1.04	2.04
3 D a	NH3	33.1	30.6	5.0	40.0	40.31	373.03	-0.06	0.49	-2.30	3.50	17.51
3 F	NH3	0.0	0.0	100.0	125.0	160.08	0.00	0.00	0.00	-0.06	0.02	0.00
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	1.6	20.0	125.0	126.59	10.61	0.02	0.03	2.56	0.75	7.13
5 C	NH3	0.0	0.0	7.0	125.0	125.20	0.00	0.00	0.00	0.00	0.00	0.00
Total		**61.8**	**63.8**				**457.90**					**37.09**
Total Uncertainties						Uncertainty in total inventory %:	**21.40**				Trend uncertainty %:	**6.09**

Table 31: Uncertainty estimation of CO emissions 1990 and 2019.

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	3.9	8.0	20.0	21.54	0.03	0.00	0.00	0.05	0.04	0.00
1 A 1 b	CO	4.7	0.3	1.0	20.0	20.02	0.00	0.00	0.00	-0.03	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	152.6	5.0	125.0	125.10	1 466.82	0.05	0.12	6.85	0.86	47.68
1 A 2 b	CO	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	CO	0.5	0.4	5.0	125.0	125.10	0.01	0.00	0.00	0.02	0.00	0.00
1 A 2 d	CO	4.2	2.1	10.0	125.0	125.40	0.27	0.00	0.00	0.04	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	0.00	0.00	0.00
1 A 2 f	CO	11.0	3.8	5.0	125.0	125.10	0.92	0.00	0.00	-0.06	0.02	0.00
1 A 2 g 7	CO	3.8	3.9	1.0	40.0	40.01	0.10	0.00	0.00	0.08	0.00	0.01
1 A 2 g 8	CO	0.8	1.6	10.0	40.0	41.23	0.02	0.00	0.00	0.04	0.02	0.00
1 A 3 a	CO	2.6	3.9	3.0	40.0	40.11	0.10	0.00	0.00	0.09	0.01	0.01
1 A 3 b 1	CO	465.4	42.5	3.1	40.0	40.12	11.71	-0.11	0.03	-4.53	0.15	20.53
1 A 3 b 2	CO	42.1	3.2	3.1	40.0	40.12	0.07	-0.01	0.00	-0.43	0.01	0.19
1 A 3 b 3	CO	12.4	6.5	3.1	40.0	40.12	0.27	0.00	0.01	0.05	0.02	0.00
1 A 3 b 4	CO	7.8	6.2	3.1	40.0	40.12	0.25	0.00	0.00	0.10	0.02	0.01
1 A 3 c	CO	2.0	0.5	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	2.6	3.0	40.0	40.11	0.04	0.00	0.00	0.04	0.01	0.00
1 A 3 e	CO	0.0	0.1	1.0	125.0	125.00	0.00	0.00	0.00	0.01	0.00	0.00
1 A 4 a	CO	11.4	4.7	5.0	125.0	125.10	1.37	0.00	0.00	0.01	0.03	0.00
1 A 4 b	CO	387.7	224.1	15.0	125.0	125.90	3 204.82	0.06	0.18	6.96	3.79	62.81
1 A 4 c	CO	33.1	17.9	5.0	125.0	125.10	20.09	0.00	0.01	0.47	0.10	0.23
1 A 5 b	CO	0.2	0.3	1.0	125.0	125.00	0.01	0.00	0.00	0.02	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	19.72	0.00	0.01	0.97	0.02	0.94
2 C 1	CO	23.2	1.9	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	100.0	200.0	223.61	0.11	0.00	0.00	0.06	0.08	0.01
3 F	CO	1.2	0.3	100.0	125.0	160.08	0.01	0.00	0.00	-0.02	0.03	0.00
5 A	CO	10.3	2.7	12.0	125.0	125.57	0.47	0.00	0.00	-0.13	0.04	0.02
5 C	CO	0.1	0.0	7.0	125.0	125.20	0.00	0.00	0.00	0.00	0.00	0.00
Total		**1253.9**	**498.5**				**4 727.23**					**132.50**
Total Uncertainties						Uncertainty in total inventory %:	**68.75**				Trend uncertainty %:	**11.51**

Table 32: Uncertainty estimation of Cd emissions 1990 and 2019.

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	0.1	8.0	125.0	125.26	198.16	0.01	0.07	0.83	0.84	1.40
1 A 1 b	Cd	0.1	0.1	1.0	125.0	125.00	241.54	0.03	0.08	3.29	0.12	10.81
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	0.11	0.00	0.00	-0.07	0.01	0.00
1 A 2 b	Cd	0.0	0.0	5.0	125.0	125.10	0.01	0.00	0.00	-0.01	0.00	0.00
1 A 2 c	Cd	0.0	0.0	5.0	125.0	125.10	2.91	0.00	0.01	-0.20	0.06	0.05
1 A 2 d	Cd	0.2	0.2	10.0	125.0	125.40	268.89	0.03	0.09	3.71	1.22	15.26
1 A 2 e	Cd	0.0	0.0	5.0	125.0	125.10	0.01	0.00	0.00	-0.04	0.00	0.00
1 A 2 f	Cd	0.1	0.0	5.0	125.0	125.10	6.38	-0.02	0.01	-2.91	0.09	8.46
1 A 2 g 7	Cd	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.02	0.00	0.00
1 A 2 g 8	Cd	0.0	0.1	10.0	125.0	125.40	32.36	0.02	0.03	2.73	0.42	7.62
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	0.05	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	0.00	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	0.61	0.01	0.01	0.33	0.06	0.11
1 A 3 c	Cd	0.0	0.0	3.0	40.0	40.11	0.00	0.00	0.00	-0.01	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	7.09	-0.01	0.01	-0.92	0.10	0.86
1 A 4 b	Cd	0.3	0.2	15.0	125.0	125.90	622.87	0.01	0.13	1.68	2.78	10.58
1 A 4 c	Cd	0.0	0.0	5.0	125.0	125.10	22.12	0.01	0.02	1.64	0.18	2.72
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	0.2	0.5	40.0	40.00	61.99	-0.04	0.13	-1.66	0.09	2.76
2 C 5	Cd	0.1	0.0	10.0	40.0	41.23	0.03	-0.02	0.00	-0.95	0.04	0.91
2 C 7	Cd	0.0	0.0	5.0	40.0	40.31	0.00	-0.01	0.00	-0.20	0.00	0.04
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	100.0	200.0	223.61	193.62	0.01	0.04	1.20	5.83	35.40
3 F	Cd	0.0	0.0	100.0	125.0	160.08	0.02	0.00	0.00	-0.31	0.08	0.10
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	-0.86	0.00	0.75
5 E	Cd	0.0	0.0	50.0	200.0	206.16	0.04	0.00	0.00	0.04	0.05	0.00
Total		**1.8**	**1.2**				**1 658.79**					**97.85**
Total Uncertainties						Uncertainty in total inventory %:	**40.73**				Trend uncertainty %:	**9.89**

Table 33: Uncertainty estimation of Hg emissions 1990 and 2019.

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	0.1	8.0	125.0	125.26	300.37	-0.01	0.06	-1.19	0.71	1.92
1 A 1 b	Hg	0.0	0.0	1.0	125.0	125.00	3.67	0.01	0.01	0.70	0.01	0.49
1 A 1 c	Hg	0.0	0.0	1.0	125.0	125.00	0.01	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	0.00	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	0.00	0.00	0.00
1 A 2 c	Hg	0.0	0.0	5.0	40.0	40.31	0.15	0.00	0.00	0.08	0.03	0.01
1 A 2 d	Hg	0.1	0.1	10.0	40.0	41.23	13.22	0.03	0.04	1.03	0.57	1.38
1 A 2 e	Hg	0.0	0.0	5.0	40.0	40.31	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 f	Hg	0.7	0.2	5.0	40.0	40.31	48.05	-0.07	0.08	-2.76	0.55	7.93
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	9.65	0.01	0.01	1.17	0.16	1.40
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	0.02	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	-0.01	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	0.01	0.00	0.00
1 A 4 a	Hg	0.0	0.0	5.0	125.0	125.10	1.32	0.00	0.00	-0.10	0.03	0.01
1 A 4 b	Hg	0.4	0.1	15.0	125.0	125.90	359.77	-0.01	0.07	-1.68	1.46	4.96
1 A 4 c	Hg	0.0	0.0	5.0	125.0	125.10	2.37	0.00	0.01	0.35	0.04	0.12
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	-0.06	0.00	-1.14	0.00	1.29
2 C 1	Hg	0.3	0.3	0.5	40.0	40.00	169.12	0.09	0.15	3.75	0.10	14.10
2 C 7	Hg	0.0	0.0	5.0	40.0	40.31	0.11	0.00	0.00	0.09	0.03	0.01
2 G	Hg	0.0	0.0	100.0	200.0	223.61	0.00	0.00	0.00	0.00	0.01	0.00
3 F	Hg	0.0	0.0	100.0	125.0	160.08	0.00	0.00	0.00	-0.03	0.02	0.00
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	2.57	0.01	0.02	0.27	0.18	0.10
5 E	Hg	0.0	0.0	50.0	200.0	206.16	0.06	0.00	0.00	0.06	0.04	0.00
Total		**2.2**	**1.0**				**910.44**					**33.73**
Total Uncertainties						Uncertainty in total inventory %:	**30.17**				Trend uncertainty %:	**5.81**

Table 34: Uncertainty estimation of Pb emissions 1990 and 2019.

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	1.9	8.0	125.0	125.26	133.67	0.01	0.01	0.95	0.09	0.92
1 A 1 b	Pb	0.2	0.4	1.0	125.0	125.00	6.09	0.00	0.00	0.21	0.00	0.04
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	0.83	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	0.3	5.0	125.0	125.10	4.24	0.00	0.00	0.17	0.01	0.03
1 A 2 d	Pb	0.6	1.0	10.0	125.0	125.40	38.42	0.00	0.00	0.51	0.06	0.27
1 A 2 e	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 f	Pb	4.3	0.3	5.0	125.0	125.10	3.91	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	0.5	10.0	125.0	125.40	8.76	0.00	0.00	0.25	0.03	0.07
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	161.7	0.0	3.1	125.0	125.04	0.00	-0.06	0.00	-7.58	0.00	57.41
1 A 3 b 2	Pb	6.9	0.0	3.1	125.0	125.04	0.00	0.00	0.00	-0.33	0.00	0.11
1 A 3 b 3	Pb	4.1	0.0	3.1	125.0	125.04	0.00	0.00	0.00	-0.19	0.00	0.04
1 A 3 b 4	Pb	1.7	0.0	3.1	125.0	125.04	0.00	0.00	0.00	-0.08	0.00	0.01
1 A 3 b 6	Pb	2.7	4.9	3.1	40.0	40.12	91.52	0.02	0.02	0.80	0.09	0.64
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	0.2	5.0	125.0	125.10	1.18	0.00	0.00	0.08	0.01	0.01
1 A 4 b	Pb	6.8	1.8	15.0	125.0	125.90	124.01	0.01	0.01	0.65	0.16	0.45
1 A 4 c	Pb	1.0	0.1	5.0	125.0	125.10	0.78	0.00	0.00	0.03	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	6.9	0.5	125.0	125.00	1 757.75	0.02	0.03	2.16	0.02	4.68
2 C 3	Pb	0.0	0.1	2.0	125.0	125.02	0.32	0.00	0.00	0.05	0.00	0.00
2 C 5	Pb	3.5	0.6	10.0	125.0	125.40	12.93	0.00	0.00	0.15	0.04	0.02
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	1.3	100.0	200.0	223.61	188.54	0.00	0.01	0.99	0.76	1.55
3 F	Pb	0.0	0.0	100.0	125.0	160.08	0.00	0.00	0.00	0.00	0.00	0.00
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	-0.02	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		**232.5**	**20.4**				**2 372.96**					**66.26**
Total Uncertainties						Uncertainty in total inventory %:	**48.71**				Trend uncertainty %:	**8.14**

Table 35: Uncertainty estimation of PAH emissions 1990 and 2019.

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	0.19	0.00	0.00	0.14	0.01	0.02
1 A 1 b	PAH	0.0	0.0	1.0	200.0	200.00	0.01	0.00	0.00	0.03	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	0.20	0.00	0.00	0.11	0.01	0.01
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	0.00	0.00	0.00
1 A 2 f	PAH	0.0	0.0	5.0	125.0	125.10	0.03	0.00	0.00	0.05	0.00	0.00
1 A 2 g 7	PAH	0.0	0.1	1.0	200.0	200.00	13.13	0.01	0.01	1.15	0.01	1.31
1 A 2 g 8	PAH	0.0	0.1	10.0	200.0	200.25	3.18	0.00	0.00	0.55	0.04	0.31
1 A 3 b 1	PAH	0.2	0.2	3.1	125.0	125.04	9.68	0.01	0.01	0.68	0.04	0.46
1 A 3 b 2	PAH	0.0	0.0	3.1	125.0	125.04	0.12	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	7.11	0.01	0.01	0.79	0.03	0.63
1 A 3 b 4	PAH	0.0	0.0	3.1	200.0	200.02	0.01	0.00	0.00	0.02	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	0.02	0.00	0.00
1 A 3 d	PAH	0.0	0.0	3.0	200.0	200.02	0.12	0.00	0.00	0.10	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	7.14	0.00	0.00	-0.23	0.03	0.05
1 A 4 b	PAH	10.7	4.8	15.0	200.0	200.56	22 527.88	0.06	0.25	12.86	5.38	194.20
1 A 4 c	PAH	0.6	0.7	5.0	200.0	200.06	452.67	0.03	0.04	5.20	0.25	27.13
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	0.3	0.2	0.5	125.0	125.00	13.24	0.00	0.01	0.46	0.01	0.22
2 C 3	PAH	6.1	NE	2.0	125.0	125.02						
2 D	PAH	0.2	NA	20.0	40.0	44.72						
2 G	PAH	0.0	0.0	100.0	200.0	223.61	0.01	0.00	0.00	0.02	0.02	0.00
2 H	PAH	0.5	0.0	10.0	750.0	750.07	18.36	-0.01	0.00	-5.78	0.03	33.45
3 F	PAH	0.1	0.0	100.0	125.0	160.08	0.96	0.00	0.00	0.08	0.29	0.09
5 C	PAH	0.0	0.0	7.0	125.0	125.20	0.00	0.00	0.00	0.00	0.00	0.00
Total		**19.1**	**6.5**				**23 054.14**					**257.91**
Total Uncertainties						Uncertainty in total inventory %:	**151.84**				Trend uncertainty %:	**16.06**

Table 36: Uncertainty estimation of DIOX emissions 1990 and 2019.

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	1.3	8.0	125.0	125.26	24.53	-0.02	0.01	-1.92	0.12	3.70
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	0.30	0.00	0.00	0.09	0.00	0.01
1 A 2 b	DIOX	0.0	0.0	5.0	750.0	750.02	0.65	0.00	0.00	0.18	0.00	0.03
1 A 2 c	DIOX	0.4	0.6	5.0	750.0	750.02	176.25	0.00	0.00	2.87	0.03	8.22
1 A 2 d	DIOX	0.5	0.6	10.0	750.0	750.07	203.63	0.00	0.01	3.03	0.07	9.21
1 A 2 e	DIOX	0.0	0.0	5.0	750.0	750.02	0.82	0.00	0.00	0.20	0.00	0.04
1 A 2 f	DIOX	0.3	0.5	5.0	750.0	750.02	110.05	0.00	0.00	2.35	0.03	5.51
1 A 2 g 7	DIOX	0.0	0.1	1.0	200.0	200.00	0.73	0.00	0.00	0.22	0.00	0.05
1 A 2 g 8	DIOX	0.3	1.5	10.0	200.0	200.25	75.72	0.01	0.01	2.19	0.17	4.81
1 A 3 b 1	DIOX	3.6	0.6	3.1	200.0	200.02	14.44	0.00	0.01	-0.53	0.02	0.28
1 A 3 b 2	DIOX	0.2	0.1	3.1	200.0	200.02	0.34	0.00	0.00	0.09	0.00	0.01
1 A 3 b 3	DIOX	0.3	0.8	3.1	200.0	200.02	22.26	0.01	0.01	1.13	0.03	1.27
1 A 3 b 4	DIOX	0.0	0.0	3.1	200.0	200.02	0.01	0.00	0.00	0.02	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	0.7	5.0	200.0	200.06	17.18	0.00	0.01	0.37	0.04	0.14
1 A 4 b	DIOX	40.7	16.3	15.0	200.0	200.56	9 407.96	0.04	0.13	8.50	2.76	79.84
1 A 4 c	DIOX	1.5	1.4	5.0	200.0	200.06	68.87	0.01	0.01	1.58	0.08	2.49
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	37.2	2.7	0.5	125.0	125.00	97.38	-0.06	0.02	-7.31	0.02	53.40
2 C 3	DIOX	2.4	3.2	2.0	125.0	125.02	143.77	0.02	0.03	2.58	0.07	6.65
2 C 5	DIOX	0.1	0.1	10.0	125.0	125.40	0.07	0.00	0.00	0.05	0.01	0.00
2 C 7	DIOX	0.3	0.4	5.0	125.0	125.10	2.22	0.00	0.00	0.31	0.02	0.10
2 D	DIOX	1.1	NA	20.0	40.0	44.72						
2 G	DIOX	0.0	0.0	100.0	200.0	223.61	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	8.52	0.00	0.00	-2.09	0.01	4.39
3 F	DIOX	0.2	0.1	100.0	125.0	160.08	0.06	0.00	0.00	0.00	0.06	0.00
5 C	DIOX	18.2	0.3	7.0	125.0	125.20	1.44	-0.04	0.00	-4.55	0.03	20.71
5 E	DIOX	2.1	2.1	50.0	200.0	206.16	162.84	0.01	0.02	2.43	1.18	7.27
Total		**125.2**	**33.7**				**10 540.06**					**208.12**
Total Uncertainties						Uncertainty in total inventory %:	**102.66**				Trend uncertainty %:	**14.43**

Table 37: Uncertainty estimation of HCB emissions 1990 and 2019.

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	12.90	0.01	0.01	0.66	0.07	0.44
1 A 1 b	HCB	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.01	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	0.00	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	1.13	0.00	0.00	0.19	0.01	0.04
1 A 2 d	HCB	0.1	0.1	10.0	200.0	200.25	2.22	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	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 f	HCB	0.1	0.1	5.0	200.0	200.06	0.89	0.00	0.00	0.17	0.01	0.03
1 A 2 g 7	HCB	0.0	0.0	1.0	200.0	200.00	0.11	0.00	0.00	0.07	0.00	0.00
1 A 2 g 8	HCB	0.1	0.2	10.0	200.0	200.25	7.07	0.00	0.00	0.53	0.04	0.28
1 A 3 b 1	HCB	0.7	0.1	3.1	200.0	200.02	2.21	0.00	0.00	-0.05	0.01	0.00
1 A 3 b 2	HCB	0.0	0.0	3.1	200.0	200.02	0.05	0.00	0.00	0.03	0.00	0.00
1 A 3 b 3	HCB	0.1	0.2	3.1	200.0	200.02	3.40	0.00	0.00	0.35	0.01	0.12
1 A 3 b 4	HCB	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	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	14.78	0.00	0.00	0.21	0.03	0.05
1 A 4 b	HCB	48.9	6.9	15.0	200.0	200.56	6 457.13	-0.04	0.08	-7.78	1.76	63.65
1 A 4 c	HCB	0.9	0.5	5.0	200.0	200.06	37.54	0.00	0.01	0.82	0.04	0.68
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	3.9	0.5	125.0	125.00	786.36	0.03	0.05	3.29	0.03	10.80
2 C 3	HCB	1.2	1.6	2.0	125.0	125.02	137.32	0.02	0.02	2.06	0.06	4.23
2 C 7	HCB	0.1	0.1	5.0	125.0	125.10	1.10	0.00	0.00	0.19	0.01	0.03
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	1.30	0.00	0.00	-0.43	0.00	0.19
3 D f	HCB	10.1	2.4	0.0	125.0	125.00	293.21	0.00	0.03	0.39	0.00	0.15
3 F	HCB	0.0	0.0	100.0	125.0	160.08	0.01	0.00	0.00	0.00	0.02	0.00
5 C	HCB	0.4	0.1	7.0	125.0	125.20	0.22	0.00	0.00	-0.03	0.01	0.00
Total		**82.9**	**17.2**				**7 758.96**					**80.77**
Total Uncertainties						Uncertainty in total inventory %:	**88.08**				Trend uncertainty %:	**8.99**

Table 38: Uncertainty estimation of PCB emissions 1990 and 2019.

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	0.02	-0.02	0.00	-2.18	0.01	4.73
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	0.01	0.00	0.00	-0.19	0.00	0.04
1 A 2 b	PCB	0.0	0.0	5.0	200.0	200.06	0.01	0.00	0.00	-0.04	0.00	0.00
1 A 2 c	PCB	0.2	0.1	5.0	200.0	200.06	0.39	0.00	0.00	-0.19	0.02	0.04
1 A 2 d	PCB	1.5	0.7	10.0	200.0	200.25	15.86	-0.01	0.01	-1.73	0.21	3.04
1 A 2 e	PCB	0.2	0.0	5.0	200.0	200.06	0.01	0.00	0.00	-0.38	0.00	0.15
1 A 2 f	PCB	0.5	0.4	5.0	200.0	200.06	6.11	0.00	0.01	0.33	0.06	0.11
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	0.00	0.00	0.00	-0.60	0.00	0.36
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	-3.53	0.00	12.49
1 A 4 b	PCB	4.5	0.1	15.0	750.0	750.15	9.10	-0.07	0.00	-50.72	0.06	2 572.65
1 A 4 c	PCB	0.1	0.0	5.0	750.0	750.02	0.00	0.00	0.00	-1.04	0.00	1.08
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	19.3	33.3	0.5	125.0	125.00	14 324.02	0.40	0.71	50.29	0.50	2 528.95
2 C 5	PCB	19.2	0.0	10.0	125.0	125.40	0.00	-0.30	0.00	-37.23	0.00	1 385.99
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	0.01	0.00	0.00	0.05	0.00	0.00
Total		**47.2**	**34.8**				**14 355.53**					**6 509.62**
Total Uncertainties						Uncertainty in total inventory %:	**119.81**				Trend uncertainty %:	**80.68**

Table 39: Uncertainty estimation of TSP emissions 1990 and 2019.

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	0.8	1.1	8.0	40.0	40.79	1.26	0.01	0.02	0.34	0.23	0.17
1 A 1 b	TSP	0.2	0.1	1.0	20.0	20.02	0.00	0.00	0.00	-0.02	0.00	0.00
1 A 1 c	TSP	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	TSP	0.1	0.0	5.0	125.0	125.10	0.00	0.00	0.00	-0.08	0.00	0.01
1 A 2 b	TSP	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	TSP	0.2	0.2	5.0	125.0	125.10	0.45	0.00	0.00	0.09	0.03	0.01
1 A 2 d	TSP	1.1	0.2	10.0	125.0	125.40	0.59	-0.01	0.00	-1.24	0.06	1.55
1 A 2 e	TSP	0.1	0.0	5.0	125.0	125.10	0.01	0.00	0.00	-0.14	0.00	0.02
1 A 2 f	TSP	0.1	0.1	5.0	125.0	125.10	0.08	0.00	0.00	0.07	0.01	0.01
1 A 2 g 7	TSP	0.5	0.1	1.0	40.0	40.01	0.01	-0.01	0.00	-0.20	0.00	0.04
1 A 2 g 8	TSP	0.3	0.2	10.0	40.0	41.23	0.06	0.00	0.00	0.02	0.06	0.00
1 A 3 a	TSP	0.0	0.1	3.0	40.0	40.11	0.02	0.00	0.00	0.08	0.01	0.01
1 A 3 b 1	TSP	1.6	0.7	3.1	40.0	40.12	0.57	-0.01	0.01	-0.33	0.06	0.11
1 A 3 b 2	TSP	0.8	0.2	3.1	40.0	40.12	0.03	-0.01	0.00	-0.33	0.01	0.11
1 A 3 b 3	TSP	2.5	0.2	3.1	40.0	40.12	0.06	-0.03	0.00	-1.17	0.02	1.37
1 A 3 b 4	TSP	0.1	0.1	3.1	40.0	40.12	0.01	0.00	0.00	0.00	0.01	0.00
1 A 3 b 6	TSP	1.1	2.0	3.1	125.0	125.04	40.72	0.02	0.04	2.83	0.16	8.04
1 A 3 b 7	TSP	0.9	1.6	3.1	125.0	125.04	28.36	0.02	0.03	2.34	0.14	5.52
1 A 3 c	TSP	2.0	1.6	3.0	40.0	40.11	2.80	0.00	0.03	0.12	0.13	0.03
1 A 3 d	TSP	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	TSP	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	TSP	0.9	0.4	5.0	125.0	125.10	1.44	-0.01	0.01	-0.70	0.05	0.49
1 A 4 b	TSP	11.6	6.7	15.0	125.0	125.90	478.99	-0.03	0.13	-4.09	2.67	23.85
1 A 4 c	TSP	2.6	0.9	5.0	125.0	125.10	9.10	-0.02	0.02	-2.23	0.12	5.00
1 A 5 b	TSP	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	TSP	0.9	0.4	5.0	200.0	200.06	4.14	0.00	0.01	-0.86	0.05	0.74
2 A 1	TSP	0.2	0.1	1.1	200.0	200.00	0.09	0.00	0.00	-0.26	0.00	0.07
2 A 2	TSP	0.1	0.1	1.6	200.0	200.01	0.25	0.00	0.00	0.19	0.00	0.04
2 A 5	TSP	10.0	13.1	5.0	200.0	200.06	4 634.81	0.11	0.25	22.06	1.74	489.82
2 B-10	TSP	1.0	0.5	2.0	20.0	20.10	0.06	0.00	0.01	-0.08	0.03	0.01
2 C 1	TSP	6.4	0.6	0.5	40.0	40.00	0.44	-0.08	0.01	-3.02	0.01	9.15
2 C 2	TSP	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	TSP	0.1	0.0	2.0	40.0	40.05	0.00	0.00	0.00	-0.06	0.00	0.00
2 C 5	TSP	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	TSP	0.0	0.0	5.0	40.0	40.31	0.00	0.00	0.00	-0.01	0.00	0.00
2 G	TSP	0.6	0.5	100.0	125.0	160.08	4.78	0.00	0.01	0.17	1.40	1.99
2 H	TSP	0.0	0.0	10.0	200.0	200.25	0.00	0.00	0.00	0.00	0.00	0.00
2 I	TSP	0.9	1.1	1.0	40.0	40.01	1.40	0.01	0.02	0.36	0.03	0.13
3 B 1	TSP	0.6	0.4	1.0	200.0	200.00	5.27	0.00	0.01	0.01	0.01	0.00
3 B 2	TSP	0.1	0.1	10.0	200.0	200.25	0.24	0.00	0.00	0.16	0.03	0.03
3 B 3	TSP	0.3	0.3	4.0	200.0	200.04	1.84	0.00	0.00	0.05	0.03	0.00
3 B 4	TSP	0.2	0.3	10.0	200.0	200.25	2.58	0.00	0.01	0.53	0.08	0.29
3 D c	TSP	3.6	3.3	5.0	200.0	200.06	291.65	0.01	0.06	2.66	0.44	7.25
3 D d	TSP	0.0	0.1	5.0	200.0	200.06	0.11	0.00	0.00	0.14	0.01	0.02
3 F	TSP	0.1	0.0	100.0	125.0	160.08	0.01	0.00	0.00	-0.12	0.06	0.02
5 A	TSP	0.1	0.6	12.0	200.0	200.36	9.44	0.01	0.01	1.83	0.19	3.39
5 C	TSP	0.0	0.0	7.0	200.0	200.12	0.00	0.00	0.00	0.00	0.00	0.00
5 E	TSP	0.2	0.2	50.0	200.0	206.16	1.18	0.00	0.00	0.20	0.27	0.11
Total		**53.1**	**38.5**				**5 522.88**					**559.35**
Total Uncertainties						Uncertainty in total inventory %:	**74.32**				Trend uncertainty %:	**23.65**

Table 40: Uncertainty estimation of PM_{10} emissions 1990 and 2019.

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	20.59	0.01	0.02	1.37	0.26	1.96
1 A 1 b	PM10	0.1	0.0	1.0	40.0	40.01	0.01	0.00	0.00	-0.04	0.00	0.00
1 A 1 c	PM10	0.1	0.1	1.0	40.0	40.01	0.02	0.00	0.00	0.05	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	-0.08	0.00	0.01
1 A 2 b	PM10	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	PM10	0.2	0.2	5.0	125.0	125.10	0.79	0.00	0.00	0.16	0.03	0.03
1 A 2 d	PM10	0.9	0.2	10.0	125.0	125.40	1.03	-0.01	0.01	-1.22	0.07	1.50
1 A 2 e	PM10	0.1	0.0	5.0	125.0	125.10	0.02	0.00	0.00	-0.13	0.00	0.02
1 A 2 f	PM10	0.1	0.1	5.0	125.0	125.10	0.14	0.00	0.00	0.10	0.01	0.01
1 A 2 g 7	PM10	0.5	0.1	1.0	40.0	40.01	0.03	-0.01	0.00	-0.23	0.00	0.05
1 A 2 g 8	PM10	0.3	0.2	10.0	40.0	41.23	0.11	0.00	0.01	0.04	0.07	0.01
1 A 3 a	PM10	0.0	0.1	3.0	40.0	40.11	0.04	0.00	0.00	0.11	0.01	0.01
1 A 3 b 1	PM10	1.6	0.7	3.1	40.0	40.12	1.22	-0.01	0.02	-0.30	0.08	0.10
1 A 3 b 2	PM10	0.8	0.2	3.1	40.0	40.12	0.07	-0.01	0.00	-0.37	0.02	0.13
1 A 3 b 3	PM10	2.5	0.2	3.1	40.0	40.12	0.12	-0.03	0.01	-1.33	0.02	1.77
1 A 3 b 4	PM10	0.1	0.1	3.1	125.0	125.04	0.21	0.00	0.00	0.05	0.01	0.00
1 A 3 b 6	PM10	0.8	1.5	3.1	125.0	125.04	49.24	0.02	0.04	2.96	0.16	8.76
1 A 3 b 7	PM10	0.4	0.8	3.1	125.0	125.04	15.14	0.01	0.02	1.63	0.09	2.68
1 A 3 c	PM10	1.0	0.6	3.0	40.0	40.11	0.75	0.00	0.01	-0.05	0.06	0.01
1 A 3 d	PM10	0.1	0.1	3.0	40.0	40.11	0.01	0.00	0.00	0.03	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	2.75	0.00	0.01	-0.60	0.06	0.37
1 A 4 b	PM10	10.8	6.3	15.0	125.0	125.90	896.29	-0.02	0.15	-2.17	3.26	15.30
1 A 4 c	PM10	2.5	0.9	5.0	125.0	125.10	17.58	-0.02	0.02	-2.33	0.15	5.43
1 A 5 b	PM10	0.0	0.0	1.0	125.0	125.00	0.01	0.00	0.00	0.02	0.00	0.00
1 B 1 a	PM10	0.4	0.2	5.0	200.0	200.06	1.98	0.00	0.00	-0.37	0.03	0.14
2 A 1	PM10	0.2	0.1	1.1	200.0	200.00	0.16	0.00	0.00	-0.24	0.00	0.06
2 A 2	PM10	0.1	0.1	1.6	200.0	200.01	0.43	0.00	0.00	0.24	0.00	0.06
2 A 5	PM10	4.7	6.2	5.0	200.0	200.06	2 241.21	0.08	0.15	15.57	1.08	243.61
2 B-10	PM10	0.6	0.3	2.0	20.0	20.10	0.05	0.00	0.01	-0.04	0.02	0.00
2 C 1	PM10	4.6	0.5	0.5	40.0	40.00	0.48	-0.06	0.01	-2.44	0.01	5.94
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	-0.05	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 G	PM10	0.6	0.5	100.0	125.0	160.08	9.59	0.00	0.01	0.35	1.77	3.24
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	0.48	0.01	0.01	0.21	0.02	0.05
3 B 1	PM10	0.3	0.2	1.0	200.0	200.00	2.28	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	0.11	0.01	0.01
3 B 3	PM10	0.2	0.1	4.0	200.0	200.04	0.80	0.00	0.00	0.09	0.02	0.01
3 B 4	PM10	0.1	0.1	10.0	200.0	200.25	1.12	0.00	0.00	0.35	0.05	0.13
3 D c	PM10	3.6	3.3	5.0	200.0	200.06	622.93	0.02	0.08	4.84	0.57	23.74
3 D d	PM10	0.0	0.0	5.0	200.0	200.06	0.05	0.00	0.00	0.09	0.01	0.01
3 F	PM10	0.1	0.0	100.0	125.0	160.08	0.02	0.00	0.00	-0.12	0.08	0.02
5 A	PM10	0.1	0.3	12.0	200.0	200.36	4.51	0.01	0.01	1.15	0.12	1.34
5 C	PM10	0.0	0.0	7.0	200.0	200.12	0.00	0.00	0.00	0.00	0.00	0.00
5 E	PM10	0.2	0.2	50.0	200.0	206.16	2.53	0.00	0.00	0.35	0.35	0.24
Total		**40.8**	**26.3**				**3 894.85**					**316.75**
Total Uncertainties						Uncertainty in total inventory %:	**62.41**				Trend uncertainty %:	**17.80**

Table 41: Uncertainty estimation of $PM_{2.5}$ emissions 1990 and 2019.

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	0.8	8.0	60.0	60.53	11.73	0.02	0.03	1.00	0.33	1.12
1 A 1 b	PM2.5	0.1	0.0	1.0	40.0	40.01	0.01	0.00	0.00	-0.03	0.00	0.00
1 A 1 c	PM2.5	0.1	0.1	1.0	40.0	40.01	0.07	0.00	0.00	0.08	0.00	0.01
1 A 2 a	PM2.5	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	-0.07	0.00	0.01
1 A 2 b	PM2.5	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	PM2.5	0.2	0.2	5.0	125.0	125.10	1.92	0.00	0.01	0.30	0.04	0.09
1 A 2 d	PM2.5	0.8	0.2	10.0	125.0	125.40	2.44	-0.01	0.01	-1.06	0.09	1.14
1 A 2 e	PM2.5	0.1	0.0	5.0	125.0	125.10	0.04	0.00	0.00	-0.11	0.01	0.01
1 A 2 f	PM2.5	0.1	0.1	5.0	125.0	125.10	0.33	0.00	0.00	0.16	0.02	0.03
1 A 2 g 7	PM2.5	0.5	0.1	1.0	40.0	40.01	0.10	-0.01	0.00	-0.24	0.01	0.06
1 A 2 g 8	PM2.5	0.2	0.2	10.0	60.0	60.83	0.56	0.00	0.01	0.13	0.09	0.03
1 A 3 a	PM2.5	0.0	0.1	3.0	40.0	40.11	0.15	0.00	0.01	0.17	0.02	0.03
1 A 3 b 1	PM2.5	1.6	0.7	3.1	125.0	125.04	41.66	0.00	0.03	-0.50	0.12	0.27
1 A 3 b 2	PM2.5	0.8	0.2	3.1	125.0	125.04	2.31	-0.01	0.01	-1.23	0.03	1.52
1 A 3 b 3	PM2.5	2.5	0.2	3.1	125.0	125.04	4.11	-0.04	0.01	-4.84	0.04	23.42
1 A 3 b 4	PM2.5	0.1	0.1	3.1	125.0	125.04	0.75	0.00	0.00	0.15	0.02	0.02
1 A 3 b 6	PM2.5	0.4	0.8	3.1	125.0	125.04	50.77	0.02	0.03	2.67	0.13	7.16
1 A 3 b 7	PM2.5	0.2	0.4	3.1	125.0	125.04	15.49	0.01	0.02	1.47	0.07	2.16
1 A 3 c	PM2.5	0.6	0.2	3.0	40.0	40.11	0.34	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	0.04	0.00	0.00	0.06	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	1.98	0.00	0.01	-0.16	0.09	0.03
1 A 4 b	PM2.5	10.1	5.9	15.0	60.0	61.85	682.77	0.03	0.22	1.52	4.66	23.98
1 A 4 c	PM2.5	2.5	0.8	5.0	100.0	100.12	35.51	-0.02	0.03	-1.71	0.22	2.97
1 A 5 b	PM2.5	0.0	0.0	1.0	125.0	125.00	0.02	0.00	0.00	0.04	0.00	0.00
1 B 1 a	PM2.5	0.1	0.1	5.0	200.0	200.06	0.69	0.00	0.00	0.01	0.02	0.00
2 A 1	PM2.5	0.1	0.0	1.1	40.0	40.02	0.02	0.00	0.00	-0.04	0.00	0.00
2 A 2	PM2.5	0.0	0.1	1.6	125.0	125.01	0.31	0.00	0.00	0.19	0.01	0.04
2 A 5	PM2.5	0.5	0.7	5.0	200.0	200.06	100.68	0.02	0.03	3.17	0.18	10.10
2 B-10	PM2.5	0.3	0.1	2.0	20.0	20.10	0.04	0.00	0.01	-0.01	0.02	0.00
2 C 1	PM2.5	2.1	0.2	0.5	20.0	20.01	0.09	-0.03	0.01	-0.64	0.01	0.41
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 G	PM2.5	0.5	0.4	100.0	125.0	160.08	24.28	0.01	0.02	0.71	2.26	5.62
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	0.27	0.00	0.01	0.16	0.01	0.02
3 B 1	PM2.5	0.1	0.0	1.0	200.0	200.00	0.39	0.00	0.00	0.09	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	0.06	0.01	0.00
3 B 4	PM2.5	0.0	0.0	10.0	200.0	200.25	0.19	0.00	0.00	0.14	0.02	0.02
3 D c	PM2.5	0.1	0.1	5.0	200.0	200.06	3.23	0.00	0.00	0.41	0.03	0.17
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	0.0	100.0	125.0	160.08	0.07	0.00	0.00	-0.12	0.12	0.03
5 A	PM2.5	0.0	0.1	12.0	200.0	200.36	1.57	0.00	0.00	0.57	0.06	0.32
5 C	PM2.5	0.0	0.0	7.0	200.0	200.12	0.00	0.00	0.00	0.00	0.00	0.00
5 E	PM2.5	0.2	0.2	50.0	200.0	206.16	8.86	0.00	0.01	0.71	0.53	0.79
Total		**27.1**	**14.1**				**993.97**					**81.62**
Total Uncertainties						Uncertainty in total inventory %:	**31.53**				Trend uncertainty %:	**9.03**

1.8 Completeness

The emission data presented in this report were compiled according to the revised 2014 Reporting Guidelines (ECE/EB.AIR.125) approved by the Executive Body for the UNECE/LRTAP Convention at its 36th 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 revised 2014 Reporting Guidelines (ECE/EB.AIR.125), 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. 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 differ from the LRTAP Totals presented in this report (see Appendix, Chapter 12.2).

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 1990–2019 for the main pollutants, from 1990 onwards for POPs and HMs and for the years 1990, 1995 and from 2000 onwards for PM.

In submission 2020 Austria reports 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[66].

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 in the current submission 2021.

Notation Keys

Notation keys are used according to the revised 2014 Reporting Guidelines (ECE/EB.AIR.125) (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 2019.

[66] 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/

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.

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[67], Ferroalloys Production, Aluminium Production, Copper Production, Other Metal Production) and *Waste* (Other Waste).

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

The transparency analysis for the reporting year 2019 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 2021.

Pollutants	**Submission 2021**			
	IE	**NE**	**Transparency**	**Completeness**
NO_x (as NO_2)	10	1	92%	99%
NMVOC	10	3	92%	98%
SO_x (as SO_2)	11	1	91%	99%
NH_3	9	0	93%	100%
$PM_{2.5}$	6	5	95%	96%
PM_{10}	6	5	95%	96%
TSP	6	5	95%	96%
CO	8	2	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*	*8*	*94%*	*94%*
Indeno (1,2,3-cd) pyrene	*7*	*8*	*94%*	*94%*
HCB	7	6	94%	95%
PCBs	7	3	94%	98%

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 the trends of SO_2, NO_x, NH_3, NMVOC and $PM_{2.5}$ emissions not including fuel exports (fuel used) as reported under Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants 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[68]. In the current submission 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 2019, 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[69] 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.

[68] 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/

[69] 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 (1990–2019) 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'. Austria's emissions based on fuel used – thus excluding 'fuel export' – are presented in Chapter 2.5.

Table 44: National total emissions and trends 1990–2019 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	217.35	335.54	61.84	1 253.89
1991	70.73	226.86	329.85	62.69	1 261.36
1992	54.20	215.47	306.28	61.23	1 204.82
1993	52.82	206.93	286.28	62.28	1 142.89
1994	47.19	198.81	263.86	62.26	1 076.97
1995	46.81	198.14	248.21	63.36	972.96
1996	43.94	215.97	238.76	62.70	967.45
1997	40.41	202.25	224.52	62.98	893.04
1998	35.64	214.07	216.04	63.35	847.47
1999	33.75	205.88	204.89	62.14	730.93
2000	31.58	211.68	181.18	60.81	726.08
2001	32.46	222.46	175.87	60.89	699.22
2002	31.39	230.37	171.12	60.22	668.01
2003	31.18	241.42	167.04	60.29	670.30
2004	26.60	241.26	153.70	60.16	653.13
2005	25.93	247.33	157.73	60.08	627.86
2006	26.71	237.90	159.84	60.53	627.62
2007	23.33	230.90	155.67	61.84	604.34
2008	20.27	217.85	150.38	61.51	585.08
2009	14.75	204.07	137.50	62.93	564.35
2010	15.99	204.45	137.91	62.89	579.92
2011	15.19	195.98	132.93	62.32	562.37
2012	14.80	190.50	130.75	62.61	561.41
2013	14.38	189.75	124.85	62.67	564.07
2014	14.53	181.98	118.17	63.41	528.22

Year	Emission [kt]				
	SO_2	NO_x	NMVOC	NH_3	CO
2015	14.14	178.98	113.06	64.21	539.25
2016	13.30	171.50	111.88	64.98	534.16
2017	12.82	162.74	112.40	65.85	525.04
2018	11.62	151.42	109.03	64.88	484.21
2019	10.93	144.20	108.59	63.82	498.47
Trend 1990–2019	**-85.2%**	**-33.7%**	**-67.6%**	**3.2%**	**-60.2%**

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 2019, 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 economic crisis in 2009 caused a decrease in emissions, followed by an increase due to the recovery of the economy. 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. From 2018 to 2019 emissions decreased by 5.9%, mainly because of lower coal consumption in power plants and lower emissions of oil refinery.

Main sources and emission trends in Austria

As shown in Figure 7 the main source of SO_2 emissions in Austria in 2019 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 5.2%.

NFR sectors *1.B Fugitive Emissions*, *3 Agriculture* and *5 Waste* are only minor contributors to national total SO_2 emissions in 2019 with 0.2%, 0.01% and 0.1%, respectively.

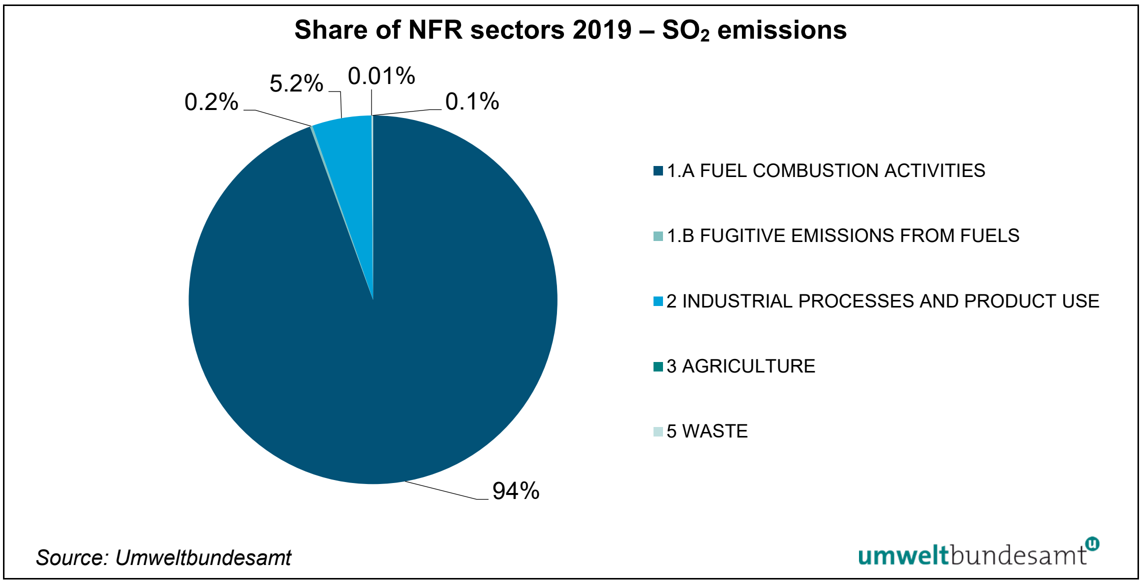


Figure 7: Share of NFR sectors 2019 in SO_2 emissions.

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 2019 is category *1.A Fuel Combustion Activities*. Within this source, the main contributors to total SO_2 emissions are *1.A.2 Manufacturing Industries* with 67% (more than half of the emissions stem from iron and steel industry), *1.A.4 Other Sectors* (residential heating) with 13% and *1.A.1 Energy Industries* with 12%.

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[70]),
- 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[71] and preceding national legislation),
- abatement techniques like combined flue gas treatment.

2 Industrial Processes and Product Use

The share in national total SO_2 emissions from NFR sector *2 Industrial Processes and Product Use* in 2019 is 5.2%. Within this source, SO_2 emissions result from *2.B Chemical Industry* (64%) and *2.C Metal Production* (35%). In both subcategories emissions have decreased since 1990 mainly caused by abatement techniques such as systems for purification of waste gases and desulfurization facilities, as well as due to improved processes.

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

[71] Luftreinhaltegesetzes 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)

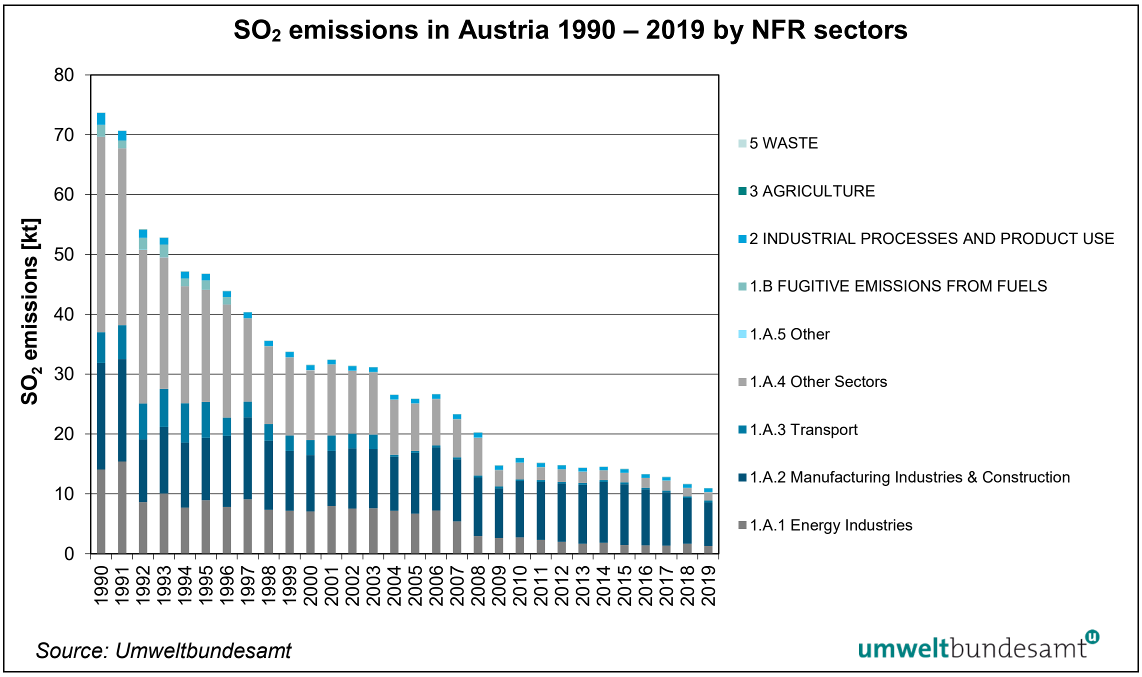


Figure 8: SO_2 emissions in Austria 1990–2019 by sectors in absolute terms.

Table 45: SO_2 emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		SO_2 Emission in [kt]		Trend		Share in National Total	
		1990	**2019**	**1990–2019**	**2018–2019**	**1990**	**2019**
1	ENERGY	71.69	10.35	-86%	-6%	97%	95%
1.A	FUEL COMBUSTION ACTIVITIES	69.69	10.32	-85%	-6%	95%	94%
1.A.1	Energy Industries	14.07	1.30	-91%	-21%	19%	12%
1.A.1.a	Public Electricity and Heat Production	11.81	0.81	-93%	-18%	16%	7%
1.A.1.b	Petroleum refining	2.25	0.49	-78%	-26%	3%	4%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-46%	30%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	17.83	7.29	-59%	-5%	24%	67%
1.A.2.a	Iron and Steel	6.73	4.62	-31%	8%	9%	42%
1.A.2.b	Non-ferrous Metals	0.18	0.10	-46%	28%	<1%	1%
1.A.2.c	Chemicals	0.66	0.17	-74%	-21%	1%	2%
1.A.2.d	Pulp, Paper and Print	4.30	0.52	-88%	-35%	6%	5%
1.A.2.e	Food Processing, Beverages and Tobacco	1.65	0.09	-95%	-22%	2%	1%
1.A.2.f	Non-metallic Minerals	2.23	0.79	-65%	-13%	3%	7%
1.A.2.g	Manufacturing Industries and Constr. - other	2.08	1.01	-52%	-21%	3%	9%
1.A.3	Transport	5.13	0.31	-94%	5%	7%	3%
1.A.3.a	Civil Aviation	0.04	0.11	165%	12%	<1%	1%
1.A.3.b	Road Transportation	4.77	0.14	-97%	<1%	6%	1%
1.A.3.c	Railways	0.26	0.04	-85%	<1%	<1%	<1%
1.A.3.d	Navigation	0.05	0.02	-71%	14%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	141%	-8%	<1%	<1%
1.A.4	Other Sectors	32.66	1.41	-96%	<1%	44%	13%
1.A.4.a	Commercial/Institutional	4.95	0.06	-99%	-24%	7%	1%
1.A.4.b	Residential	25.93	1.26	-95%	2%	35%	12%
1.A.4.c	Agriculture/Forestry/Fisheries	1.78	0.08	-95%	-9%	2%	1%
1.A.5	Other	0.01	0.02	29%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	2.00	0.02	-99%	<1%	3%	<1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	1.93	0.57	-71%	<1%	3%	5%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	1.56	0.37	-77%	<1%	2%	3%
2.C	METAL PRODUCTION	0.36	0.20	-45%	-1%	<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	3%	51%	<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	0.01	0.00	-78%	-3%	<1%	<1%
5	WASTE	0.07	0.01	-81%	1%	<1%	<1%
	Total without sinks	**73.70**	**10.93**	**-85%**	**-6%**		

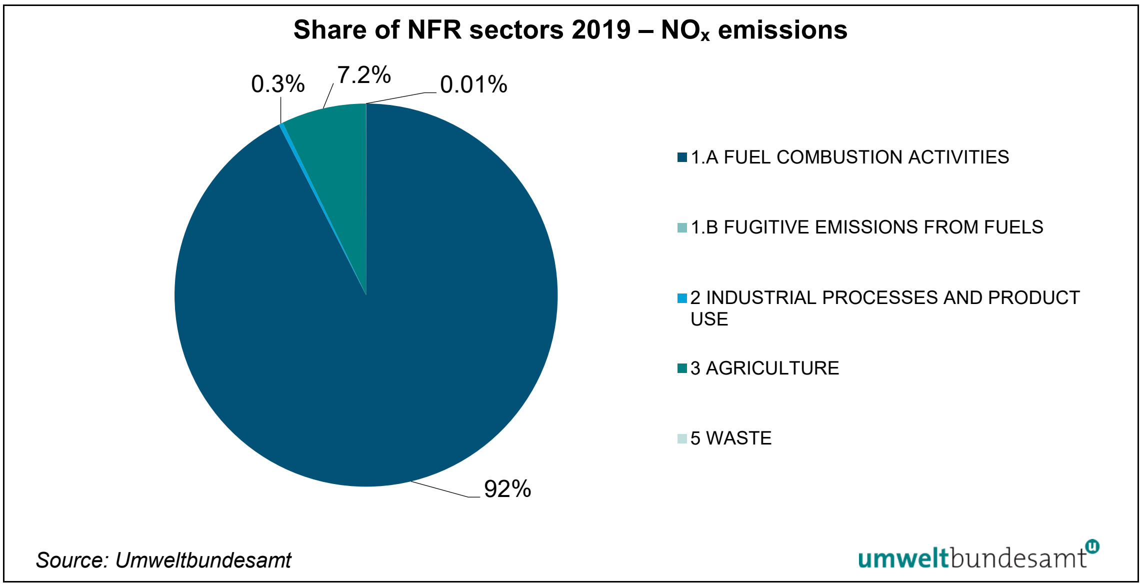
2.1.2 NO_x Emissions

In 1990, national total NO_x emissions amounted to 217 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 2019, NO_x emissions amounted to 144 kt and were about 34% lower than in 1990. From 2018 to 2019 emissions decreased by 4.8%. This was caused by a decline in road traffic, especially passenger cars and heavy duty vehicles. In 2019 52% of the total nitrogen oxides emissions originate from road transport (including fuel exports).

Main sources and emission trends in Austria

As can be seen in Figure 9 and Table 46, the main source for NO_x emissions in Austria with a share of 92% in 2019 are *1.A Fuel Combustion Activities.* Sector *3 Agriculture* contributes with 7.2%*.*

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 0.01% to national total NO_x emissions in 2019.



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

Figure 9: Share of NFR sectors 2019 in NO_x emissions.

1.A Fuel Combustion Activities

Within source category *1.A Fuel Combustion Activities*, *1.A.3.b Road Transportation*, with about 52% of national total emissions in 2019, 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: Emissions for 2019 based on fuel used amount to 131 kt and are about 14 kt lower than based on fuel sold (see also 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 kilometer. Nevertheless the specific emissions of the diesel passenger car fleet will only decrease when the fleet penetration of the new vehicles (Euro 6d_temp) continues.
- Although energy consumption (especially biomass) increased significantly, NOX emissions from *NFR 1.A.2 Manufacturing Industries and Construction*- decreased compared to 1990 (-25%), 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 2019 (-36%) mainly due to increased efficiency and modern fuel technology. From 2018 to 2019 NO_x emissions of this source category increased by 1.1% because of higher emissions from residential heating, due to increased heating demand of households (heating degree days increased by 1.4%).

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 7.2% of national total NO_x emissions in Austria in 2019. Within the Agriculture sector, source category 3*.D Agricultural Soils* is the biggest contributor with 94% in 2019. 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 14%, mainly influenced by livestock numbers and N-fertilizer consumption. Compared to the previous year 2018 emissions decreased by 4.2%, which was due to reduced mineral fertilizer consumption.

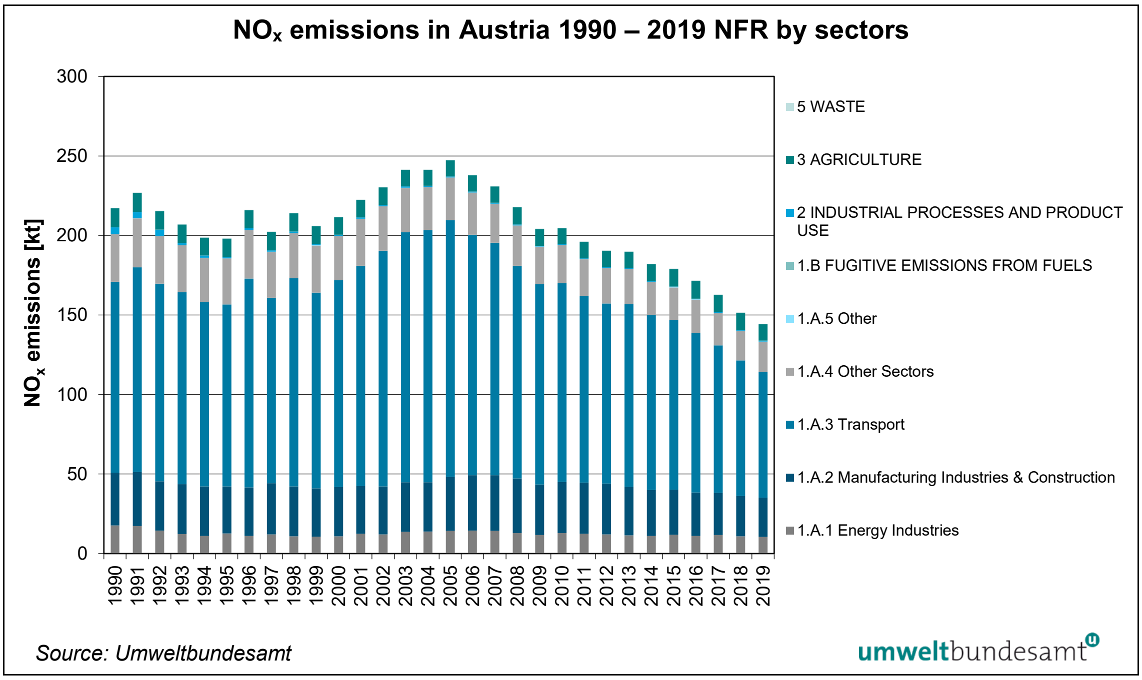


Figure 10: NO_x emissions in Austria 1990–2019 by sectors in absolute terms.

Table 46: NO_x emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		**NO_x Emission in [kt]**		**Trend**		**Share in National Total**	
		1990	**2019**	**1990–2019**	**2018–2019**	**1990**	**2019**
1	ENERGY	200.93	133.35	-34%	-5%	92%	92%
1.A	FUEL COMBUSTION ACTIVITIES	200.93	133.35	-34%	-5%	92%	92%
1.A.1	Energy Industries	17.78	10.39	-42%	-3%	8%	7%
1.A.1.a	Public Electricity and Heat Production	12.09	8.50	-30%	-6%	6%	6%
1.A.1.b	Petroleum refining	4.32	1.05	-76%	-3%	2%	1%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	1.37	0.84	-39%	30%	1%	1%
1.A.2	Manufacturing Industries and Construction	33.04	24.75	-25%	-3%	15%	17%
1.A.2.a	Iron and Steel	5.41	3.84	-29%	8%	2%	3%
1.A.2.b	Non-ferrous Metals	0.25	0.23	-8%	-9%	<1%	<1%
1.A.2.c	Chemicals	1.69	1.37	-19%	1%	1%	1%
1.A.2.d	Pulp, Paper and Print	7.17	4.58	-36%	5%	3%	3%
1.A.2.e	Food Processing, Beverages & Tobacco	1.74	0.63	-64%	-7%	1%	<1%
1.A.2.f	Non-metallic Minerals	9.99	5.50	-45%	-5%	5%	4%
1.A.2.g	Manufacturing Industries and Constr. - other	6.77	8.60	27%	-10%	3%	6%
1.A.3	Transport	120.19	79.15	-34%	-7%	55%	55%
1.A.3.a	Civil Aviation	0.37	1.85	405%	14%	<1%	1%
1.A.3.b	Road Transportation	116.25	74.61	-36%	-8%	53%	52%
1.A.3.c	Railways	1.82	0.73	-60%	-1%	1%	1%
1.A.3.d	Navigation	1.15	1.65	44%	12%	1%	1%
1.A.3.e	Other transportation	0.61	0.31	-48%	-10%	<1%	<1%
1.A.4	Other Sectors	29.85	18.98	-36%	1%	14%	13%
1.A.4.a	Commercial/Institutional	3.09	1.24	-60%	2%	1%	1%
1.A.4.b	Residential	16.26	10.87	-33%	2%	7%	8%
1.A.4.c	Agriculture/Forestry/Fisheries	10.49	6.87	-34%	<1%	5%	5%
1.A.5	Other	0.07	0.08	10%	<1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	IE	IE	IE	IE	IE	IE
2	INDUSTRIAL PROCESSES /PRODUCT USE	4.27	0.50	-88%	22%	2%	<1%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	4.07	0.37	-91%	35%	2%	<1%
2.C	METAL PRODUCTION	0.17	0.11	-37%	-4%	<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	-23%	<1%	<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	12.05	10.33	-14%	-4%	6%	7%
3.B	MANURE MANAGEMENT	0.60	0.55	-9%	-1%	<1%	<1%
3.D	AGRICULTURAL SOILS	11.40	9.76	-14%	-4%	5%	7%
3.F	FIELD BURNING OF AGRICULTURAL RESIDUE	0.05	0.02	-61%	-1%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.10	0.02	-81%	1%	<1%	<1%
	Total without sinks	**217.35**	**144.20**	**-34%**	**-5%**		

2.1.3 NMVOC Emissions

In 1990, national total NMVOC emissions amounted to 336 kt. Emissions have decreased steadily since then and in the year 2019 emissions were reduced by 68% to 109 kt compared to 1990. The largest reductions since 1990 have been achieved in the road transport sector due to an increased use of catalytic converters and diesel cars. Reductions in the solvent sector were due to various regulations (Solvent Ordinance, Cogeneration Act, VOC Emissions Ordinance). From 2018 to 2019 emissions decreased by 0.4%.

Main sources and emission trends in Austria

As can be seen in Figure 11 and Table 47, the main sources of NMVOC emissions in 2019 in Austria are NFR sectors *3 Agriculture* with a contribution of 34%, *2 Industrial Processes and Product Use* with a share of 33% in national total emissions *and 1.A Fuel Combustion Activities* with a contribution of 31%.

NMVOC emissions resulting from NFR sectors *1.B Fugitive Emissions* and *5 Waste* are minor sources contributing to national total NMVOC emissions with 2.1% and 0.05%, respectively.

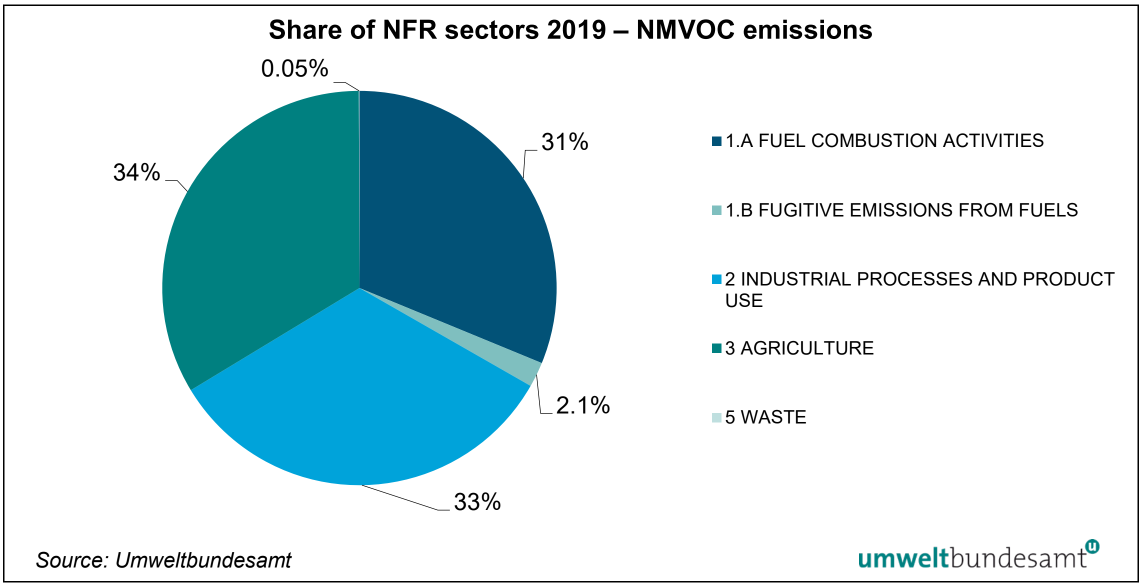


Figure 11: Share of NFR sectors 2019 in NMVOC emissions.

3 Agriculture

Within NFR sector *3 Agriculture*, the largest part of NMVOC emissions stems from NFR subcategory *3.B Manure Management* (73%). Smaller amounts arise from NFR subcategory *3.D Agricultural Soils* (27%) and source category *3.F Field burning of agricultural residues* is negligible with 0.02%.

- *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 25% between 1990 and 2019. Compared to the previous year 2018 emissions decreased by 1.3%. Within this source category manure management of cattle has the highest contribution with 90%.
- *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 41% is mainly driven by the reduced livestock numbers resulting in smaller amounts of manure that is applied to agricultural soils.

1.A Fuel Combustion Activities

NMVOC emissions from *1.A Fuel Combustion Activities* contribute with 31% to the national total. Within sector *1.A Fuel Combustion Activities* the main emitters in 2019 are *1.A.4 Other Sectors* (25% of the national total, mainly residential heating) and *1.A.3 Transport* (5.2% of the national total).

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

- *NFR 1.A.4 Other Sectors*: NMVOC emissions from this sector decreased by 45% 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 2018 emissions from this source category increased by 0.5% in 2019 because of higher emissions from residential heating, due to increased heating demand of households (heating degree days increased by 1.4%).
- *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 (-94%).

2 Industrial Processes and Product Use

The main source of NMVOC emissions in Austria within sector *2 Industrial Processes and Product Use* is NFR *2.D.3 Solvent Use* (30% of the national total).

The overall reduction in sector *Solvent Use* is due to abatement measures such as substitution, using products with lower solvent content as well as exhaust gas cleaning systems and after treatment as a result of legal requirements.

- *NFR 2.D.3.a Domestic Solvent use including fungicides:* The increase of the NMVOC emissions until 1999 in this category is due to an increased use of solvent containing products in households; from 2000 onwards are based on surveys regarding the solvent contents in the early 2000s and another in 2015, which showed that solvent contents were decreasing due to legal and technical measures.
- *NFR 2.D.3.d Coating Application*: This category contributed mainly to the overall decrease in the emissions of the concerned sector, which was primarily achieved from 1990 to 2000 due to various legal and regulatory enforcements (especially for coil and wood coating until 1999) and due to a reduction of solvents in paint as well as due to the substitution of solvent-based paint for paint with less or without solvents, due to the paints directive (see Chapter 4.5).
- *NFR 2.D.3.e and 2.D.3.f Degreasing and Dry Cleaning*: The emission reduction in this sub sectors was achieved due to technical abatement measures such as closed loop processes, waste gas purification and recycling.
- *NFR 2.D.3.g Chemical Products*: An emission reduction of 80% between 1990 and 2019 could be achieved due to technical abatement measures such as closed loop processes, waste gas purification and recycling but also due to product substitution. The NFR *2.D.3.g* covers manufacturing activities mainly of pharmaceutical products, paints, wood preservatives and glues.
- *NFR 2.D.3.h Printing*: The decrease of NMVOC emissions (-95% between 1990 and 2019) is a result of legal/abatement measures.
- *NFR 2.D.3.i Other solvent use*: The significant long term emission reduction of 93% could be achieved due to technical abatement measures such as closed loop processes, waste gas purification and recycling.

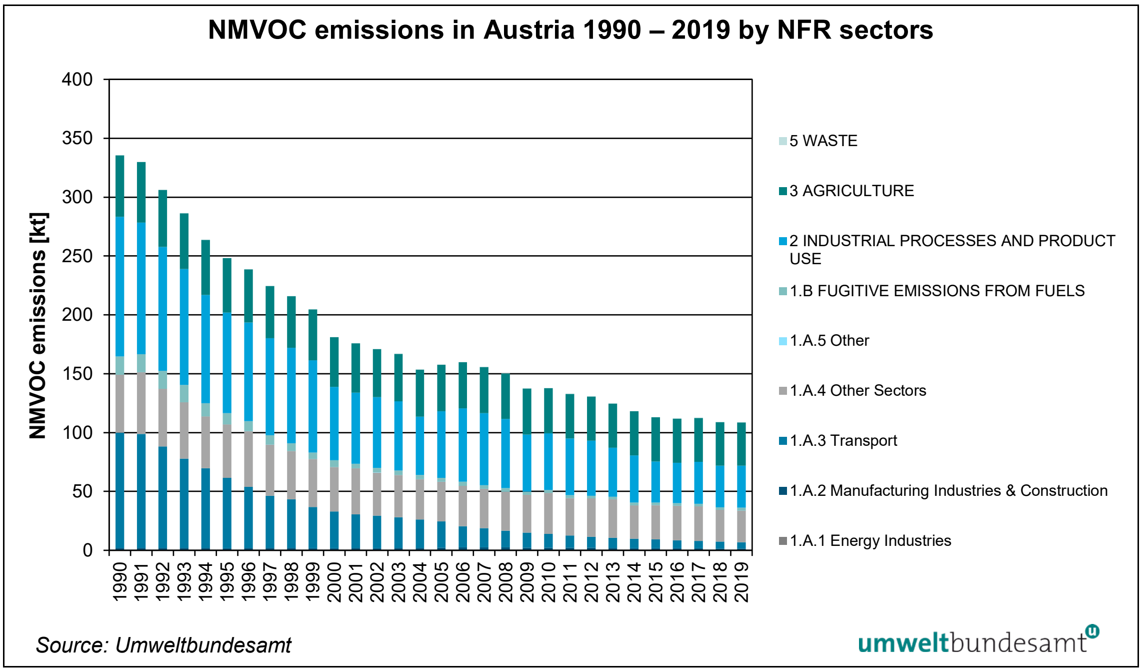


Figure 12: NMVOC emissions in Austria 1990–2019 by sectors in absolute terms.

Table 47: NMVOC emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		**NMVOC Emission in [kt]**		**Trend**		**Share in National Total**	
		1990	**2019**	**1990–2019**	**2018–2019**	**1990**	**2019**
1	ENERGY	164.65	36.13	-78%	-1%	49%	33%
1.A	FUEL COMBUSTION ACTIVITIES	149.16	33.90	-77%	-1%	44%	31%
1.A.1	Energy Industries	0.32	0.30	-4%	-6%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	1.68	1.03	-39%	-12%	1%	1%
1.A.3	Transport	97.88	5.60	-94%	-6%	29%	5%
1.A.3.a	Civil Aviation	0.20	0.21	5%	3%	<1%	<1%
1.A.3.b	Road Transportation	96.37	4.70	-95%	-8%	29%	4%
1.A.3.c	Railways	0.37	0.07	-81%	-2%	<1%	<1%
1.A.3.d	Navigation	0.94	0.61	-35%	6%	<1%	1%
1.A.3.e	Other transportation	0.00	0.00	141%	-8%	<1%	<1%
1.A.4	Other Sectors	49.27	26.94	-45%	<1%	15%	25%
1.A.4.a	Commercial/Institutional	1.32	0.67	-49%	4%	<1%	1%
1.A.4.b	Residential	42.42	23.66	-44%	1%	13%	22%
1.A.4.c	Agriculture/Forestry/Fisheries	5.53	2.61	-53%	-3%	2%	2%
1.A.5	Other	0.01	0.02	13%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	15.49	2.23	-86%	3%	5%	2%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	118.54	35.90	-70%	1%	35%	33%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	1.62	0.27	-83%	<1%	<1%	<1%
2.C	METAL PRODUCTION	0.51	0.44	-15%	-6%	<1%	<1%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	114.44	32.42	-72%	1%	34%	30%
2.D.3	Solvent use	114.44	32.42	-72%	1%	34%	30%
2.D.3.a	Domestic solvent use including fungicides	16.30	16.73	3%	4%	5%	15%
2.D.3.b	Road paving with asphalt	0.01	0.03	329%	15%	<1%	<1%
2.D.3.c	Asphalt roofing	NE	NE	NE	NE	NE	NE
2.D.3.d	Coating applications	45.79	8.74	-81%	1%	14%	8%
2.D.3.e	Degreasing	13.26	2.79	-79%	-3%	4%	3%
2.D.3.f	Dry cleaning	0.44	0.04	-91%	<1%	<1%	<1%
2.D.3.g	Chemical products	12.79	2.52	-80%	-3%	4%	2%
2.D.3.h	Printing	12.65	0.66	-95%	-24%	4%	1%
2.D.3.i	Other solvent use	13.20	0.92	-93%	-5%	4%	1%
2.G	Other product manufacture and use	0.08	0.06	-23%	-1%	<1%	<1%
2.H	Other Processes	1.89	2.71	44%	<1%	1%	2%
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	52.19	36.51	-30%	-1%	16%	34%
3.B	MANURE MANAGEMENT	35.42	26.60	-25%	-1%	11%	24%
3.D	AGRICULTURAL SOILS	16.71	9.90	-41%	-1%	5%	9%
3.F	FIELD BURNING OF AGRICULTURAL RES.	0.06	0.01	-89%	-2%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.16	0.05	-65%	-3%	<1%	<1%
	Total without sinks	**335.54**	**108.59**	**-68%**	**<1%**		

2.1.4 NH_3 Emissions

In 1990, national total NH_3 emissions amounted to 62 kt; emissions have increased over the period from 1990 to 2019. In 2019, emissions were 3.2% above 1990 levels and amounted to 64 kt. NH_3 in Austria is almost exclusively emitted in the agricultural sector. The higher NH_3 emissions can be explained by an increased number of cattle kept in loose house systems (for reasons of animal welfare and stipulated by EU law), an increase in the number of cows with higher milk yields and an increased use of urea as nitrogen fertilizer (cost-saving, but less efficient than other types of mineral fertilizer). Compared to the previous year, emissions in 2019 decreased by 1.6%. The main reasons for this short-term decrease are on the one hand a significantly lower consumption of mineral fertilizers and on the other hand a smaller number of cattle.

Main sources and emission trends in Austria

As it is illustrated in Figure 13 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 93% for 2019. Sector *1.A Fuel Combustion Activities* contributes with 4.0% 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 2019 with 0.3% and 2.6%, respectively.

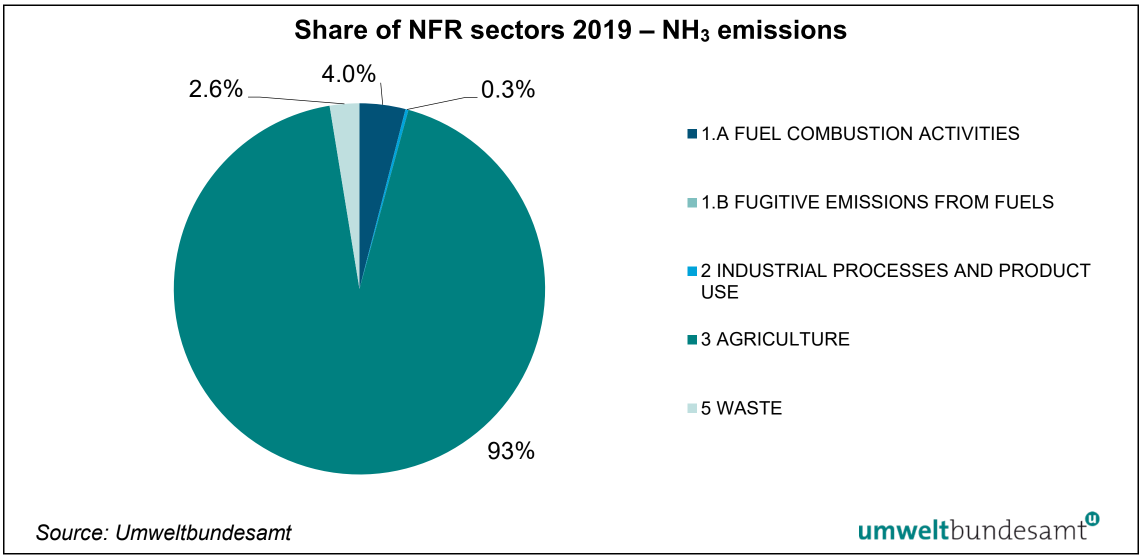


Figure 13: Share of NFR sectors 2019 in NH_3 emissions.

3 Agriculture

In 1990 national NH_3 emissions from the sector *Agriculture* amounted to 59 kt. Since 1990, emissions from this sector have increased by 0.5%. This slight increase of 0.5 % can be explained by an increased number of cattle kept in loose house systems (for reasons of animal welfare and stipulated by EU law), an increase in the number of cows with higher milk yields and an increased use of urea as nitrogen fertilizer (cost-saving, but less efficient than other types of mineral fertilizer). Compared to the previous year, emissions decreased in 2019 (-1.9%), The main reasons for this short-term decrease are on the one hand a significantly lower consumption of mineral fertilizers and on the other hand a smaller number of cattle.

NFR 3.B Manure Management has a share of 45% in national total NH_3 emissions in 2019. The emissions result from animal husbandry and the storage of manure. Within this source category manure management of cattle has the highest contribution with 61%. 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 11%, mainly due to higher emissions from cattle.

- *NFR 3.D Agricultural Soils* with a share of 48% has the highest contribution to national total NH_3 emissions in 2019. 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.

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 4.0% in 2019. NH_3 emissions from NFR sector *1.A* are increasing: in 1990, emissions amounted to about 2.0 kt. In the year 2019, they were about 30% higher than 1990 levels and amounted to about 2.5 kt. The rise is mainly due to increased emissions from *1.A.3.b.i Passenger Cars* and an increase of biomass use in category *1.A.1.a Public Electricity and Heat.*

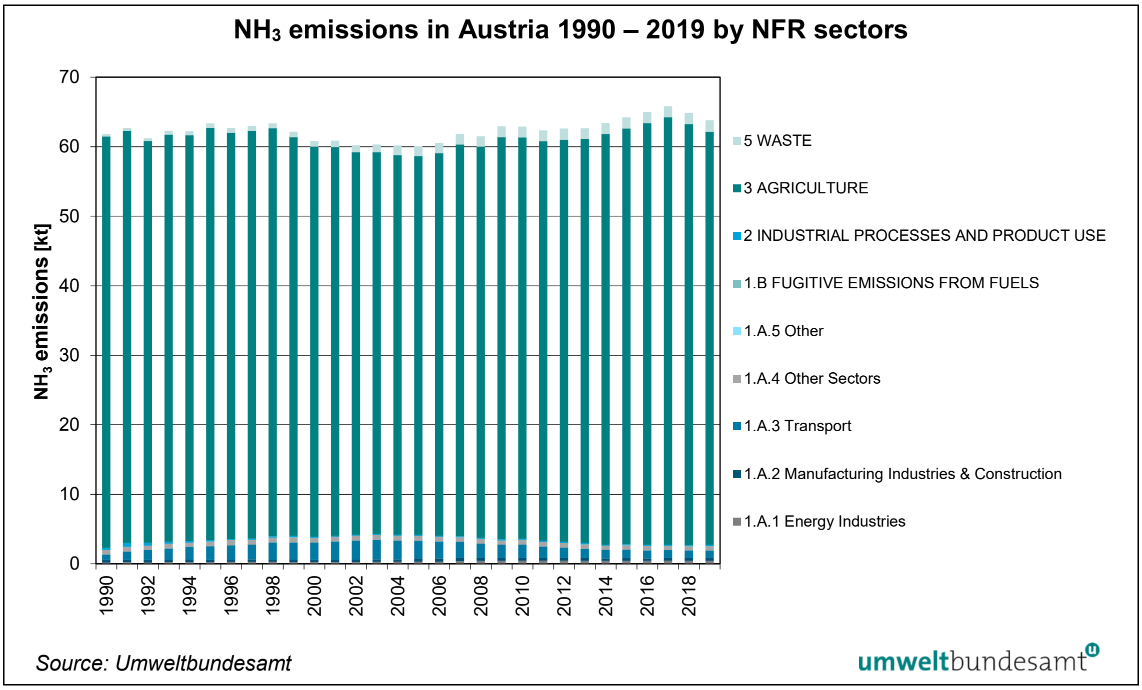


Figure 14: NH_3 emissions in Austria 1990–2019 by sectors in absolute terms.

Table 48: NH_3 emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		NH_3 Emission in [kt]		Trend		Share in National Total	
		1990	2019	1990–2019	2018–2019	1990	2019
1	ENERGY	1.96	2.55	30%	<1%	3%	4%
1.A	FUEL COMBUSTION ACTIVITIES	1.96	2.55	30%	<1%	3%	4%
1.A.1	Energy Industries	0.20	0.43	117%	-1%	<1%	1%
1.A.2	Manufacturing Industries and Construction	0.33	0.42	25%	6%	1%	1%
1.A.3	Transport	0.80	1.10	38%	-2%	1%	2%
1.A.4	Other Sectors	0.63	0.60	-4%	2%	1%	1%
1.A.5	Other	0.00	0.00	40%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	IE	0.00		-17%	IE	<1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	0.34	0.16	-51%	22%	1%	<1%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.27	0.11	-59%	38%	<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%	<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	59.18	59.46	<1%	-2%	96%	93%
3.B	MANURE MANAGEMENT	26.05	28.87	11%	-1%	42%	45%
3.B.1	Cattle	13.89	17.66	27%	-1%	22%	28%
3.B.2	Sheep	0.74	0.97	30%	-1%	1%	2%
3.B.3	Swine	8.47	5.70	-33%	<1%	14%	9%
3.B.4	Other livestock	2.94	4.55	55%	<1%	5%	7%
3.B.4.a	Buffalo	NO	NO	NO	NO	NO	NO
3.B.4.d	Goats	0.11	0.28	148%	1%	<1%	<1%
3.B.4.e	Horses	0.65	1.72	164%	<1%	1%	3%
3.B.4.f	Mules and asses	IE	IE	IE	IE	IE	IE
3.B.4.g	Poultry	2.15	2.52	17%	<1%	3%	4%
3.B.4.h	Other animals	0.03	0.03	11%	<1%	<1%	<1%
3.D	AGRICULTURAL SOILS	33.09	30.58	-8%	-3%	54%	48%
3.D.a	Direct Soil Emissions	33.09	30.58	-8%	-3%	54%	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.	0.04	0.01	-75%	-2%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.37	1.64	348%	2%	1%	3%
	Total without sinks	**61.84**	**63.82**	**3%**	**-2%**		

2.1.5 Carbon monoxide (CO) Emissions

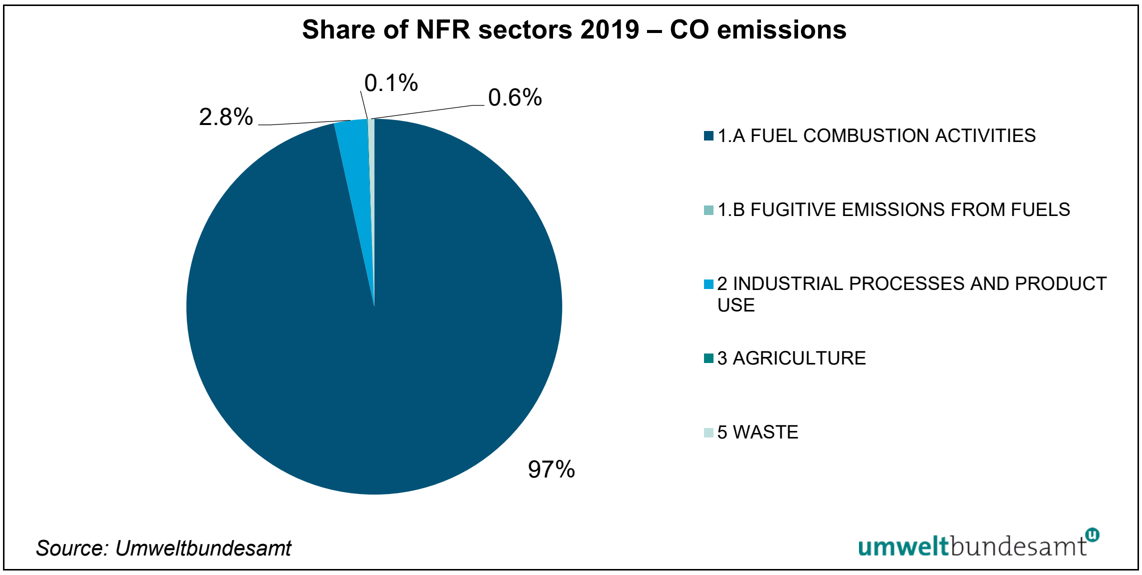
CO is a colourless and odourless gas, formed when carbon in fuel is not burned completely. It is a component of motor vehicle exhaust; other sources of CO emissions include industrial processes, non-transportation fuel combustion, and natural sources such as wildfires.

In 1990, national total CO emissions amounted to 1 254 kt. Emissions considerably decreased from 1990 to 2019. In 2019, emissions were 60% below 1990 levels and amounted to 498 kt. This reduction was mainly due to decreasing emissions from road transport (catalytic converters). The emissions increased between 2018 and 2019 by 2.9%, mainly due to sector iron and steel.

Main sources and emission trends in Austria

As can be seen in Figure 15 and Table 49, CO emissions in Austria are almost exclusively emitted by the Energy sector, and more specifically, *1.A Fuel Combustion Activities*. The share in national total CO emissions is about 97% for 2019.

CO emissions resulting from NFR sectors *2 Industrial Processes and Product Use*, *3 Agriculture* and *5 Waste* are minor sources. These sectors contribute to national total CO emissions with 2.8%, 0.1% and 0.6%, respectively.



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

Figure 15: Share of NFR sectors 2019 in CO emissions.

1.A Fuel Combustion Activities

In the period 1990–2019 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 subsectors.

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 43% due to the switch-over to improved technologies and decreased use of coke. Between 2018 and 2019 emissions increased by 0.6% because of higher emissions from residential heating, due to increased heating demand of households (heating degree days increased by 1.4%).
- NFR *1.A.2 Manufacturing Industries and Construction:* Compared to 1990 emissions decreased by 29%. The trend is dominated by fuel combustion from iron and steel industry. The emissions increase of 12% compared to the previous year 2018 is due to higher emissions from the sector iron and steel.
- NFR *1.A.3 Transport:* The significant emission reduction of 88% 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.

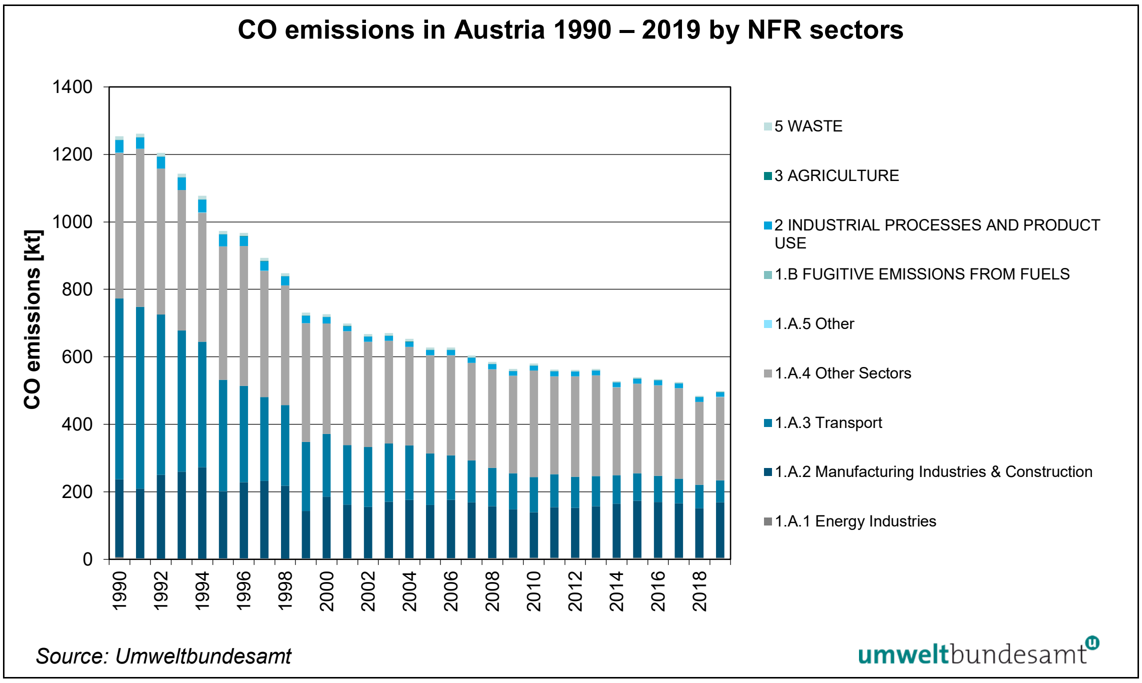


Figure 16: CO emissions in Austria 1990–2019 by sectors in absolute terms.

Table 49: CO emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		CO Emission in [kt]		Trend		Share in National Total	
		1990	2019	1990–2019	2018–2019	1990	2019
1	ENERGY	1 205.16	481.29	-60%	3%	96%	97%
1.A	FUEL COMBUSTION ACTIVITIES	1 205.16	481.29	-60%	3%	96%	97%
1.A.1	Energy Industries	6.10	4.26	-30%	-2%	<1%	1%
1.A.2	Manufacturing Industries and Construction	231.22	164.57	-29%	12%	18%	33%
1.A.2.a	Iron and Steel	210.72	152.61	-28%	14%	17%	31%
1.A.2.b	Non-ferrous Metals	0.05	0.05	-5%	3%	<1%	<1%
1.A.2.c	Chemicals	0.46	0.43	-8%	-13%	<1%	<1%
1.A.2.d	Pulp, Paper and Print	4.15	2.08	-50%	4%	<1%	<1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.20	0.11	-46%	-7%	<1%	<1%
1.A.2.f	Non-metallic Minerals	11.03	3.82	-65%	-33%	1%	1%
1.A.2.g	Manufacturing Industries and Constr. - other	4.61	5.49	19%	-4%	<1%	1%
1.A.3	Transport	535.43	65.49	-88%	-6%	43%	13%
1.A.3.a	Civil Aviation	2.56	3.94	54%	-1%	<1%	1%
1.A.3.b	Road Transportation	527.68	58.38	-89%	-7%	42%	12%
1.A.3.c	Railways	2.04	0.50	-76%	-1%	<1%	<1%
1.A.3.d	Navigation	3.12	2.58	-17%	4%	<1%	1%
1.A.3.e	Other transportation	0.04	0.10	141%	-8%	<1%	<1%
1.A.4	Other Sectors	432.19	246.66	-43%	1%	34%	49%
1.A.4.a	Commercial/Institutional	11.40	4.66	-59%	5%	1%	1%
1.A.4.b	Residential	387.69	224.15	-42%	1%	31%	45%
1.A.4.c	Agriculture/Forestry/Fisheries	33.10	17.86	-46%	-2%	3%	4%
1.A.5	Other	0.22	0.30	38%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	IE	IE	IE	IE	IE	IE
2	INDUSTRIAL PROCESSES AND PRODUCT USE	37.19	14.14	-62%	-1%	3%	3%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	12.67	11.10	-12%	<1%	1%	2%
2.C	METAL PRODUCTION	23.32	2.05	-91%	-2%	2%	<1%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.27	0.27	<1%	<1%	<1%	<1%
2.G	Other product manufacture and use	0.94	0.73	-23%	<1%	<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	1.23	0.30	-76%	-2%	<1%	<1%
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	1.23	0.30	-76%	-2%	<1%	<1%
3.I	AGRICULTURE OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	10.31	2.75	-73%	-6%	1%	1%
5.A	SOLID WASTE DISPOSAL ON LAND	10.26	2.73	-73%	-6%	1%	1%
5.B	BIOLOGICAL TREATMENT OF WASTE	NA	NA	NA	NA	NA	NA
5.C	INCINERATION/BURNING OF WASTE	0.05	0.02	-66%	2%	<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	**1 253.89**	**498.47**	**-60%**	**3%**		

2.2 Emission Trends for Particulate matter (PM)

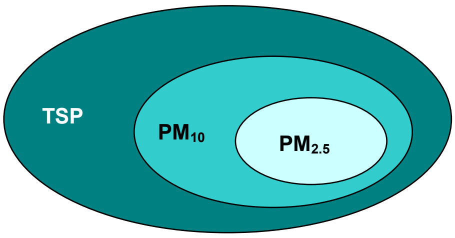
Particulate matter (PM) is a complex mixture consisting of both directly emitted and secondarily formed components of both natural and anthropogenic origin (e.g. geological material, combustion by-products and biological material). It has an inhomogeneous composition of sulphate, nitrate, ammonium, organic 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 17).

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 of time 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 crop land.



Source: Umweltbundesamt

umweltbundesamt

Figure 17: 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.

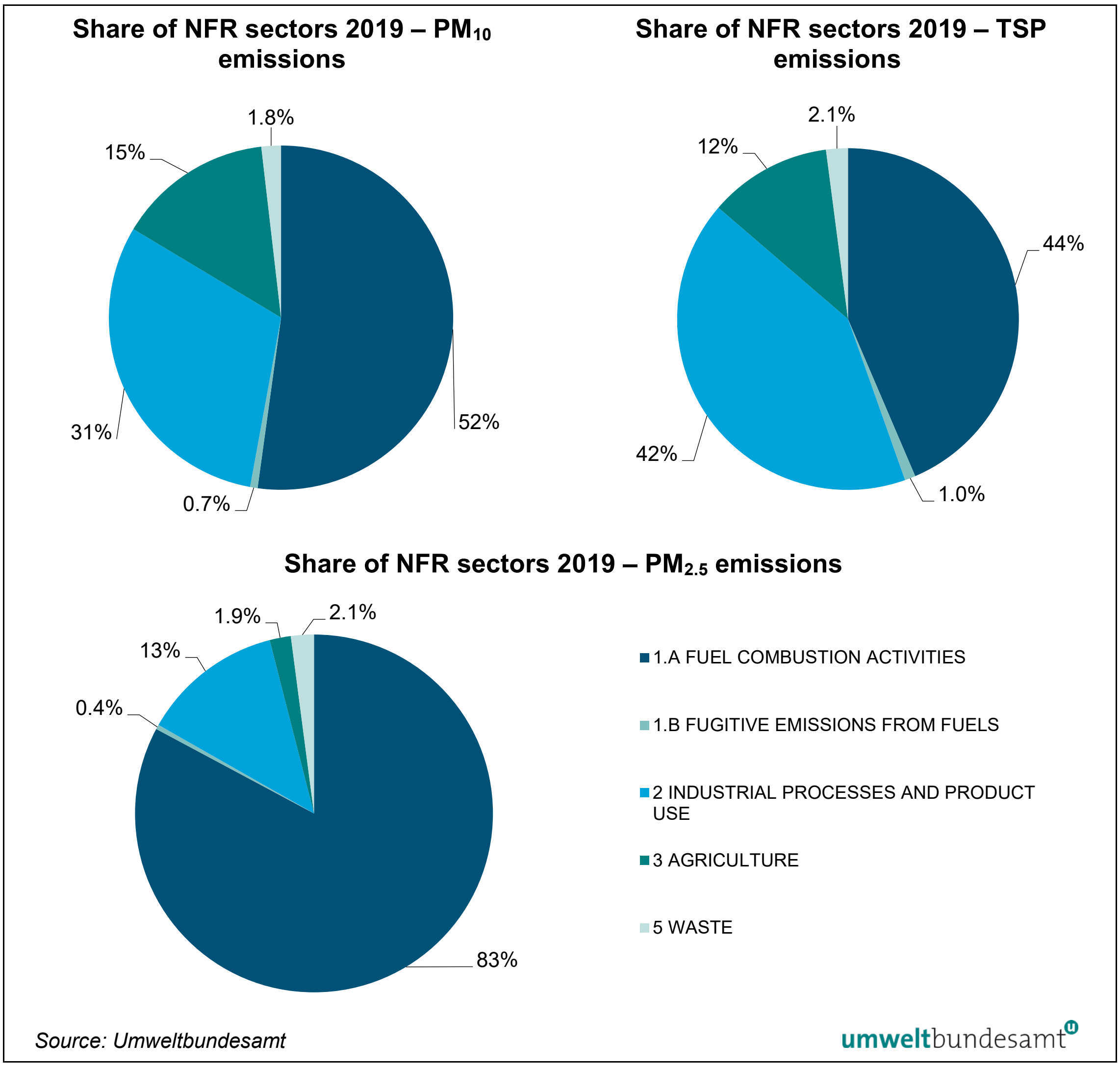


Figure 18: Share of NFR sectors 2019 in PM emissions (TSP, PM_{10} and $PM_{2.5}$).

Table 50: National total emissions and emission trends for particulate matter (PM) 1990–2019.

Year	**Emissions [kt]**		
	TSP	**PM_{10}**	**$PM_{2.5}$**
1990	53.12	40.81	27.07
:	NR	NR	NR
1995	51.92	39.23	25.60
:	NR	NR	NR
2000	50.51	37.75	24.02
2001	50.19	37.73	24.28
2002	49.10	36.66	23.45
2003	48.76	36.42	23.30
2004	48.69	36.05	22.71
2005	48.01	35.64	22.56
2006	46.61	34.66	22.05
2007	45.57	33.67	21.22
2008	45.55	33.19	20.37
2009	43.14	31.46	19.22
2010	43.75	32.04	19.81
2011	42.99	31.07	18.67
2012	42.24	30.45	18.20
2013	41.57	29.82	17.62
2014	40.24	28.31	16.05
2015	39.70	27.91	15.83
2016	39.38	27.54	15.46
2017	39.66	27.53	15.25
2018	38.33	26.37	14.23
2019	38.49	26.34	14.06
Trend 1990–2019	**-27.5%**	**-35.5%**	**-48.1%**

Particulate matter (PM) emissions show a decreasing trend over the period 1990 to 2019: TSP emissions decreased by 28%, PM_{10} emissions were about 35% below the level of 1990, and $PM_{2.5}$ emissions dropped by about 48%. Between 2018 and 2019 PM_{10} and $PM_{2.5}$ emissions decreased by 0.1% (PM_{10}) and 1.2% ($PM_{2.5}$). TSP emissions increased by 0.4%. The short-term decrease of PM_{10} and $PM_{2.5}$ was mainly due to lower emissions from *1.A.3 Road transport* (passenger cars). In the transport sector PM emissions show a general decrease since several years as a result of improved technology. TSP emissions increased slightly compared to the previous year because of rising emissions from *2.A Mineral Products* and *2.B Chemical Industry*.

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.* Further important sources of PM emissions are the sectors *2 Industrial Processes and Product Use (2.A Mineral Products)* as well as *3 Agriculture* (*3.D Agricultural Soils)*.

- *NFR 1.A.4 Other Sectors*: small combustion plants, residential heating, household ovens and stoves (NFR 1.A.4.b) are large sources of TSP, PM_{10} and $PM_{2.5}$, as well as Off Road Vehicles and Other Machinery (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.

  This downward trend counteracted the application of CO_2-neutral fuels such as biomass (wood, pellets etc.).

- *NFR 1.A.3 Transport* includes transportation activities, mechanical abrasion from tyres, brakes and road surfaces and has a contribution of 17% TSP, 16% PM_{10} and 20% $PM_{2.5}$ 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 2.4% of the national total TSP emissions, 3.2% of PM_{10} emissions and 5.1% of $PM_{2.5}$ emissions. *1.A.1 Energy Industries* contributes in 2019 with 3.1% of TSP, 4.2% of PM_{10} and 6.6% 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 production.

  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.

2 Industrial Processes and Product Use

- *NFR 2.A Mineral Products*: The handling of bulk materials like mineral products and the activities in the field of civil engineering represent the majority of PM sources within sector *2 Industrial Processes and Product Use*. The increase of PM emissions since 1990 of subcategory NFR *2.A Mineral products* is a result of increased activities due to manifold construction activities, whereas from 2008 to 2010 a decrease because of the economic crisis can be noted. Since 2011 the emission trend shows ups and downs. Between 2018 and 2019 an increase can be observed.
- *NFR 2.C Metal Production*, a decreasing trend of about 90% of all PM fractions can be noted for the period 1990 to 2019 because considerable efforts were made by introducing low-PM technologies, abatement techniques, flue gas collection and flue gas cleaning systems etc. In 2019 this sub category represents a minor source of PM emissions.

3 Agriculture

- *NFR 3.D Agricultural Soils***,** which consider 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 4.5% of the agricultural $PM_{2.5}$ emissions from this source category. TSP and PM_{10} emissions from *3.D Agricultural Soils* decreased by 6.9% and 7.3% over the period 1990 to 2019.
- *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 2019 emissions decreased by 12% for all PM fractions due to falling livestock numbers. Compared to the previous year emissions decreased by 0.8%.

PM_{10} emissions and emission trends in Austria

National total PM_{10} emissions amounted to 41 kt in 1990 and have decreased steadily so that by the year 2019 emissions were reduced by 35% (to 26 kt) – see Table 51.

As shown in Figure 18 and Table 51, the main sources for PM_{10} emissions in 2019 in Austria are combustion processes in the NFR category 1.A *Fuel Combustion Activities* (52% in national total emissions) as well as handling of bulk materials like mineral products and the activities in the field of civil engineering of category 2 *Industrial Processes and Product Use* (31% in national total emissions). Sector *3 Agriculture* contributes with a share of 15% in national total PM_{10} emissions.

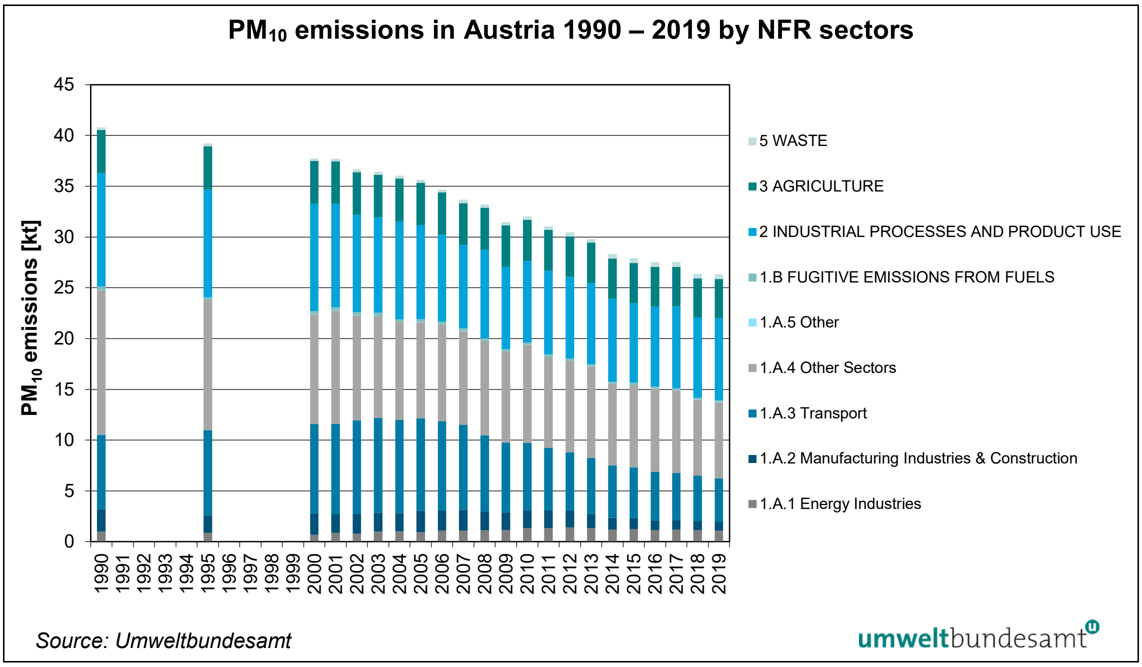


Figure 19: PM_{10} emissions in Austria 1990–2019 by sectors in absolute terms.

Table 51: PM_{10} emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		PM_{10} Emission in [kt]		Trend		Share in National Total	
		1990	2019	1990–2019	2018–2019	1990	2019
1	ENERGY	25.13	13.93	-45%	-2%	62%	53%
1.A	FUEL COMBUSTION ACTIVITIES	24.73	13.74	-44%	-2%	61%	52%
1.A.1	Energy Industries	1.00	1.10	10%	-5%	2%	4%
1.A.2	Manufacturing Industries and Construction	2.18	0.84	-62%	-6%	5%	3%
1.A.2.a	Iron and Steel	0.05	0.01	-85%	-32%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.01	0.01	-33%	-2%	<1%	<1%
1.A.2.c	Chemicals	0.21	0.19	-11%	-4%	1%	1%
1.A.2.d	Pulp, Paper and Print	0.95	0.21	-78%	1%	2%	1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.11	0.03	-75%	-10%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.07	0.08	13%	-5%	<1%	<1%
1.A.2.g	Manufacturing Ind. and Constr. - other	0.78	0.32	-60%	-10%	2%	1%
1.A.3	Transport	7.33	4.30	-41%	-3%	18%	16%
1.A.3.a	Civil Aviation	0.04	0.14	216%	13%	<1%	1%
1.A.3.b	Road Transportation	6.27	3.52	-44%	-5%	15%	13%
1.A.3.c	Railways	0.96	0.57	-41%	<1%	2%	2%
1.A.3.d	Navigation	0.06	0.07	21%	11%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	141%	-8%	<1%	<1%
1.A.4	Other Sectors	14.20	7.49	-47%	<1%	35%	28%
1.A.4.a	Commercial/Institutional	0.85	0.35	-59%	4%	2%	1%
1.A.4.b	Residential	10.81	6.26	-42%	1%	26%	24%
1.A.4.c	Agriculture/Forestry/Fisheries	2.55	0.88	-65%	-4%	6%	3%
1.A.5	Other	0.02	0.02	11%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	0.40	0.19	-54%	4%	1%	1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	11.16	8.09	-28%	2%	27%	31%
2.A	MINERAL PRODUCTS	4.94	6.37	29%	2%	12%	24%
2.A.1	Cement Production	0.16	0.05	-67%	-2%	<1%	<1%
2.A.2	Lime Production	0.06	0.09	53%	7%	<1%	<1%
2.A.3	Glass production	IE	IE	IE	IE	IE	IE
2.A.5	Mining, construction, handling of products	4.73	6.23	32%	2%	12%	24%
2.A.6	Other Mineral products	NO	NO	NO	NO	NO	NO
2.B	CHEMICAL INDUSTRY	0.57	0.28	-50%	37%	1%	1%
2.C	METAL PRODUCTION	4.68	0.47	-90%	-6%	11%	2%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	0.61	0.51	-17%	11%	1%	2%
2.H	Other Processes	0.00	0.00	-23%	4%	<1%	<1%
2.I	Wood processing	0.37	0.45	24%	-1%	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	4.24	3.84	-10%	-1%	10%	15%
3.B	MANURE MANAGEMENT	0.56	0.50	-12%	-1%	1%	2%
3.D	AGRICULTURAL SOILS	3.58	3.32	-7%	-1%	9%	13%
3.F	FIELD BURNING OF AGRICUL. RESIDUES	0.10	0.02	-76%	-2%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.28	0.48	75%	9%	1%	2%
	Total without sinks	**40.81**	**26.34**	**-35%**	**<1%**		

$PM_{2.5}$ 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 2019 emissions were reduced by 48% (to 14 kt) – see Table 52.

As shown in Figure 18 and Table 52, $PM_{2.5}$ emissions in Austria mainly arose from combustion processes in the energy sector with a share of 83% in the total emissions in 2019. A further emission source is NFR sector *2 Industrial Processes and Product Use,* which had a share of 13% 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.

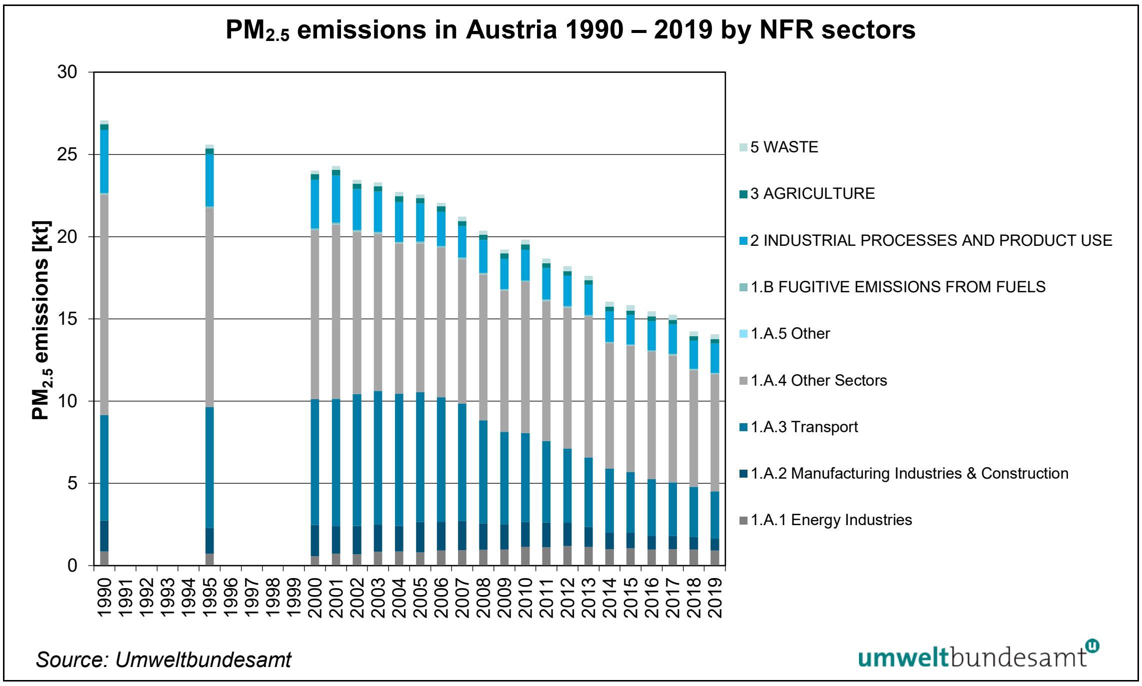


Figure 20: $PM_{2.5}$ emissions in Austria 1990–2019 by sectors in absolute terms.

Table 52: $PM_{2.5}$ emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		$PM_{2.5}$ Emission in [kt]		Trend		Share in National Total	
		1990	2019	1990–2019	2018–2019	1990	2019
1	ENERGY	22.66	11.71	-48%	-2%	84%	83%
1.A	FUEL COMBUSTION ACTIVITIES	22.55	11.65	-48%	-2%	83%	83%
1.A.1	Energy Industries	0.85	0.93	9%	-5%	3%	7%
1.A.2	Manufacturing Industries and Construction	1.90	0.71	-62%	-6%	7%	5%
1.A.2.a	Iron and Steel	0.04	0.01	-85%	-32%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.01	0.01	-33%	-2%	<1%	<1%
1.A.2.c	Chemicals	0.17	0.16	-11%	-4%	1%	1%
1.A.2.d	Pulp, Paper and Print	0.78	0.18	-78%	1%	3%	1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.09	0.02	-75%	-10%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.06	0.06	13%	-5%	<1%	<1%
1 A 2 g	Manufacturing Industries and Constr. – other	0.74	0.28	-62%	-11%	3%	2%
1.A.3	Transport	6.40	2.88	-55%	-6%	24%	20%
1.A.3.a	Civil Aviation	0.04	0.14	216%	13%	<1%	1%
1.A.3.b	Road Transportation	5.70	2.47	-57%	-7%	21%	18%
1.A.3.c	Railways	0.60	0.21	-65%	-1%	2%	1%
1.A.3.d	Navigation	0.06	0.07	21%	11%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	141%	-8%	<1%	<1%
1.A.4	Other Sectors	13.39	7.11	-47%	<1%	49%	51%
1.A.4.a	Commercial/Institutional	0.77	0.33	-57%	3%	3%	2%
1.A.4.b	Residential	10.11	5.94	-41%	1%	37%	42%
1.A.4.c	Agriculture/Forestry/Fisheries	2.50	0.84	-67%	-4%	9%	6%
1.A.5	Other	0.02	0.02	11%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	0.11	0.06	-46%	4%	<1%	<1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	3.82	1.80	-53%	4%	14%	13%
2.A	MINERAL PRODUCTS	0.71	0.81	15%	3%	3%	6%
2.A.1	Cement Production	0.14	0.05	-67%	-2%	1%	<1%
2.A.2	Lime Production	0.04	0.06	53%	7%	<1%	<1%
2.A.3	Glass production	IE	IE	IE	IE	IE	IE
2.A.5	Mining, construction, handling of products	0.53	0.71	33%	3%	2%	5%
2.A.6	Other Mineral products	NO	NO	NO	NO	NO	NO
2.B	CHEMICAL INDUSTRY	0.30	0.15	-51%	37%	1%	1%
2.C	METAL PRODUCTION	2.13	0.22	-90%	-6%	8%	2%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	0.54	0.43	-19%	6%	2%	3%
2.H	Other Processes	0.00	0.00	-44%	4%	<1%	<1%
2.I	Wood processing	0.15	0.18	24%	-1%	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	0.36	0.27	-26%	-1%	1%	2%
3.B	MANURE MANAGEMENT	0.13	0.11	-12%	-1%	<1%	1%
3.D	AGRICULTURAL SOILS	0.14	0.14	-4%	<1%	1%	1%
3.F	FIELD BURNING OF AGRICULT. RES.	0.09	0.02	-76%	-2%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.23	0.29	27%	5%	1%	2%
	Total without sinks	**27.07**	**14.06**	**-48%**	**-1%**		

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

National total TSP emissions amounted to 53 kt in 1990, decreased over the period 1990 to 2019 by 28% and amounted to 38 kt in 2019, 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 44% and 42%, respectively, in national total emissions in 2019. Important subcategories of *1.A Fuel Combustion Activities* are *1.A.4 Other Sectors* (mainly small heating installations) with a share of 21%, 1*.A.3 Transport* contributing with 17% as well as *1.A.1 Energy Industries* with 3.1% and *1.A.2 Manufacturing Industries and Construction* with 2.4% in national total emissions. NFR sector *3 Agriculture* also participates with 12%.

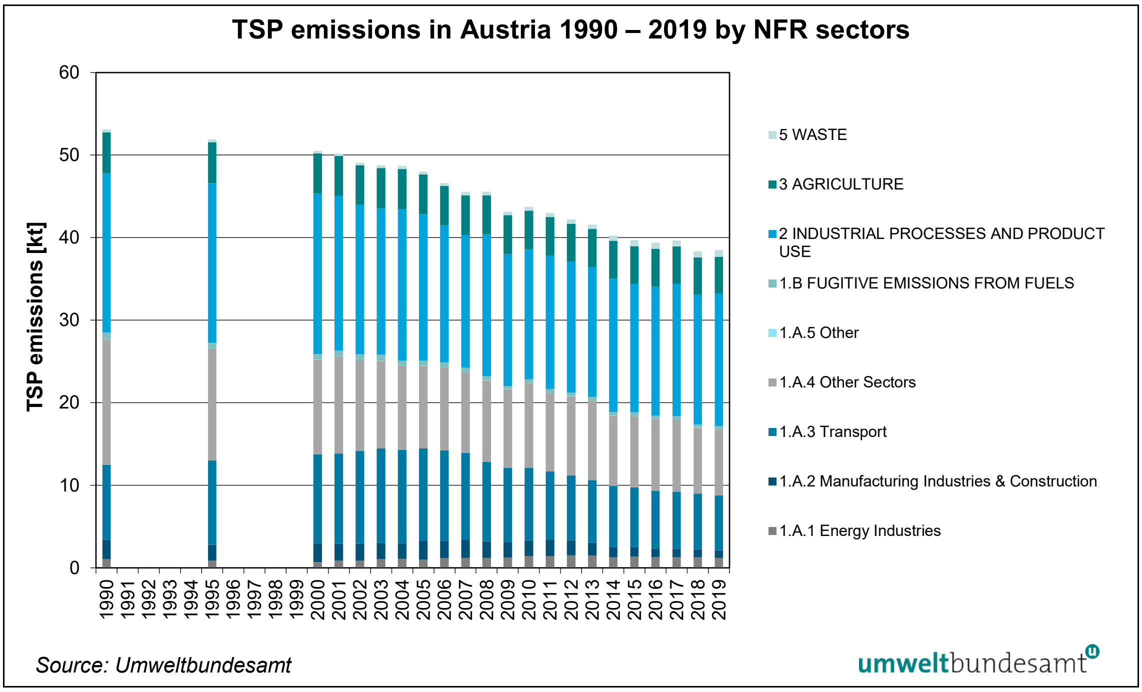


Figure 21: TSP emissions in Austria 1990–2019 by sectors in absolute terms.

Table 53: TSP emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		TSP Emission in [kt]		Trend		Share in National Total	
		1990	**2019**	**1990–2019**	**2018–2019**	**1990**	**2019**
1	ENERGY	28.51	17.16	-40%	-1%	54%	45%
1.A	FUEL COMBUSTION ACTIVITIES	27.66	16.77	-39%	-1%	52%	44%
1.A.1	Energy Industries	1.06	1.20	14%	-5%	2%	3%
1.A.2	Manufacturing Industries and Construction	2.37	0.92	-61%	-6%	4%	2%
1.A.2.a	Iron and Steel	0.06	0.01	-85%	-32%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.01	0.01	-33%	-2%	<1%	<1%
1.A.2.c	Chemicals	0.23	0.21	-11%	-4%	<1%	1%
1.A.2.d	Pulp, Paper and Print	1.06	0.24	-78%	1%	2%	1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.12	0.03	-75%	-10%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.08	0.09	13%	-5%	<1%	<1%
1 A 2 g	Manufacturing Industries and Constr. – other	0.81	0.34	-58%	-10%	2%	1%
1.A.3	Transport	9.07	6.64	-27%	-2%	17%	17%
1.A.3.a	Civil Aviation	0.04	0.14	216%	13%	<1%	<1%
1.A.3.b	Road Transportation	6.97	4.83	-31%	-3%	13%	13%
1.A.3.c	Railways	2.00	1.61	-20%	<1%	4%	4%
1.A.3.d	Navigation	0.06	0.07	21%	11%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	141%	-8%	<1%	<1%
1.A.4	Other Sectors	15.15	7.99	-47%	<1%	29%	21%
1.A.4.a	Commercial/Institutional	0.92	0.37	-60%	4%	2%	1%
1.A.4.b	Residential	11.64	6.69	-42%	1%	22%	17%
1.A.4.c	Agriculture/Forestry/Fisheries	2.59	0.93	-64%	-4%	5%	2%
1.A.5	Other	0.02	0.02	11%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	0.85	0.39	-54%	4%	2%	1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	19.31	16.06	-17%	2%	36%	42%
2.A	MINERAL PRODUCTS	10.21	13.25	30%	1%	19%	34%
2.A.1	Cement Production	0.17	0.06	-67%	-2%	<1%	<1%
2.A.2	Lime Production	0.06	0.10	53%	7%	<1%	<1%
2.A.3	Glass production	IE	IE	IE	IE	IE	IE
2.A.5	Mining, construction, handling of products	9.97	13.10	31%	1%	19%	34%
2.A.6	Other Mineral products	NO	NO	NO	NO	NO	NO
2.B	CHEMICAL INDUSTRY	0.96	0.48	-50%	37%	2%	1%
2.C	METAL PRODUCTION	6.60	0.66	-90%	-6%	12%	2%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	0.63	0.53	-16%	12%	1%	1%
2.H	Other Processes	0.00	0.00	-19%	4%	<1%	<1%
2.I	Wood processing	0.92	1.14	24%	-1%	2%	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	4.95	4.48	-9%	-1%	9%	12%
3.B	MANURE MANAGEMENT	1.25	1.11	-12%	-1%	2%	3%
3.D	AGRICULTURAL SOILS	3.59	3.35	-7%	<1%	7%	9%
3.F	FIELD BURNING OF AGRICULTURAL RES.	0.10	0.02	-76%	-2%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.35	0.79	126%	12%	1%	2%
	Total without sinks	**53.12**	**38.49**	**-28%**	**<1%**		

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).

2.3 Emission Trends for Heavy Metals

In general emissions of heavy metals decreased remarkably from 1990 to 2019. Emission trends for heavy metals from 1990 to 2019 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 1990–2019.

Year	Emissions [t]		
	Cd	Hg	Pb
1990	1.76	2.16	232.54
1991	1.66	2.06	196.46
1992	1.38	1.66	139.96
1993	1.25	1.41	99.17
1994	1.14	1.20	68.68
1995	1.06	1.22	20.32
1996	1.05	1.18	19.89
1997	1.01	1.15	18.81
1998	0.95	0.97	17.65
1999	1.01	0.95	17.91
2000	0.99	0.91	17.15
2001	1.00	0.97	16.74
2002	0.98	0.94	17.61
2003	1.00	0.98	17.80
2004	1.00	0.95	17.78
2005	1.03	0.99	18.36
2006	1.08	1.02	19.15
2007	1.10	1.03	19.88
2008	1.12	1.04	19.92
2009	1.06	0.92	17.54
2010	1.18	1.03	20.09
2011	1.16	1.02	20.38
2012	1.18	1.04	20.33
2013	1.20	1.09	21.06
2014	1.13	1.03	20.15

Year	Emissions [t]		
	Cd	Hg	Pb
2015	1.15	1.01	19.59
2016	1.13	0.95	19.87
2017	1.18	1.03	20.52
2018	1.14	0.96	19.29
2019	1.16	0.99	20.42
Trend 1990–2019	**-34%**	**-54%**	**-91%**

2.3.1 Cadmium (Cd) Emissions

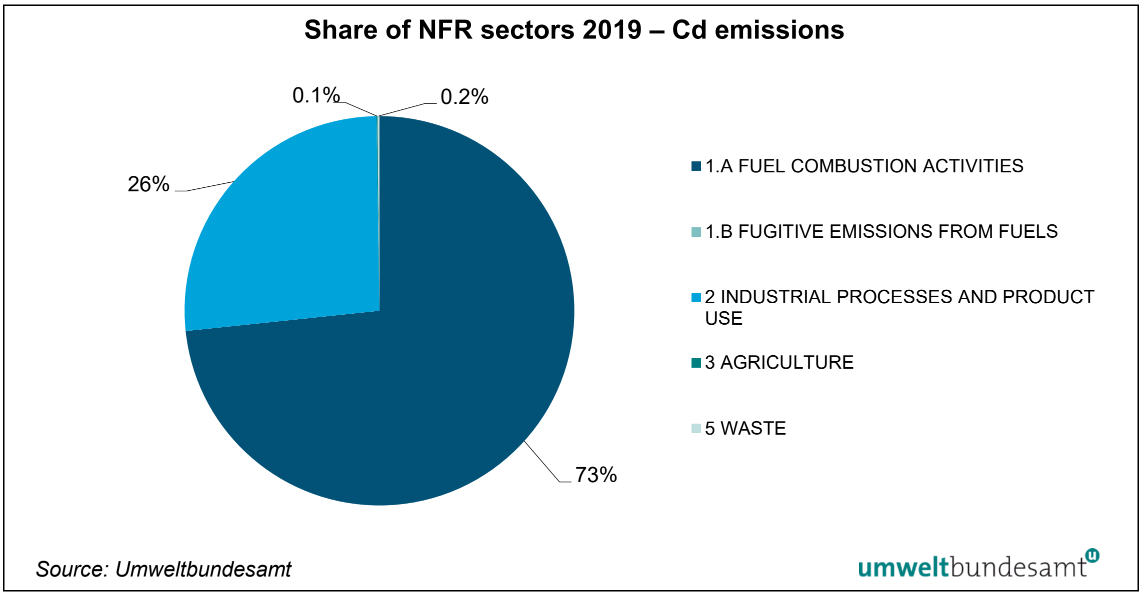
Cadmium (Cd) has been ubiquitously distributed in the natural environment for millions of years. It occurs in the earth's crust with a content estimated to be between 0.08 and 0.5 ppm. Unlike some other heavy metals, such as lead or mercury, which have been used since ancient times, Cd has been refined 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 73% to national total Cd emissions in 2019. The second important source is 2 *Industrial Processes and Product Use* with 26% in national total (see Figure 22 and Table 55).

Cd emissions resulting from NFR sectors *3 Agriculture* and *5 Waste* are minor sources. These sectors contribute to national total Cd emissions with about 0.2% (*Waste*) and 0.1% (*Agriculture)*.



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

Figure 22: Share of NFR sectors 2019 in Cd emissions.

National total Cd emissions amounted to 1.76 t in 1990; emissions have decreased and by the year 2019 emissions were reduced by 34% to 1.16 t in the period 1990–2019. 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 decrease in the use of heavy fuel oil and lower process emissions from iron and steel production. From 2000 to 2010 Cd emissions were increasing again, which was due to the growing activities in the industrial processes sector and energy sector. The emissions peak in 2013 can be explained with the colder winter 2013 and the resulting higher heating demand. Since then emissions remained quite stable. The increase 2017 was due to higher emissions from iron and steel production and other sectors (*1.A.4.a Commercial/Institutional*).

1.A Fuel Combustion Activities

In the period from 1990 to 2019 Cd emissions of *1.A Fuel Combustion Activities* decreased by 19% to 0.85 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 25% since 1990 to 0.30 t, representing a share of 26% in national total emissions in 2019. The reduction is mainly due to a decreased use of coal.
- *NFR 1.A.2 Manufacturing Industries and Construction*: Between 1990 and 2019 Cd emissions decreased by 19%, however since 2003 emissions show an increasing trend due to increased use of biomass in pulp and paper industries.

- *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.

2 Industrial Processes and Product Use

Within sector *2 Industrial Processes and Product Use* the main source for Cd emission is sub-category *2.C Metal Production*.

- *NFR 2.C Metal Production*: As shown in Table 55 in the period from 1990 to 2019 the Cd emissions decreased by 57% to 0.23 t, which is a share of 20% to the total Cd emission. Emissions from NFR *2.C.1 Iron and steel* decreased significantly due to extensive abatement measures but also by production and product substitution. Compared to the previous year emissions from NFR *2.C.1 Iron and steel* increased in 2019 by 9.5%.

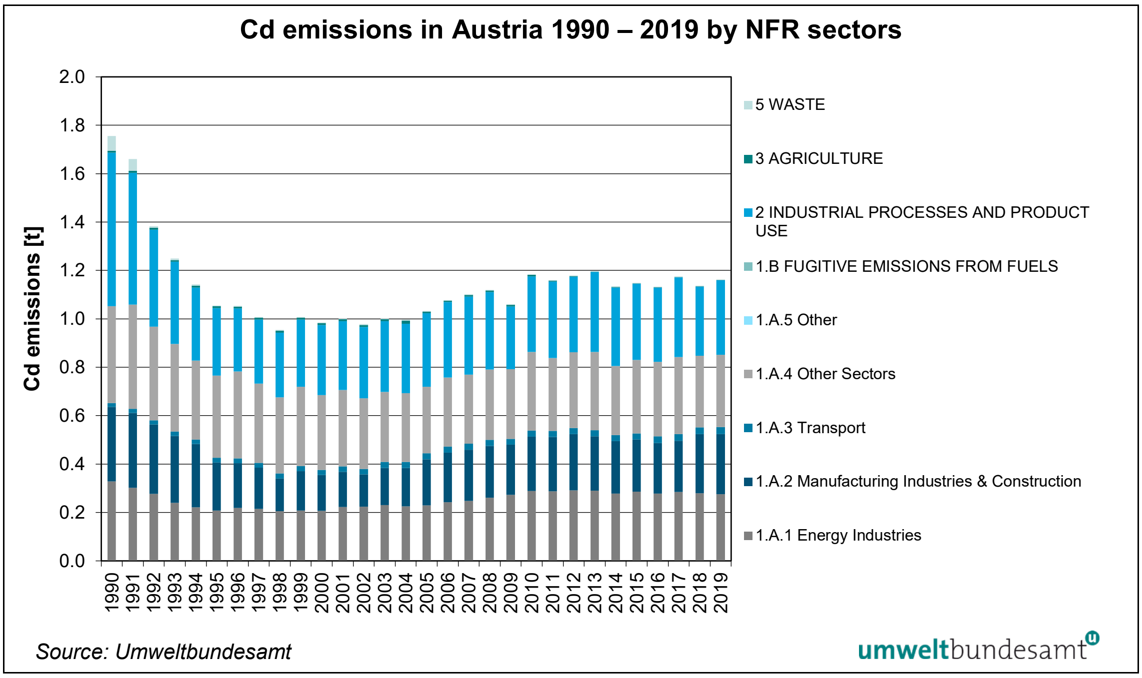


Figure 23: Cd emissions in Austria 1990–2019 by sectors in absolute terms.

Table 55: Cd emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		Cd Emission in [t]		Trend		Share in National Total	
		1990	2019	1990–2019	2018–2019	1990	2019
1	ENERGY	1.05	0.85	-19%	1%	60%	73%
1.A	FUEL COMBUSTION ACTIVITIES	1.05	0.85	-19%	1%	60%	73%
1.A.1	Energy Industries	0.33	0.28	-16%	-2%	19%	24%
1.A.1.a	Public Electricity and Heat Production	0.18	0.13	-27%	-4%	10%	11%
1.A.1.b	Petroleum refining	0.15	0.14	-3%	1%	8%	12%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-39%	30%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	0.31	0.25	-19%	2%	18%	21%
1.A.2.a	Iron and Steel	0.01	0.00	-49%	-4%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	-43%	-42%	<1%	<1%
1.A.2.c	Chemicals	0.03	0.02	-44%	23%	2%	1%
1.A.2.d	Pulp, Paper and Print	0.15	0.15	1%	5%	9%	13%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.00	-63%	-10%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.10	0.02	-76%	5%	6%	2%
1.A 2.g	Manufacturing Industries and Constr. - other	0.02	0.05	143%	-9%	1%	5%
1.A.3	Transport	0.02	0.03	79%	1%	1%	3%
1.A.3.a	Civil Aviation	0.00	0.00	205%	12%	<1%	<1%
1.A.3.b	Road Transportation	0.02	0.03	83%	1%	1%	2%
1.A.3.c	Railways	0.00	0.00	-88%	-1%	<1%	<1%
1.A.3.d	Navigation	0.00	0.00	74%	13%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	141%	-8%	<1%	<1%
1.A.4	Other Sectors	0.40	0.30	-25%	1%	23%	26%
1.A.4.a	Commercial/Institutional	0.06	0.02	-57%	10%	3%	2%
1.A.4.b	Residential	0.31	0.23	-26%	2%	18%	20%
1.A.4.c	Agriculture/Forestry/Fisheries	0.03	0.04	40%	-7%	2%	4%
1.A.5	Other	0.00	0.00	47%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	0.63	0.31	-52%	7%	36%	26%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.00	0.00	-27%	37%	<1%	<1%
2.C	METAL PRODUCTION	0.54	0.23	-57%	9%	31%	20%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.00	0.00	<1%	<1%	<1%	<1%
2.G	Other product manufacture and use	0.09	0.07	-22%	<1%	5%	6%
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	0.00	-87%	-6%	<1%	<1%
5	WASTE	0.06	0.00	-97%	-1%	3%	<1%
	Total without sinks	**1.76**	**1.16**	**-34%**	**2%**		

2.3.2 Mercury (Hg) Emissions

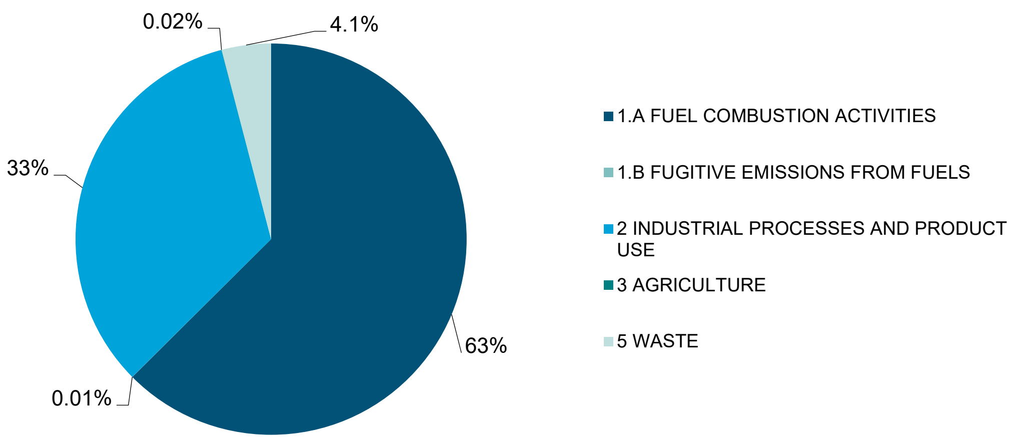
Mercury (Hg) has been ubiquitously distributed in the natural environment for millions of years. It occurs in the earth's crust with a content estimated to be about $4 \cdot 10^{-5}$%. Because of its special properties, mercury has had a number of uses for a long time: the conventional application is 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 24 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 2019 of 63% and 33%, respectively.

NFR sectors *3 Agriculture, 1.B Fugitive Emissions from fuels* and *5 Waste* are only minor Hg sources. These sectors contribute to national total Hg emissions with 0.02% (*Agriculture*), 0.01% (*1.B*) and 4.1% (*Waste*), respectively.

Share of NFR sectors 2019 – Hg emissions



Source: Umweltbundesamt

Figure 24: Share of NFR sectors 2019 in Hg emissions.

In 1990 national total Hg emissions amounted to 2.2 t; since then emissions have decreased. In the year 2019 national total Hg emissions were 54% below the level of 1990 (see Table 56). Between 2018 and 2019 emissions increased by 2.7% because of larger emissions from NFR *2.C.1 Iron and Steel Production.*

The overall reduction of about 54% for the period 1990 to 2019 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 sub-sectors and in the agriculture sector led to the sharp fall of total Hg emission in Austria by the year 2000.

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

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 could be 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.

2 Industrial Processes and Product Use

- *NFR 2.C Metal Production:* Emissions from iron and steel production are the main source within this source category and increased by about 25% since 1990 due to increased activities, which were partly compensated by implemented extensive abatement measures.
- *NFR 2.B Chemical Industry:* Hg emissions from this source were remarkable in 1990 but decreased steadily to a share of less than 0.01% in 2019. It covers processes in inorganic chemical industries reported under NFR *2.B.10 Other*. The decrease is a result of abatement measures but also due to production process substitution and product substitution. Furthermore, in 1999, the process of chlorine production was changed from mercury cell to membrane cell.

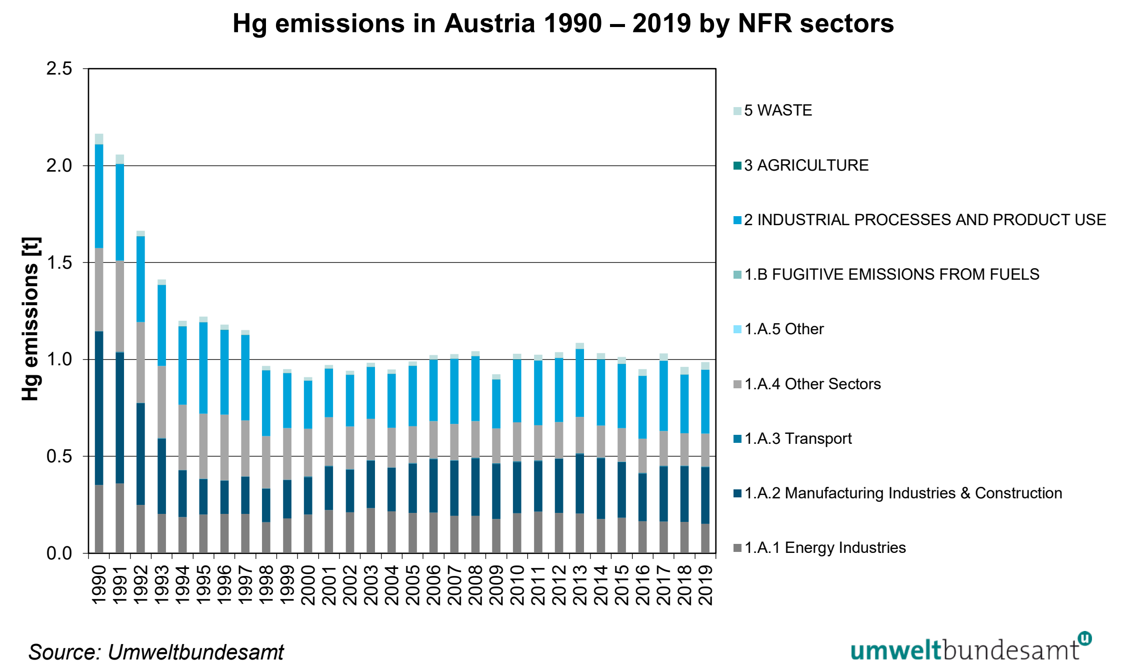


Figure 25: Hg emissions in Austria 1990–2019 by sectors in absolute terms.

Table 56: Hg emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		**Hg Emission in [t]**		**Trend**		**Share in National Total**	
		1990	**2019**	**1990–2019**	**2018–2019**	**1990**	**2019**
1	ENERGY	1.57	0.62	-61%	<1%	73%	63%
1.A	FUEL COMBUSTION ACTIVITIES	1.57	0.62	-61%	<1%	73%	63%
1.A.1	Energy Industries	0.35	0.15	-57%	-6%	16%	15%
1.A.1.a	Public Electricity and Heat Production	0.34	0.14	-60%	-6%	16%	14%
1.A.1.b	Petroleum refining	0.01	0.02	129%	-9%	<1%	2%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-39%	30%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	0.79	0.29	-63%	2%	37%	30%
1.A.2.a	Iron and Steel	0.00	0.00	-39%	-1%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	-33%	27%	<1%	<1%
1.A.2.c	Chemicals	0.01	0.01	-18%	5%	1%	1%
1.A.2.d	Pulp, Paper and Print	0.07	0.09	27%	3%	3%	9%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.00	-39%	-10%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.70	0.17	-76%	2%	32%	17%
1.A.2.g	Manufacturing Industries and Constr. - other	0.01	0.02	172%	-10%	<1%	2%
1.A.3	Transport	0.00	0.00	35%	-2%	<1%	<1%
1.A.3.a	Civil Aviation	0.00	0.00	205%	12%	<1%	<1%
1.A.3.b	Road Transportation	0.00	0.00	78%	<1%	<1%	<1%
1.A.3.c	Railways	0.00	0.00	-92%	-2%	<1%	<1%
1.A.3.d	Navigation	0.00	0.00	74%	13%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	141%	-8%	<1%	<1%
1.A.4	Other Sectors	0.43	0.17	-60%	2%	20%	17%
1.A.4.a	Commercial/Institutional	0.02	0.01	-62%	9%	1%	1%
1.A.4.b	Residential	0.39	0.15	-62%	2%	18%	15%
1.A.4.c	Agriculture/Forestry/Fisheries	0.01	0.01	-9%	-7%	1%	1%
1.A.5	Other	0.00	0.00	47%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	0.00	NA	-17%	NA	<1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	0.53	0.33	-38%	9%	25%	33%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.27	0.00	-100%	37%	12%	<1%
2.C	METAL PRODUCTION	0.26	0.33	25%	9%	12%	33%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NA	NA	NA	NA	NA	NA
2.G	Other product manufacture and use	0.00	0.00	3%	51%	<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	0.00	-85%	-4%	<1%	<1%
5	WASTE	0.05	0.04	-27%	2%	3%	4%
	Total without sinks	**2.16**	**0.99**	**-54%**	**3%**		

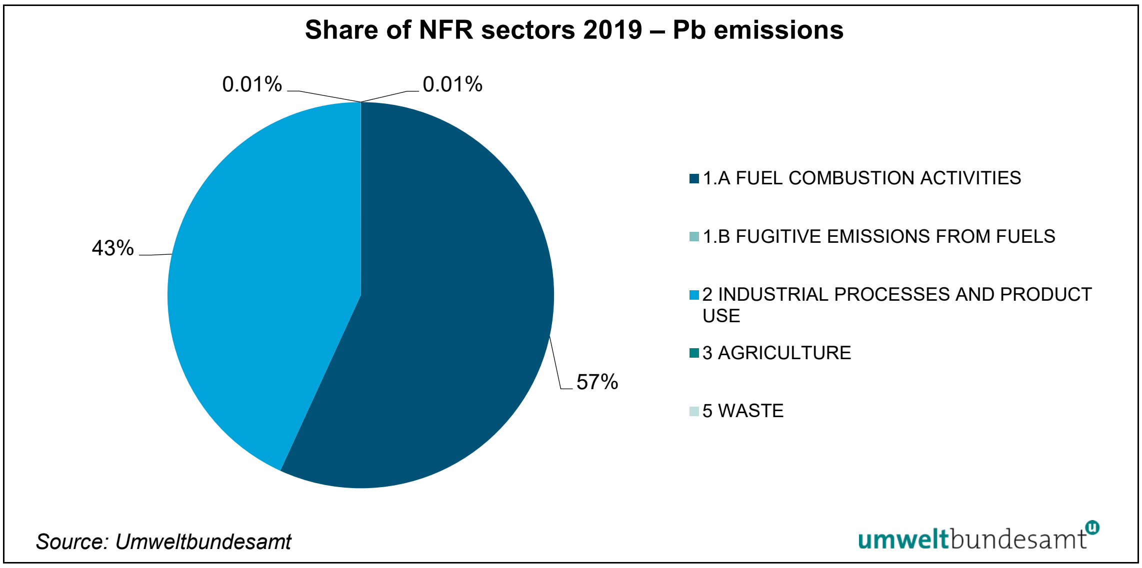
2.3.3 Lead (Pb) Emissions

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 two decades. Today, industrial processes, primarily metals processing, are the major sources of lead emissions. The highest air concentrations of lead are usually found in the vicinity of smelters and battery manufacturers. 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 26 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 57% and 43%, respectively.

Pb emissions resulting from NFR sectors *3 Agriculture* and *5 Waste* are minor sources. These sectors contribute to national total Pb emissions with about 0.01% each.



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

Figure 26: Share of NFR sectors 2019 in Pb emissions.

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 2019 emissions were 91% lower than in 1990 and amounted to 20 t. Compared to the previous year Pb emissions show an increase of 5.9% mainly as a result of increased emissions from *Iron and Steel Production (NFR 2.C.1)* and *Other product manufacture and use (NFR 2.G).*

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.
- *NFR 1.A.4 Other Sectors*: Between 1990 and 2019 emissions decreased due to a decreased use of coal and a reduced content of Pb in the heating oil.
- *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%.

2 Industrial Processes and Product Use

- *NFR 2.C Metal Production*: Emissions from this sub sector decreased significantly between 1990 and 2019 (-79%) due to extensive abatement measures but also due to production process substitution and product substitution.

In addition to emission reduction in the energy sector the sector industrial processes reduced its emissions remarkably due to improved dust abatement technologies.

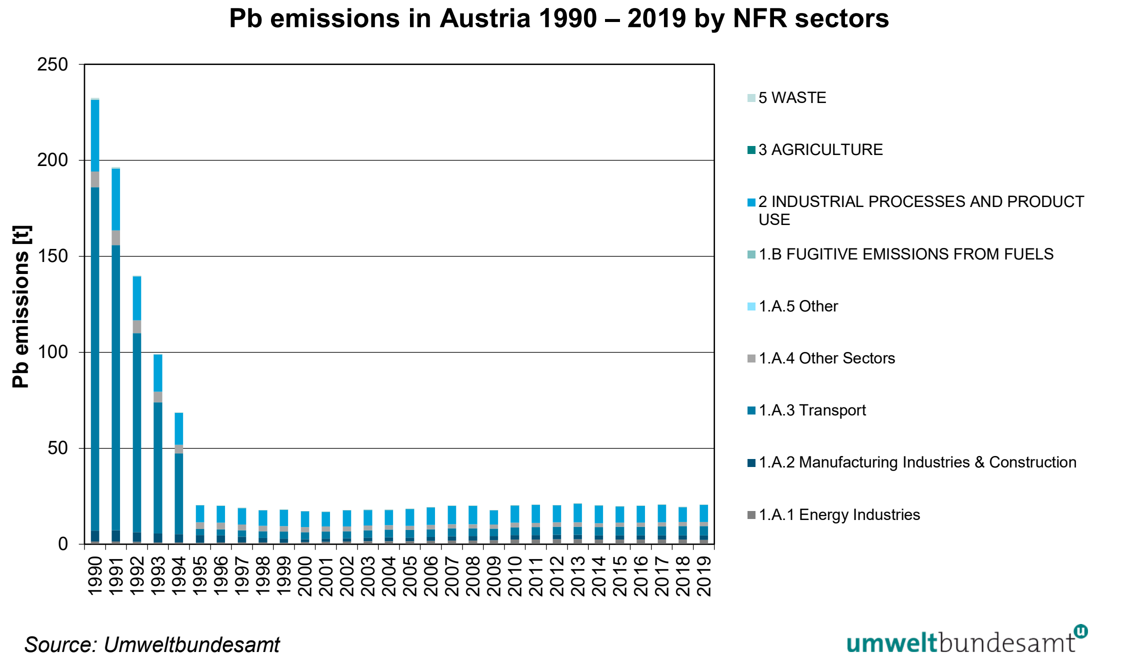


Figure 27: Pb emissions in Austria 1990–2019 by sectors in absolute terms.

Table 57: Pb emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		Pb Emission in [t]		Trend		Share in National Total	
		1990	2019	1990–2019	2018–2019	1990	2019
1	ENERGY	194.10	11.61	-94%	1%	83%	57%
1.A	FUEL COMBUSTION ACTIVITIES	194.10	11.61	-94%	1%	83%	57%
1.A.1	Energy Industries	1.45	2.29	58%	-5%	1%	11%
1.A.1.a	Public Electricity and Heat Production	1.27	1.89	48%	-4%	1%	9%
1.A.1.b	Petroleum refining	0.18	0.40	129%	-9%	<1%	2%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-39%	30%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	5.59	2.31	-59%	4%	2%	11%
1.A.2.a	Iron and Steel	0.26	0.15	-44%	-3%	<1%	1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	8%	-3%	<1%	<1%
1.A.2.c	Chemicals	0.21	0.34	63%	26%	<1%	2%
1.A.2.d	Pulp, Paper and Print	0.65	1.01	56%	3%	<1%	5%
1.A.2.e	Food Processing, Beverages and Tobacco	0.01	0.01	45%	-12%	<1%	<1%
1.A.2.f	Non-metallic Minerals	4.27	0.32	-92%	7%	2%	2%
1.A.2.g	Manufacturing Industries and Constr. - other	0.20	0.48	143%	-4%	<1%	2%
1.A.3	Transport	178.94	4.88	-97%	2%	77%	24%
1.A.3.a	Civil Aviation	1.64	0.00	-100%	32%	1%	<1%
1.A.3.b	Road Transportation	177.04	4.88	-97%	1%	76%	24%
1.A.3.c	Railways	0.01	0.00	-93%	-2%	<1%	<1%
1.A.3.d	Navigation	0.26	0.00	-100%	10%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	141%	-8%	<1%	<1%
1.A.4	Other Sectors	8.12	2.13	-74%	2%	3%	10%
1.A.4.a	Commercial/Institutional	0.36	0.18	-50%	10%	<1%	1%
1.A.4.b	Residential	6.77	1.81	-73%	2%	3%	9%
1.A.4.c	Agriculture/Forestry/Fisheries	0.99	0.14	-86%	-7%	<1%	1%
1.A.5	Other	0.00	0.00	47%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	37.41	8.81	-76%	13%	16%	43%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.00	0.00	-27%	37%	<1%	<1%
2.C	METAL PRODUCTION	36.17	7.54	-79%	9%	16%	37%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.02	0.02	<1%	<1%	<1%	<1%
2.G	Other product manufacture and use	1.22	1.25	3%	51%	1%	6%
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	0.00	-35%	<1%	<1%	<1%
5	WASTE	1.02	0.00	-100%	-1%	<1%	<1%
	Total without sinks	**232.54**	**20.42**	**-91%**	**6%**		

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[72]. PCB emissions are reported from submission 2016 onwards.

Emissions of all POPs decreased remarkably from 1990 to 2019 (HCB -79%, PAH -66%, PCDD/F -73% and PCBs -26%), where the highest achievement was made until 1995. 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 2019 PCDD/F emissions increased by 0.3% compared to the previous year 2018, PAH emissions increased by 0.8% and HCB emissions by 7.6% in the same time. This increase of HCB emissions was mainly due to higher emissions from sectors *3.D.f Use of pesticides* and 2.*C.1 Iron and Steel Production*. PAH emissions and PCDD/F emissions rose because of higher emissions from sectors *2 Industrial Processes* and *1.A.4 Other Sectors (only PAH).*

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 2019 PCB emissions increased by 8.5% compared to the previous year 2018, due to increased emissions from *sector 2.C.1 Iron and Steel Production*.

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

Table 58: Emissions and emission trends for POPs 1990–2019.

Year	Emission			
	PAH [t]	PCDD/F [g]	HCB [kg]	PCB [kg]
1990	19.13	125.24	82.95	47.23
1991	19.87	124.91	80.52	35.89
1992	14.68	76.66	67.93	28.87
1993	11.84	66.76	60.08	29.16
1994	10.63	56.48	45.46	26.91
1995	10.86	57.79	42.48	29.16
1996	11.36	58.03	39.23	26.37
1997	10.18	58.31	35.70	29.95
1998	9.52	55.08	30.23	30.20
1999	9.24	51.79	26.21	28.76
2000	8.52	50.55	20.18	30.18
2001	8.61	50.80	20.26	30.64
2002	7.74	37.77	18.57	31.46
2003	7.34	37.02	18.11	31.71

[72] 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]**
2004	7.02	36.12	17.50	32.54
2005	7.11	35.75	16.69	34.93
2006	7.33	37.00	16.73	35.24
2007	7.29	36.72	16.44	36.48
2008	7.27	36.40	16.52	36.40
2009	7.14	36.25	15.53	27.54
2010	7.87	40.93	18.54	34.55
2011	7.19	38.09	17.08	35.30
2012	7.42	38.92	41.40	34.83
2013	7.57	39.34	120.08	37.20
2014	6.73	36.38	124.11	36.69
2015	6.80	36.86	15.94	35.74
2016	7.02	36.61	16.58	34.77
2017	7.03	37.15	18.16	38.26
2018	6.42	33.55	16.00	32.09
2019	6.48	33.66	17.22	34.81
Trend 1990–2019	**-66%**	**-73%**	**-79%**	**-26%**

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.

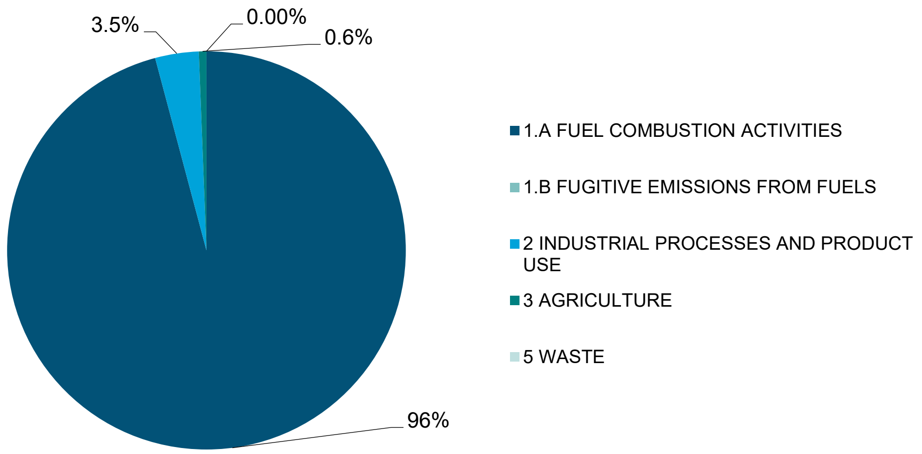
In response to a recommendation of the NEC Review 2020 (EC 2020) Austria reports benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene emissions for all sectors across all years in the current submission 2021 for the first time.

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 *Industrial Processes and Product Use* (37%). In 2019 emissions are almost exclusively emitted by source category *1.A Fuel Combustion* Activities with 96% of national total PAH emissions as it is illustrated in Figure 28 and Table 59 NFR sector *Industrial Processes and Product Use* contributes in 2019 with 3.5% of national total emissions.

From 1990 to 2019 PAH emissions from Agriculture decreased remarkably by 51% due to prohibition of open field burning. In 2019 NFR sectors *3 Agriculture* (0.6%) and *5 Waste* (<0.1%) are minor sources.

Share of NFR sectors 2019 – total PAH emissions



Source: Umweltbundesamt

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

Figure 28: Share of NFR sectors 2019 in PAH emissions.

In 1990 national total PAH emissions amounted to 19.1 t; emissions have decreased since then, where the main achievement was made until 1993, by the year 2019 emissions were reduced by about 66% (to 6.5 t in 2019).

1.A Fuel Combustion Activities

In 2019 PAH emissions are largely emitted by *1.A Fuel Combustion Activities* with a share of 96% 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*.

- *1.A.4.b Residential (stationary):* Emissions have decreased since 1990 by 55% because of a decreased use of coal and an increased share of efficient biomass boilers with lower specific emissions. Compared to the previous year 2018 emissions increased by 0.5% because of higher emissions from residential heating, due to increased heating demand of households (heating degree days increased by 1.4%).
- *1.A.4.c Agriculture/Forestry/Fisheries (stationary):* Compared to 1990 emissions have increased by 22% as a result of a higher biomass consumption. Between 2018 and 2019 emissions increased by 1.3%, that was also due to larger biomass usage.
- *1.A.3 Transport:* Emissions have increased by 20% 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.

2 Industrial Processes and Product Use

PAH emissions from the sector *Industrial processes and Product Use* decreased by 97% since 1990 due to the shutdown of primary aluminium production in Austria, which was a main source for PAH emissions.

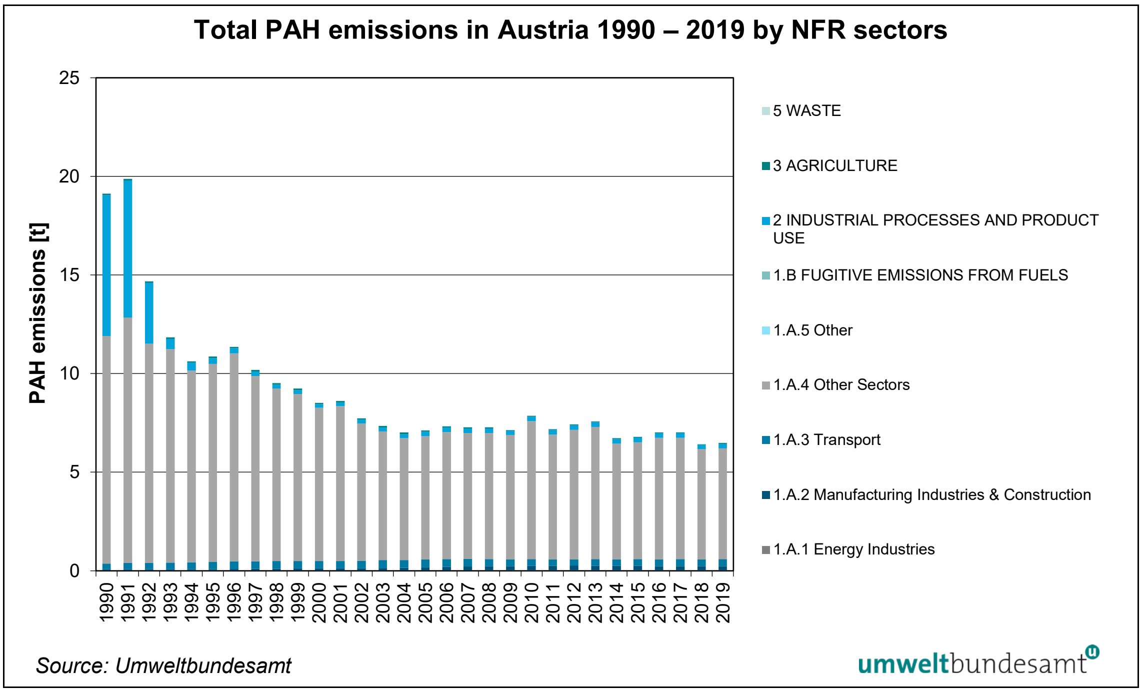


Figure 29: Total PAH emissions in Austria 1990–2019 by sectors in absolute terms.

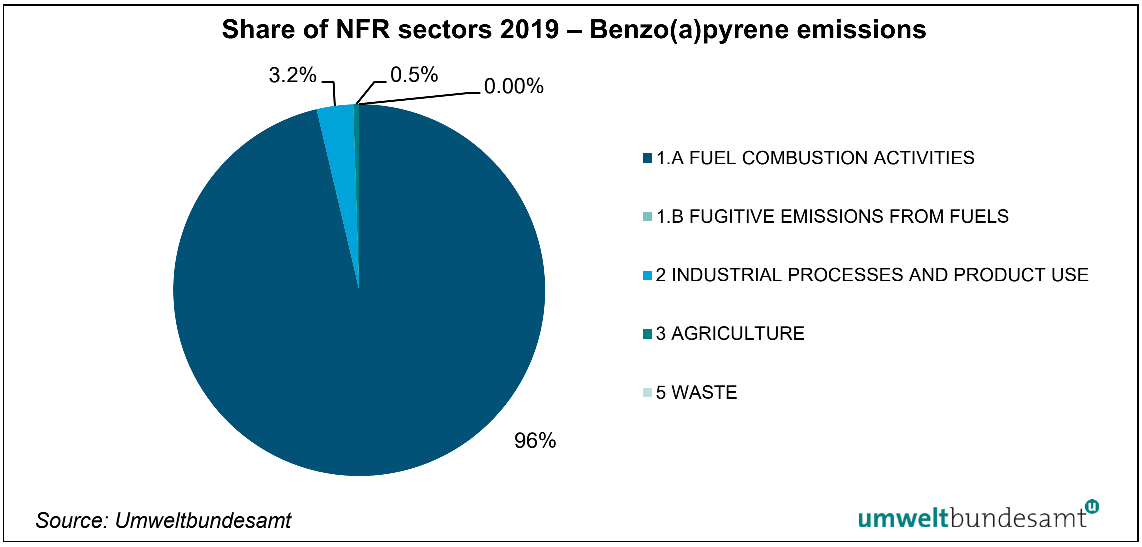
Table 59: Total PAH emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		PAH Emission in [t]		Trend		Share in National Total	
		1990	2019	1990–2019	2018–2019	1990	2019
1	ENERGY	11.91	6.21	-48%	1%	62%	96%
1.A	FUEL COMBUSTION ACTIVITIES	11.91	6.21	-48%	1%	62%	96%
1.A.1	Energy Industries	0.01	0.03	393%	-4%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	0.06	0.21	231%	1%	<1%	3%
1.A.2.a	Iron and Steel	0.00	0.00	-37%	-4%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	-40%	-6%	<1%	<1%
1.A.2.c	Chemicals	0.02	0.02	34%	14%	<1%	<1%
1.A.2.d	Pulp, Paper and Print	0.00	0.00	29%	4%	<1%	<1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.00	-25%	-11%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.00	0.01	116%	-3%	<1%	<1%
1.A.2.g	Manufacturing Industries and Constr. - other	0.04	0.18	373%	-1%	<1%	3%
1.A.3	Transport	0.29	0.35	20%	<1%	2%	5%
1.A.3.a	Civil Aviation	NE	NE	NE	NE	NE	NE
1.A.3.b	Road Transportation	0.26	0.33	24%	<1%	1%	5%
1.A.3.c	Railways	0.02	0.01	-58%	1%	<1%	<1%
1.A.3.d	Navigation	0.01	0.01	82%	13%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	141%	-8%	<1%	<1%
1.A.4	Other Sectors	11.55	5.62	-51%	1%	60%	87%
1.A.4.a	Commercial/Institutional	0.32	0.09	-73%	6%	2%	1%
1.A.4.b	Residential	10.66	4.85	-55%	<1%	56%	75%
1.A.4.c	Agriculture/Forestry/Fisheries	0.56	0.69	22%	1%	3%	11%
1.A.5	Other	0.00	0.00	-7%	<1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	7.14	0.23	-97%	7%	37%	4%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	NE	NE	NE	NE	NE	NE
2.C	METAL PRODUCTION	6.44	0.19	-97%	9%	34%	3%
2.C.1	Iron and Steel Production	0.35	0.19	-46%	9%	2%	3%
2.C.2	Ferroalloys Production	NE	NE	NE	NE	NE	NE
2.C.3	Aluminium production	6.09	NE	NE	NE	32%	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	NE	NE	NE	NE	NE	NE
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.15	NA	NA	NA	1%	NA
2.G	Other product manufacture and use	0.00	0.00	-23%	-1%	<1%	<1%
2.H	Other Processes	0.55	0.04	-93%	<1%	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	0.08	0.04	-51%	<1%	<1%	1%
5	WASTE	0.00	0.00	-92%	2%	<1%	<1%
	Total without sinks	**19.13**	**6.48**	**-66%**	**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* (63%) and 2 *Industrial Processes and Product Use* (36%). In 2019 emissions are almost exclusively emitted by source category *1.A Fuel Combustion* Activities with 96% of national total Benzo(a)pyrene emissions as illustrated in Figure 30. NFR sector 2 *Industrial Processes and Product Use* contributes with 3.2% of national total emissions in 2019.

From 1990 to 2019 Benzo(a)pyrene emissions from Agriculture decreased remarkably by 45% due to prohibition of open field burning. In 2019 NFR sectors *3 Agriculture* (0.5%) and *5 Waste* (<0.1%) are minor sources.



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

Figure 30: Share of NFR sectors 2019 in Benzo(a)pyrene emissions.

In 1990 national total Benzo(a)pyrene emissions amounted to 6.3 t; emissions have decreased between 1990 and 2019 by about 68% (to 2.0 t in 2019). The greatest reductions were made until 1993.

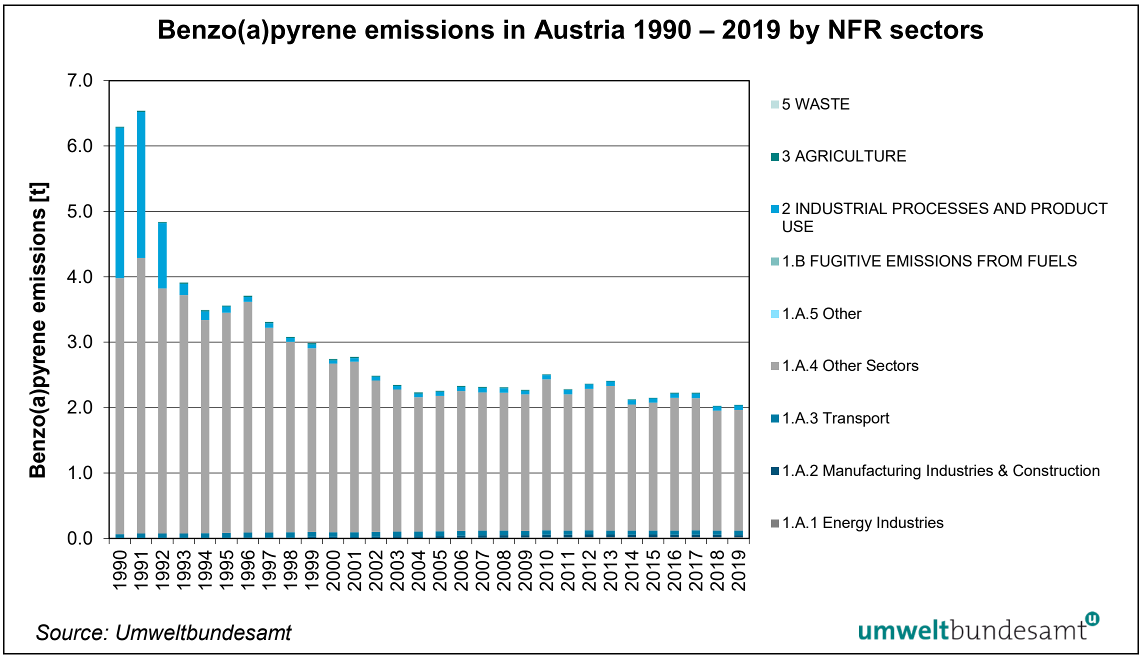
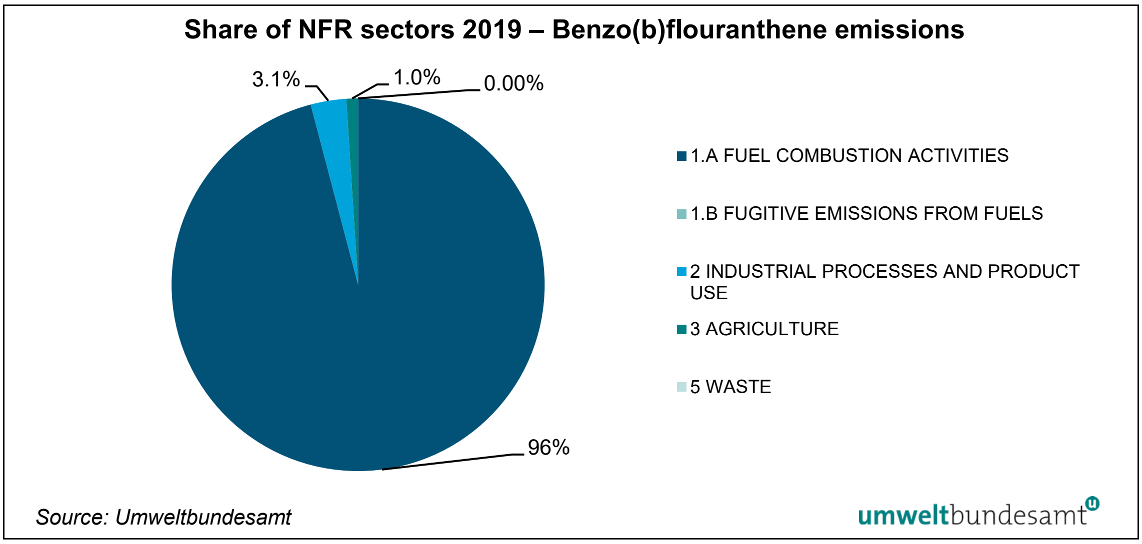


Figure 31: Benzo(a)pyrene emissions in Austria 1990–2019 by sectors in absolute terms.

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 2019 emissions are arising almost solely from source category *1.A Fuel Combustion Activities* with 96% of national total Benzo(b)floranthene emissions as it is indicated in Figure 32. NFR sector *2 Industrial Processes and Product Use* contributes with 3.1% of national total emissions in 2019.

From 1990 to 2019 Benzo(b)floranthene emissions from Agriculture decreased remarkably by 50% due to prohibition of open field burning. In 2019 NFR sectors 3 Agriculture (1.0 %) and 5 Waste (<0.1%) are minor sources.



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

Figure 32: Share of NFR sectors 2019 in Benzo(b)flouranthene emissions.

In 1990 national total Benzo(b)flouranthene emissions amounted to 6.4 t; emissions have decreased between 1990 and 2019 by about 64% (to 2.3 t in 2019), where the largest reductions were made until 1993.

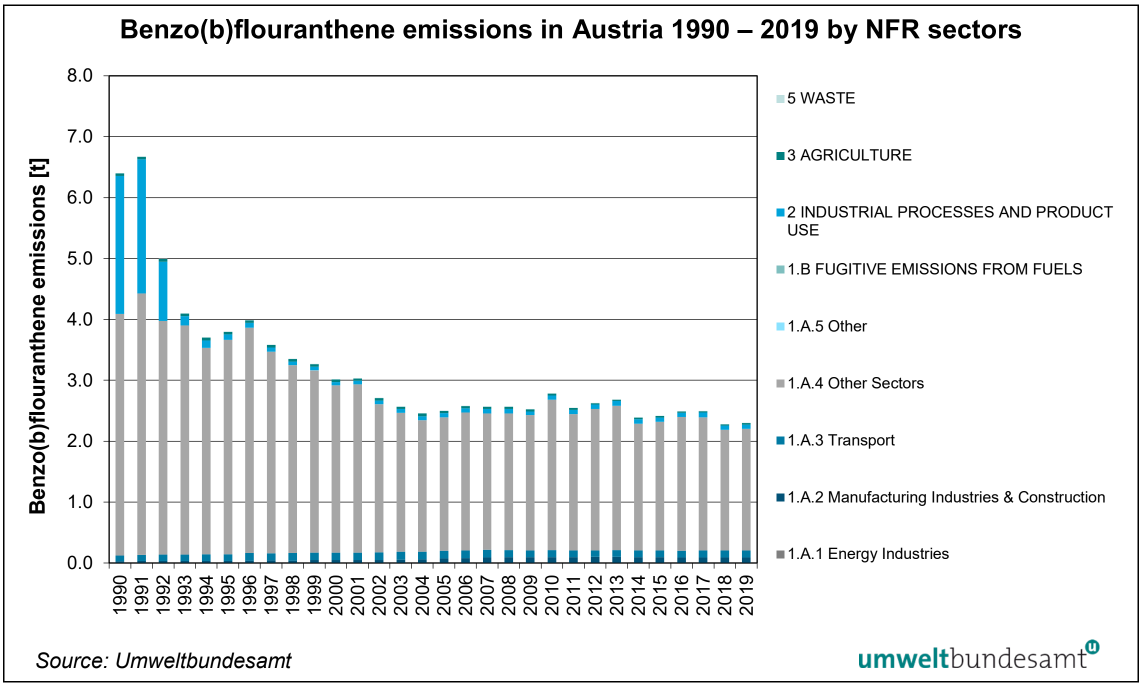
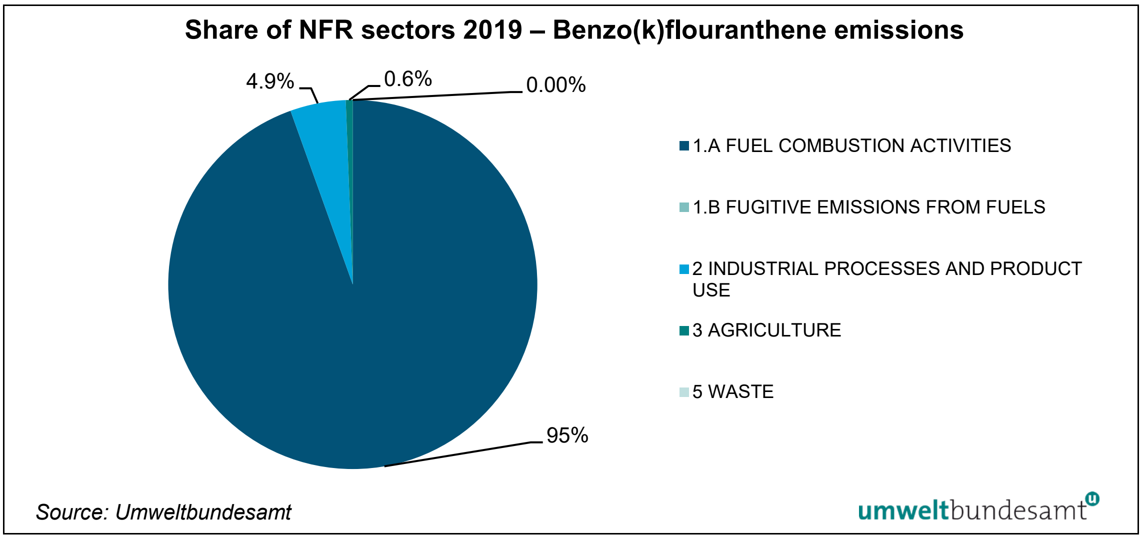


Figure 33: Benzo(b)flouranthene emissions in Austria 1990–2019 by sectors in absolute terms.

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* (43%) and *2 Industrial Processes and Product Use* (57%). In 2019 emissions are stemming almost exclusively from source category *1.A Fuel Combustion Activities* with 95% of national total Benzo(k)floranthene emissions (please refer to Figure 34). NFR sector *2 Industrial Processes and Product Use* contributes in 2019 with 4.9% of national total emissions.

Benzo(k)floranthene emissions from Agriculture decreased remarkably by 55% between 1990 and 2019 as a result of the prohibition of open field burning. In 2019 NFR sectors 3 Agriculture (0.6%) and 5 Waste (<0.1%) are minor sources.



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

Figure 34: Share of NFR sectors 2019 in Benzo(k)flouranthene emissions.

In 1990 national total Benzo(k)flouranthene emissions amounted to 3.7 t; emissions have decreased between 1990 and 2019 by about 75% (to 1.0 t in 2019). The largest reductions took place until 1993.

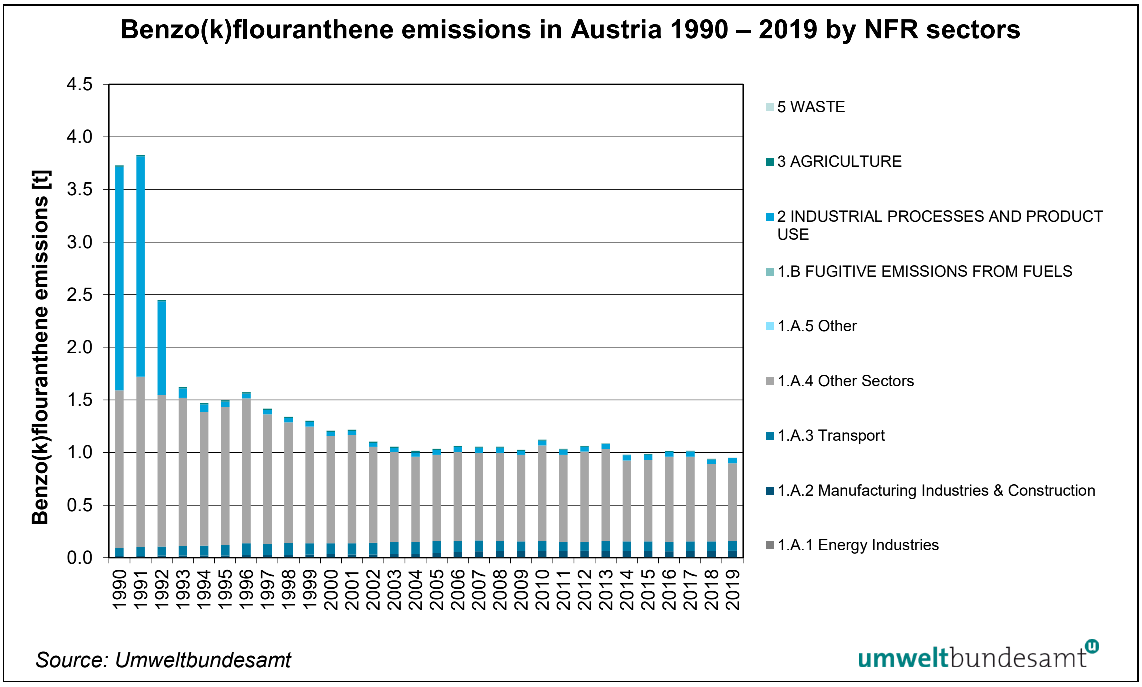


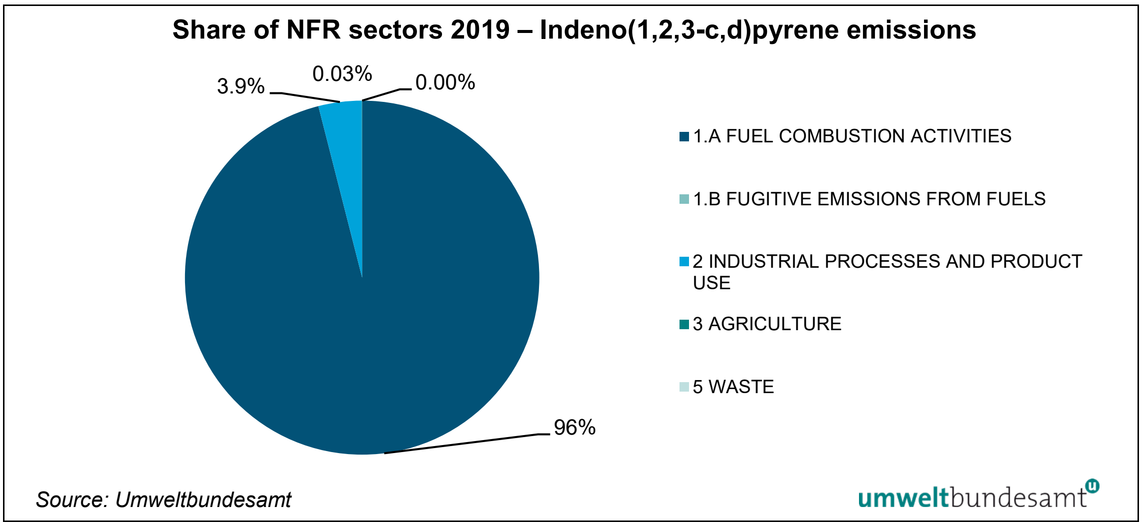
Figure 35: Benzo(k)flouranthene emissions in Austria 1990–2019 by sectors in absolute terms.

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* (17%). In 2019 emissions are almost exclusively emitted from source category *1.A Fuel Combustion Activities* with 96% of national total Indeno (1,2,3-cd) pyrene emissions as indicated in Figure 36.

NFR sector *2 Industrial Processes and Product Use* contributes in 2019 with 3.9% of national total emissions.

Due to prohibition of open field burning Indeno (1,2,3-cd) pyrene emissions from Agriculture fell remarkably by 91% between 1990 and 2019. In 2019 NFR sectors *3 Agriculture* (0.03%) and *5 Waste* (<0.1%) are minor sources.



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

Figure 36: Share of NFR sectors 2019 in Indeno (1,2,3-cd) pyrene emissions.

In 1990 national total Indeno (1,2,3-cd) pyrene emissions amounted to 2.7 t; emissions have decreased between 1990 and 2019 by about 56% (to 1.2 t in 2019). The largest reductions could be achieved until 1993.

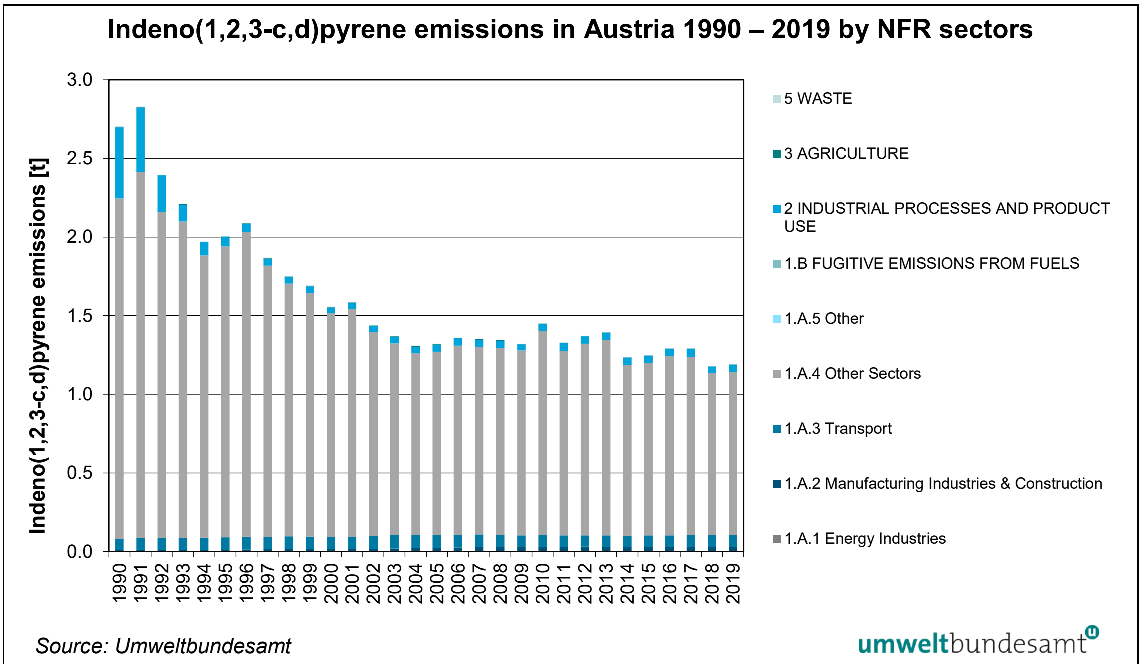


Figure 37: Indeno (1,2,3-cd) pyrene emissions in Austria 1990–2019 by sectors in absolute terms.

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.

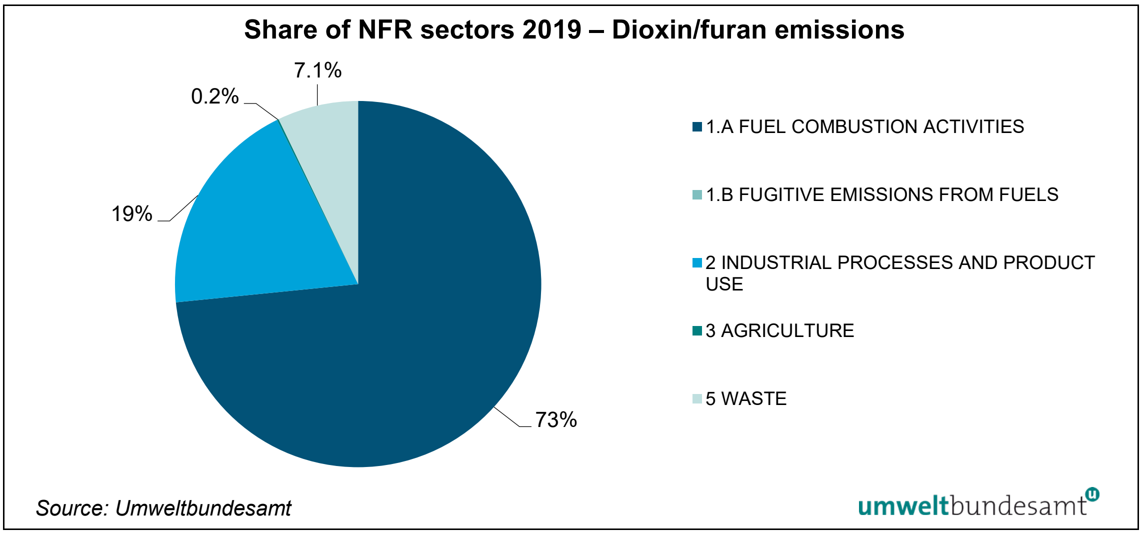
Dioxins are formed as a result of combustion processes such as commercial or municipal waste incineration and from burning fuels like wood, coal or oil as a main source of dioxins. Dioxins can also be formed when household trash is burned and as a result of natural processes such as forest fires. Dioxins 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 73% in 2019, is category *1.A Fuel Combustion Activities* (see Figure 38 and Table 60). Sector *2 Industrial Processes and Product Use* contributes with 19% in national total emissions.

In 2019 PCDD/F emissions from sectors *3 Agriculture* has a share of only 0.2% in national total emissions (*3.F Field burning of agricultural residues* is the only source). NFR sector *5 Waste* contributes with 7.1% to national total emissions (mainly due to *5.E Other Waste* comprising unwanted fires in cars and various types of houses).



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

Figure 38: Share of NFR sectors 2019 in Dioxin/furan emissions.

In 1990 national total dioxin/furan (PCDD/F) emissions amounted to about 125 g; emissions have decreased since then, where the main achievement was made until 1993, by the year 2019 emissions were reduced by about 73% (to 34 g in 2019).

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 (55%) to national total dioxin/furan (PCDD/F) emissions in 2019 within source *1.A Fuel Combustion Activities* due to biomass heating.
- *NFR 1.A.2 Manufacturing Industries and Construction:* Emissions increased significantly since 1990 and contribute with 10% to national dioxin/furan (PCDD/F) emissions in 2019.

2 Industrial Processes and Product Use

The second largest source is sector *2 Industrial Processes and Product Use* (19% in national total emissions in 2019).

- *NFR 2.C Metal Production:* Dioxin/furan (PCDD/F) emissions decreased remarkably due to extensive abatement measures since 1990 (-84%). 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).

5 Waste

- *5 Waste:* From 1990 to 2019 dioxin/furan (PCDD/F) emissions from sector *Waste* decreased by 88% due to stringent legislation and modern technology. As shown in Table 60 in the period from 1990 to 2019 dioxin/furan emissions decreased to 2.41 g, which is a share of 7.1% in total dioxin/furan emissions, whereas in 1990 dioxin/furan (PCDD/F) emissions contributed 16% to the total dioxin/furan emissions. Within sector *Waste* the main emission source is *5.E Other Waste* comprising emissions from unintentional fires, which is rated as a key source for dioxin/furan (PCDD/F) emissions in 2019.

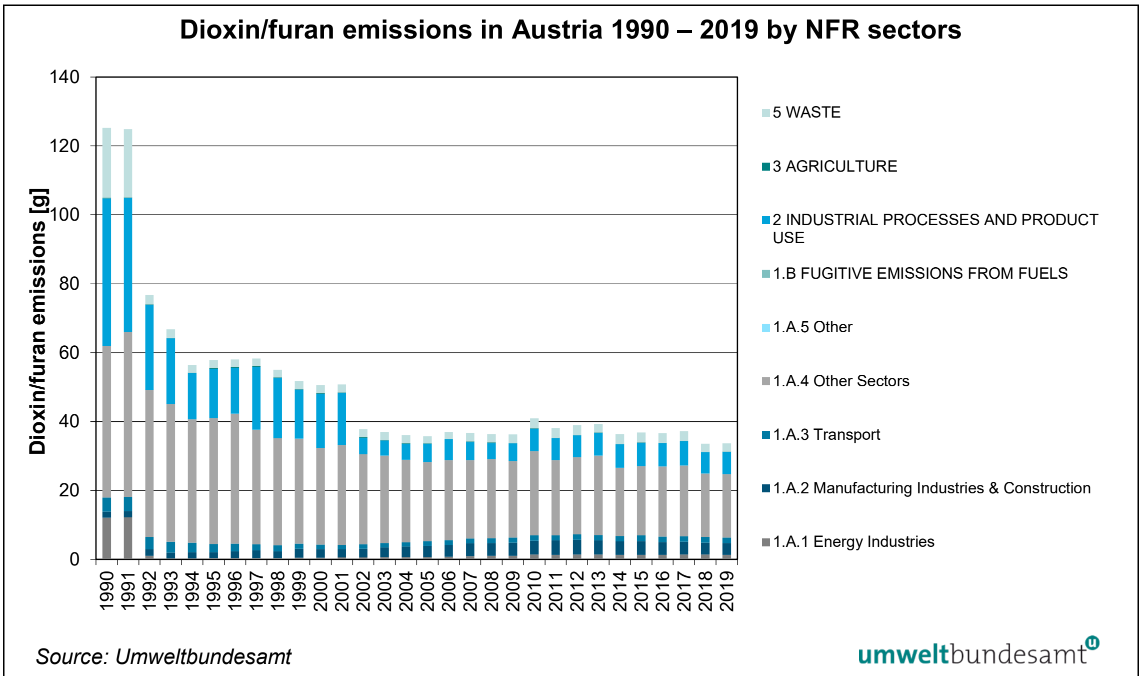


Figure 39: Dioxin/Furan emissions in Austria 1990–2019 by sectors in absolute terms.

Table 60: Dioxin/Furan (PCDD/F) emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		**Dioxin Emission in [g]**		**Trend**		**Share in National Total**	
		1990	**2019**	**1990–2019**	**2018–2019**	**1990**	**2019**
1	ENERGY	61.92	24.71	-60%	-1%	49%	73%
1.A	FUEL COMBUSTION ACTIVITIES	61.92	24.71	-60%	-1%	49%	73%
1.A.1	Energy Industries	12.14	1.35	-89%	-2%	10%	4%
1.A.2	Manufacturing Industries and Construction	1.68	3.41	103%	-2%	1%	10%
1.A.2.a	Iron and Steel	0.03	0.02	-26%	-2%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.02	0.04	77%	-2%	<1%	<1%
1.A.2.c	Chemicals	0.44	0.60	37%	15%	<1%	2%
1.A.2.d	Pulp, Paper and Print	0.50	0.64	29%	4%	<1%	2%
1.A.2.e	Food Processing, Beverages and Tobacco	0.03	0.04	38%	-8%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.29	0.47	60%	-1%	<1%	1%
1.A.2.g	Manufacturing Industries and Constr. - other	0.37	1.61	335%	-10%	<1%	5%
1.A.3	Transport	4.15	1.57	-62%	-1%	3%	5%
1.A.3.a	Civil Aviation	NE	NE	NE	NE	NE	NE
1.A.3.b	Road Transportation	4.10	1.54	-62%	-2%	3%	5%
1.A.3.c	Railways	0.04	0.01	-71%	-1%	<1%	<1%
1.A.3.d	Navigation	0.01	0.02	51%	8%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	141%	-8%	<1%	<1%
1.A.4	Other Sectors	43.95	18.37	-58%	-1%	35%	55%
1.A.4.a	Commercial/Institutional	1.73	0.70	-60%	7%	1%	2%
1.A.4.b	Residential	40.70	16.28	-60%	-1%	32%	48%
1.A.4.c	Agriculture/Forestry/Fisheries	1.52	1.40	-8%	-4%	1%	4%
1.A.5	Other	0.00	0.00	28%	-1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	42.85	6.49	-85%	5%	34%	19%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	NA	NA	NA	NA	NA	NA
2.C	METAL PRODUCTION	40.00	6.36	-84%	5%	32%	19%
2.C.1	Iron and Steel Production	37.21	2.66	-93%	6%	30%	8%
2.C.2	Ferroalloys Production	NE	NE	NE	NE	NE	NE
2.C.3	Aluminium production	2.40	3.23	34%	5%	2%	10%
2.C.4	Magnesium production	NO	NO	NO	NO	NO	NO
2.C.5	Lead Production	0.07	0.07	4%	<1%	<1%	<1%
2.C.6	Zinc production	NO	NO	NO	NO	NO	NO
2.C.7	Other metal production	0.32	0.40	26%	<1%	<1%	1%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	1.06	NA	NA	NA	1%	NA
2.G	Other product manufacture and use	0.00	0.00	-23%	-1%	<1%	<1%
2.H	Other Processes	1.79	0.13	-93%	<1%	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	0.18	0.05	-72%	-5%	<1%	<1%
5	WASTE	20.29	2.41	-88%	1%	16%	7%
	Total without sinks	**125.24**	**33.66**	**-73%**	**<1%**		

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.

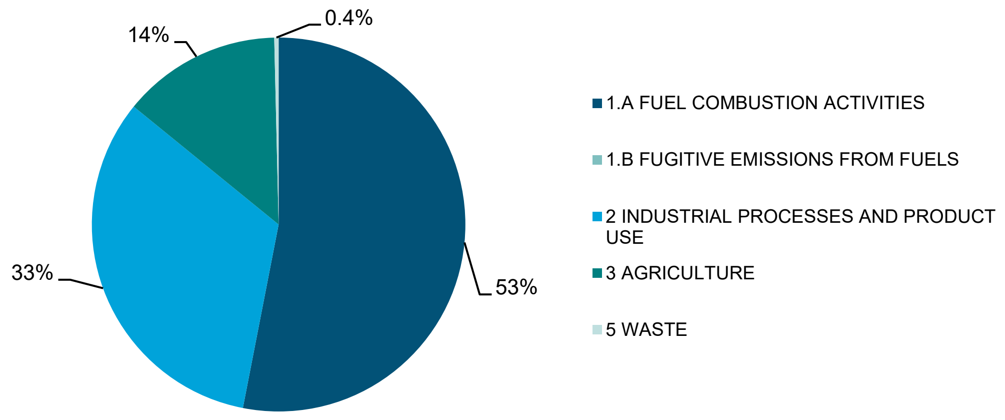
It is released to the environment as an unintentional by-product in chemical industry (production of several chlorinated hydrocarbons such as drugs, pesticides or solvents) and in metal industries and is formed in combustion processes in the presence of chlorine.

Main sources and emission trends in Austria

As can be seen in Figure 40 and Table 61 the main HCB emission source in 2019 is NFR sector *1.A Fuel Combustion Activities* with 53% in national total emissions. Sector *2 Industrial Processes and Product Use* has a share of 33% in national total emissions and sectors NFR *3 Agriculture* has a share of 14%.

From 1990 to 2019 HCB emissions from the sector NFR *5 Waste* decreased remarkably by 84%, respectively, due to stringent legislation and modern technology. This sector is a minor source of HCB emissions in 2019 with a share 0.4% in national total emissions.

Share of NFR sectors 2019 – HCB emissions



Source: Umweltbundesamt

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

Figure 40: Share of NFR sectors 2019 in HCB emissions.

Total emissions of HCB are decreasing over the period 1990–2019 by 79%. 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 2018 and 2019 HCB emissions increased by 7.6% mainly due to increased emissions from sectors *3.D.f Use of pesticides* and 2.*C.1 Iron and Steel Production*.

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 83% since 1990.

- *1.A.4 Other Sectors:* This subcategory had a share of 61% in 1990 and 45% in 2019 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 85%. Compared to the previous year a decrease of 0.3% can be observed 2019.

2 Industrial Processes and Product Use

The second largest source for HCB emissions in 2019 was sector *2 Industrial Processes and Product Use* (mainly Iron and Steel Production) with a share of 33% in national total emissions. HCB emissions of this sector decreased by 72% between 1990 and 2019. HCB was a by-product of chlorinated pesticides, which production was banned step-by-step in the beginning of the 1990s. Abatement measures in iron and steel industry were also a main reason for the reduction.

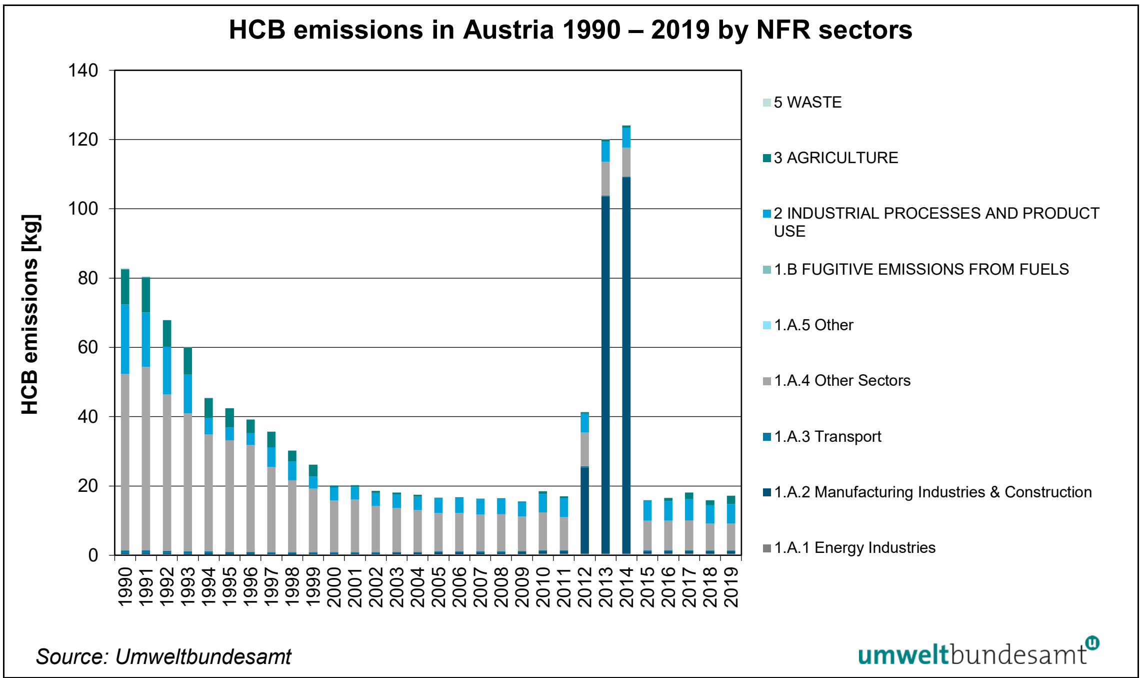


Figure 41: HCB emissions in Austria 1990–2019 by sectors in absolute terms.

Table 61: Hexachlorbenzene (HCB) emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		HCB Emission in [kg]		Trend		Share in National Total	
		1990	**2019**	**1990–2019**	**2018–2019**	**1990**	**2019**
1	ENERGY	52.33	9.14	-83%	<1%	63%	53%
1.A	FUEL COMBUSTION ACTIVITIES	52.33	9.14	-83%	<1%	63%	53%
1.A.1	Energy Industries	0.28	0.50	80%	<1%	<1%	3%
1.A.2	Manufacturing Industries and Construction	0.29	0.57	96%	-2%	<1%	3%
1.A.2.a	Iron and Steel	0.01	0.00	-32%	-2%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	-60%	-14%	<1%	<1%
1.A.2.c	Chemicals	0.07	0.09	40%	17%	<1%	1%
1.A.2.d	Pulp, Paper and Print	0.10	0.13	29%	4%	<1%	1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.01	49%	-8%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.06	0.08	43%	<1%	<1%	<1%
1.A.2.g	Manufacturing Industries and Constr. - other	0.06	0.26	361%	-9%	<1%	1%
1.A.3	Transport	0.83	0.31	-62%	-1%	1%	2%
1.A.3.a	Civil Aviation	NE	NE	NE	NE	NE	NE
1.A.3.b	Road Transportation	0.82	0.31	-62%	-2%	1%	2%
1.A.3.c	Railways	0.01	0.00	-71%	-1%	<1%	<1%
1.A.3.d	Navigation	0.00	0.00	51%	8%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	141%	-8%	<1%	<1%
1.A.4	Other Sectors	50.94	7.76	-85%	<1%	61%	45%
1.A.4.a	Commercial/Institutional	1.17	0.33	-72%	6%	1%	2%
1.A.4.b	Residential	48.87	6.90	-86%	<1%	59%	40%
1.A.4.c	Agriculture/Forestry/Fisheries	0.89	0.53	-41%	-5%	1%	3%
1.A.5	Other	0.00	0.00	28%	-1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	20.07	5.65	-72%	8%	24%	33%
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	5.62	-40%	8%	11%	33%
2.C.1	Iron and Steel Production	8.09	3.86	-52%	9%	10%	22%
2.C.2	Ferroalloys Production	NE	NE	NE	NE	NE	NE
2.C.3	Aluminium production	1.20	1.61	35%	5%	1%	9%
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	0.14	40%	<1%	<1%	1%
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	-93%	<1%	<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	10.15	2.37	-77%	56%	12%	14%
5	WASTE	0.39	0.06	-84%	2%	<1%	<1%
	Total without sinks	**82.95**	**17.22**	**-79%**	**8%**		

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)[73].

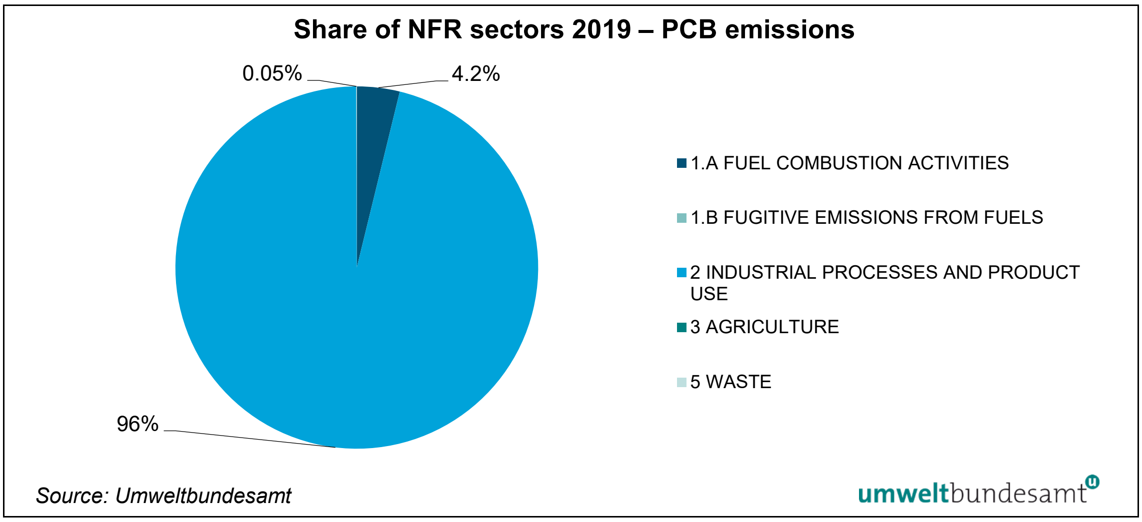
PCBs have entered the environment through both use and disposal. PCBs can be easily carried along from the place of contamination and are distributed in all global ecosystems (UMWELTBUNDESAMT 1996). Because of its substantial characteristics PCB is persistent. As it is also liposoluble it is easily accumulated 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[74] 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 almost exclusively emitted in NFR sector *2 Industrial Processes and Product Use* with a share of 96% in national total PCB emissions in 2019 (see Figure 42 and Table 62).

NFR 1.A Fuel Combustion Activities, both from stationary and mobile sources (*NFR 1.A.3 Transport*), is a minor source of PCB emissions with a share of 4.2% in total emissions in 2019. 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.



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

Figure 42: Share of NFR sectors 2019 in PCB emissions.

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

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

In 1990 national total PCB emissions amounted to about 47 kg; emissions have decreased by 26% and in 2019 emissions were at the level of 35 kg. The emission trend is largely influenced by metal production. Between 2018 and 2019 emissions increased by 8.5%, due to increased emissions from *sector 2.C.1 Iron and Steel Production*.

2 Industrial Processes and Product Use

Within the IPPU sector, all of the PCB is arising from subcategory NFR *2.C Metal Production*: NFR category *2.C.1 Iron and Steel Production* is the main source of national total PCB emissions in 2019. Emissions from *2.C.5 Lead Production* and *2.C.7 Other Metal Production* are minor sources in 2019. However, PCB emissions from *2.C.5 Lead Production* decreased by nearly 100% since 1990. The biggest reduction could be achieved between 1990 and 1993 due to the phase out of the only primary lead production plant in Austria. Since 1990 emissions from subcategory 2.C decreased by 13%; the emissions generally follow the production activities but the decrease is also due to abatement technologies.

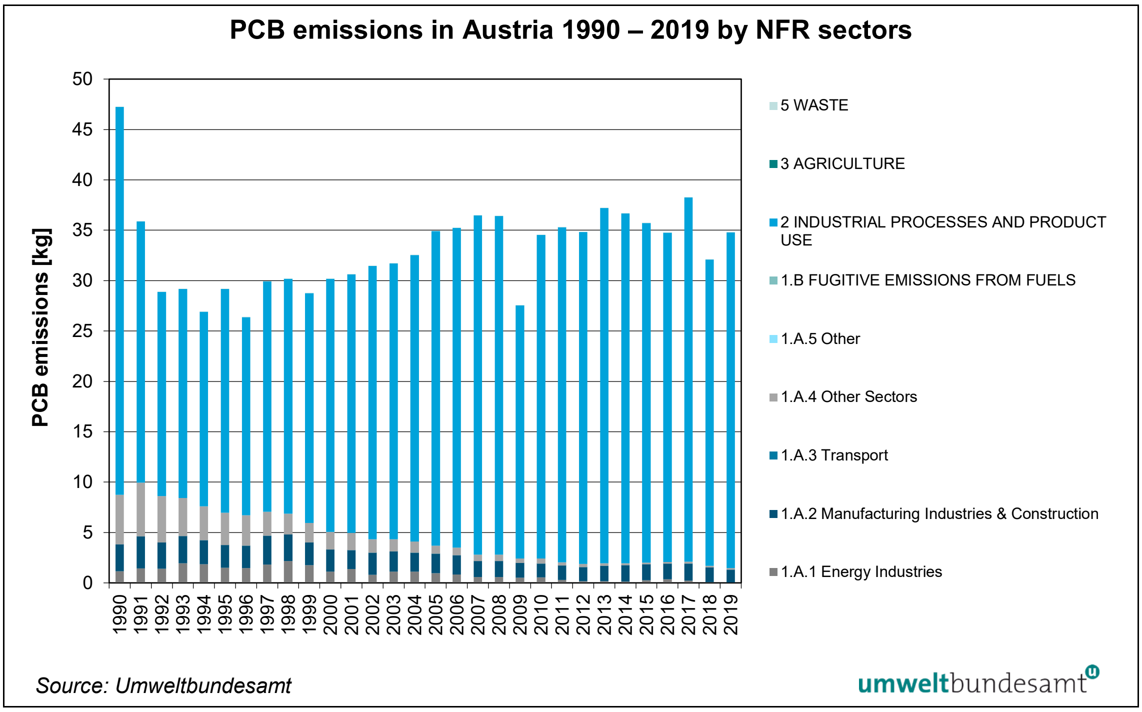


Figure 43: PCB emissions in Austria 1990–2019 by sectors in absolute terms.

Table 62: Polychlorinated biphenyl (PCB) emissions per NFR Category 1990 and 2019, trend 1990–2019 and share in total emissions.

NFR Category		PCB Emission in [kg]		Trend		Share in National Total	
		1990	2019	1990–2019	2018–2019	1990	2019
1	ENERGY	8.73	1.46	-83%	-13%	18%	4%
1.A	FUEL COMBUSTION ACTIVITIES	8.73	1.46	-83%	-13%	18%	4%
1.A.1	Energy Industries	1.16	0.04	-97%	-59%	2%	<1%
1.A.2	Manufacturing Industries and Construction	2.64	1.29	-51%	-11%	6%	4%
1.A.2.a	Iron and Steel	0.08	0.02	-81%	-24%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.04	0.02	-50%	54%	<1%	<1%
1.A.2.c	Chemicals	0.21	0.11	-48%	-50%	<1%	<1%
1.A.2.d	Pulp, Paper and Print	1.49	0.69	-54%	-4%	3%	2%
1.A.2.e	Food Processing, Beverages and Tobacco	0.15	0.02	-86%	-12%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.48	0.43	-10%	-3%	1%	1%
1.A.2.g	Manufacturing Industries and Constr. - other	0.19	0.00	-100%	-96%	<1%	<1%
1.A.3	Transport	0.00	0.00	-13%	-12%	<1%	<1%
1.A.4	Other Sectors	4.92	0.14	-97%	2%	10%	<1%
1.A.4.a	Commercial/Institutional	0.30	0.00	-100%	8%	1%	<1%
1.A.4.b	Residential	4.53	0.14	-97%	3%	10%	<1%
1.A.4.c	Agriculture/Forestry/Fisheries	0.09	0.00	-97%	-28%	<1%	<1%
1.A.5	Other	0.00	0.00	-75%	-17%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	38.50	33.33	-13%	10%	82%	96%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	NA	NA	NA	NA	NA	NA
2.C	METAL PRODUCTION	38.50	33.33	-13%	10%	82%	96%
2.C.1	Iron and Steel Production	19.34	33.33	72%	10%	41%	96%
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%	<1%	41%	<1%
2.C.6	Zinc production	NO	NO	NO	NO	NO	NO
2.C.7	Other metal production	0.00	0.00	40%	<1%	<1%	<1%
2.C.7.a	Copper production	0.00	0.00	40%	<1%	<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 products	NO	NO	NO	NO	NO	NO
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	290%	2%	<1%	<1%
	Total without sinks	**47.23**	**34.81**	**-26%**	**8%**		

2.5 National emission total calculated on the basis of fuels used

According to Article 2 of NEC Directive 2016/2284, the Directive covers emissions from all sources occurring in the territory of the Member States, their exclusive economic zones and pollution control zones. Austria is a landlocked country and fuel prices significantly vary between neighbouring countries. Fuels tend to be sold in the territories where fuel prices are lower and they are exported to (and used in) other countries. Austria has experienced a considerable amount of 'fuel export' in the last few years; this needs to be taken into account when reporting emissions occurring in the Austrian territory.

For this reason Austria has chosen the usage of the national emission totals on the basis of fuels used (not including 'fuel exports') as a basis for compliance with the 2010 emission ceilings under the NEC Directive. Further details regarding 'fuel exports' are provided below in this chapter.

The approach in the Austrian inventory is as follows: After calculating fuel consumption for inland road transport and off-road transport using a bottom-up approach (NEMO, GEORG), the sum of this fuel used is compared with the total fuel sold from the national energy balance (for details see 1.A.3.b Road Transport). The difference is then allocated to fuel export, which includes fuel consumption for ground activities at airports and harbors as well, including fuel consumption by unregistered vehicles. As the fuel consumption reported under fuel export is included in the national totals, an underestimation of emissions can be excluded.

Table 63 presents the national emission totals of SO_2, NO_x, NMVOC and NH_3 calculated on the basis of fuels used.

Table 63: Austria's emissions 1990–2019 calculated on the basis of fuels used.

	Austria's Air Emissions not including 'fuel exports' [kt]			
	SO_2	NO_x	NMVOC	NH_3
1990	72.92	200.40	331.03	61.79
1991	69.68	202.02	319.45	62.52
1992	53.17	194.09	300.31	61.11
1993	51.66	185.58	282.24	62.17
1994	46.15	181.47	261.85	62.20
1995	45.86	180.68	246.75	63.32
1996	43.20	181.09	238.52	62.79
1997	39.98	181.45	225.32	63.11
1998	34.98	179.80	214.61	63.34
1999	33.28	179.98	204.97	62.28
2000	31.05	179.76	180.88	60.95
2001	31.82	182.85	174.38	60.87
2002	30.71	182.62	167.65	59.87
2003	30.44	186.95	162.58	59.75
2004	26.54	187.04	149.23	59.57
2005	25.88	190.30	153.26	59.46
2006	26.67	191.67	156.50	59.95
2007	23.30	187.86	152.60	61.25
2008	20.23	181.22	147.94	61.01

	Austria's Air Emissions not including 'fuel exports' [kt]			
	SO_2	NO_x	NMVOC	NH_3
2009	14.72	168.67	135.24	62.42
2010	15.96	168.97	135.90	62.39
2011	15.15	167.70	131.38	61.92
2012	14.76	163.60	129.41	62.24
2013	14.34	160.25	123.61	62.34
2014	14.50	156.62	117.15	63.13
2015	14.10	154.99	112.07	63.91
2016	13.26	150.72	110.99	64.69
2017	12.78	143.99	111.60	65.56
2018	11.58	136.05	108.36	64.62
2019	10.89	130.66	108.01	63.57
Trend 90–19	**-85.1%**	**-34.8%**	**-67.4%**	**2.9%**

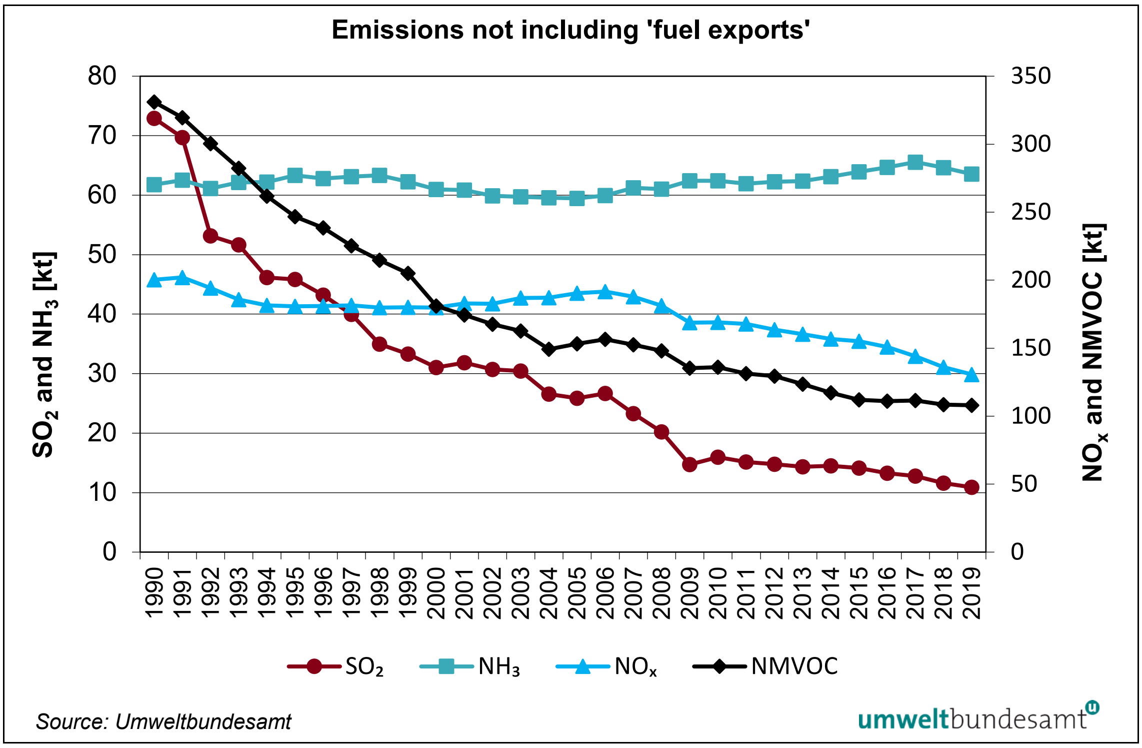


Figure 44: SO_2, NO_x, NMVOC and NH_3 emissions not including 'fuel exports.

SO_2 emissions

In 2019, SO_2 emissions amounted to 10.9 kt (not including 'fuel exports'). Since 1990 (72.9 kt), emissions have decreased by 85.1 %.

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), the installation of desulphurisation units in plants (according to the Clean Air Act for boilers) and an increased use of low-sulphur fuels such as natural gas. The economic crisis in 2009 caused a decrease in SO_2 emissions, which was followed by an increase after the recovery of the economy. 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 in SO_2 emissions from oil fired power plants (1.A.1) and from iron and steel (1.A.2.a) and pulp and paper (1.A.2.d) production.

From 2018 to 2019, SO_2 emissions (excluding fuel exports) continued to decrease (by 0.7 kt i.e. – 5.9 %), mainly because of lower coal consumption in power plants and lower emissions of oil refinery. Emissions declined in particular in the sectors Pulp, Paper and Print (1.A.2.d) and Other Stationary Combustion in Manufacturing Industries and Construction (1.A.2.g.8). In addition, lower coal consumption in the Public Electricity and Heat Production sector (1.A.1.a) and lower petroleum refinery emissions (1.A.1.b) contributed to the reduction in SO_2 emissions. The emissions in the iron and steel industry were higher again following maintenance-related production reductions in 2018.

NO_x emissions

In 1990, NO_x emissions without 'fuel exports' amounted to 200.4 kt, and in 2019 to 130.7 kt.

Since 1990, NO_x emissions (not including 'fuel exports') have decreased by 34.8 %. The reduction in NO_x emissions from 1991 to 1993 was mainly due to reductions in sector 1.A.3.b (passenger cars), sector 1.A.1.a (large oil and coal power plants) and sector 2.B.10.a (chemicals industries). The economic crisis caused a decrease in emissions between 2008 and 2009.

From 2018 to 2019 the downward trend in NO_x emissions (not including 'fuel exports') continued with a decrease of 5.4 kt (– 4.0 %). This was caused by a decline in road traffic, especially passenger cars (1.A.3.b.1) (– 2.3 kt) and heavy duty vehicles (1.A.3.b.3) (– 1.3 kt). The main share of Austria's national NO_x emissions is emitted by fuel combustion. At 46.7 %, road transport accounted for the biggest share of Austria's total NO_x emissions in the year 2019 (not including 'fuel exports').

NMVOC emissions

NMVOC emissions without 'fuel exports' amounted to 331.0 kt in 1990, and to 108.0 kt in 2019. This corresponds to a reduction of 67.4 %. From 2018 to 2019, NMVOC emissions (not including 'fuel exports') decreased 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 accounts only for a small share (3.8 %) of Austria's total NMVOC emissions.

Reductions in the solvent sector have been achieved due to various regulations (Solvent Ordinance, Cogeneration Act, VOC Emissions Ordinance). In 2019, the solvent sector accounted for around 30.0 % of Austria's total NMVOC emissions. Compared to the previous year, emissions increased by 1.2 %.

The agriculture sector accounted for the largest share of NMVOC emissions at 33.8 % with emission calculations for this sector being considerably uncertain. Here emissions fell by 1.2 % compared with 2018.

Residential stationary heating accounted for 21.0 % of the total, an increase of 1.0 % compared to 2018, mainly due to the slightly colder weather and a fairly constant level of biomass used for heating. Outdated mixed-fuel wood boilers continue to be the main source of the relatively high emissions.

NH_3 emissions

NH_3 emissions without 'fuel exports' amounted to 61.8 kt in 1990, and to 63.6 kt in 2019.

Since 1990, NH_3 emissions (not including 'fuel exports') have increased by 2.9 %. The main source of ammonia emissions is the agriculture sector with a share of 93.5 % in 2019. Within the agriculture sector about 51 % of NH_3 emissions result from Agricultural Soils (3.D) and 49 % from Manure Management (3.B). There was a slight increase in NH_3 emissions between 1990 and 2019. This increase of 0.5 % can be explained by an increased number of cattle kept in loose house systems (for reasons of animal welfare and stipulated by EU law), an increase in the number of cows with higher milk yields and an increased use of urea as nitrogen fertilizer (cost-saving, but less efficient than other types of mineral fertilizer).

Compared to the previous year 2018, emissions fell by 1.6 %, the main reasons for this short-term decrease being, on the one hand, a significantly lower consumption of mineral fertilizers and on the other, a smaller number of cattle.

Emissions from 'fuel export'

In the year 2004, a study[75] was commissioned to analyse the effects of fuel price differences between Austria and its neighbouring countries, including the so-called 'fuel export' effect, which means that fuel which is sold in Austria is used abroad. Relevant calculations were based on extensive questionnaires (addressed to truckers at the border, truckage companies), results from the Austrian transport model, and traffic counts. The importance of 'fuel exports' was confirmed by an update of the study in 2008/2009[76].

The following Table provides information on the quantities of emissions that can be attributed to fuel exports in vehicle tanks.

Table 64: Emissions from 'fuel exports'.

	Emissions [Kilotonnes]			
	SO_2	NO_x	NMVOC	NH_3
1990	0.78	16.95	4.50	0.05
1991	1.05	24.84	10.40	0.17
1992	1.03	21.38	5.97	0.13
1993	1.16	21.35	4.04	0.11
1994	1.04	17.34	2.01	0.06
1995	0.95	17.46	1.45	0.04
1996	0.74	34.88	0.24	-0.08
1997	0.43	20.80	-0.80	-0.14
1998	0.66	34.26	1.43	0.01
1999	0.47	25.91	-0.08	-0.14
2000	0.53	31.92	0.30	-0.13
2001	0.64	39.61	1.49	0.01

[75] HAUSBERGER, S. & MOLITOR, R. (2004): Assessment of the effects of fuel tourism on fuel consumption and CO_2 emission trends in Austria (in German). TU Graz by order of the Austrian Ministry of Life, not published. Graz, 2004.

[76] HAUSBERGER, S.& MOLITOR, R. (2009): Assessment of the effects of fuel tourism on fuel consumption and CO_2 emission trends in Austria (in German). TU Graz by order of the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management and the Austrian Federal Ministry of Transport, Innovation and Technology, not published. Graz, 2009.

	Emissions [Kilotonnes]			
	SO_2	NO_x	NMVOC	NH_3
2002	0.69	47.76	3.46	0.35
2003	0.74	54.46	4.46	0.54
2004	0.06	54.22	4.47	0.59
2005	0.05	57.04	4.46	0.62
2006	0.04	46.23	3.34	0.58
2007	0.04	43.04	3.07	0.59
2008	0.03	36.63	2.43	0.50
2009	0.04	35.39	2.26	0.51
2010	0.04	35.48	2.00	0.49
2011	0.03	28.29	1.54	0.41
2012	0.03	26.90	1.34	0.37
2013	0.04	29.50	1.23	0.33
2014	0.04	25.36	1.02	0.29
2015	0.04	23.99	0.99	0.30
2016	0.04	20.78	0.90	0.29
2017	0.04	18.74	0.80	0.28
2018	0.04	15.37	0.68	0.26
2019	0.03	13.54	0.58	0.25

In 2019 about 9.4% of the total reported NO_x emissions of Austria were due to 'fuel exports'. NO_x emissions from fuel export increased by 236% between 1990 and 2005. From then emissions show a falling trend e.g. due to improved specific NO_x emissions per kilometer in each vehicle fleet category. Especially NO_x after treatment systems of trucks are working very well. In the model NEMO fuel export is allocated to truck traffic (2019: 33%) and passenger car traffic (2019: 67%). In 2019 NO_x emissions of total fuel export were 20% below the level of 1990. For more details, please also refer to chapter 3.2.6.

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 and residential)
- 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 2021a) which is part of the submission under the UNFCCC.

- Additionally to information provided in this document, Annex 2 of (UMWELTBUNDESAMT 2021a) 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 2021a) and available from STATISTIK AUSTRIA at: https://www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/energie_und_umwelt/energie/energiebilanzen/index.html

3.1.1.1 Completeness

Table 65 provides information on the status of emission estimates of all sub categories. A "✓" indicates that emissions from this sub category have been estimated.

Table 65: 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]	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]	IE[2]	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 and lime kilns are included in 2.A.1 and 2.A.3.

Table 66 shows the correspondence of NFR and SNAP categories.

Table 66: 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 67.

Table 67: 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, Pb, Hg, DIOX, TSP, PM_{10}, $PM_{2.5}$	LA, TA
1.A.1.b	Petroleum refining	Cd	LA, TA
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, Cd, Hg[2)]	LA, TA
1.A.2.f	Non-metallic Minerals	SO_2, NO_x, Hg	LA, TA
1.A.2.g.viii	Other Stationary Combustion in Manufacturing Industries and Construction	SO_2, DIOX	LA, TA
1.A.4.a.1	Commercial/Institutional: Stationary	$PM_{2.5}$	LA, TA
1.A.4.b.1	Residential: stationary	SO_2, NO_x, NMVOC, CO, Cd, Pb, Hg, PAH, DIOX, HCB, TSP, PM_{10}, $PM_{2.5}$	LA, TA
1.A.4.c.1	Agriculture/Forestry/Fishing: Stationary	PAH, $PM_{2.5}$	LA, TA

LA = Level Assessment (if not further specified – for the years 1990 and 2019)

TA = Trend Assessment 2019

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 2021a). 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 68: 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

NFR Categories		NO_x Emissions [%]	NH_3 Emissions [%]	NMVOC Emissions [%]	SO_2 Emissions [%]	$PM_{2.5}$ Emissions [%]
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
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 2016 Guidelines chapter 1.A.4, table 3.13.

PCB emission factors

PCB emission factors for coal and gasoil are selected from the EMEP/EEA 2016 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 69: 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. In the inventory 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 2021a). 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 2020).

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 c*omprises 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 70 gives an overview of methodologies and data sources of sub category *1.A.1 Energy Industries*.

Table 70: 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). 2005–2019: ETS data	Reporting Obligation: NO_x, SO_2, TSP, CO (monthly) (About 130 boilers)	NMVOC, NH_3: national studies
1.A.1.a boilers < 50 MW_{th}	Energy balance 2005–2019: ETS data for plants ≥ 20 MW_{th}	Used for deriving emission factors	All pollutants: national studies
1.A.1.b (1 plant)	Reported by plant operator (yearly) 2005–2019: ETS data	Reported by plant operator: SO_2, NO_x, CO, NMVOC (yearly)	NH_3: national study
1.A.1.c	Energy balance 2005–2019: ETS data		Main pollutants and Dioxin: national studies Other Pollutants: EMEP/EEA 2016 GB

For 2005–2019, activity data from the emission trading system (ETS) are considered. ETS data fully covers category *1.A.1.b*, covers about 90% of category *1.A.1.a* fossil fuels and about 15% *(from 2013 on about 70%)* 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 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.

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 71: 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	0	0	24 427
1991	43 497	30 268	13 229	0	0	0	29 038
1992	42 848	33 530	9 318	0	0	0	27 601
1993	44 809	35 070	9 738	0	1	0	30 428
1994	44 804	34 078	10 725	0	1	0	30 729
1995	47 580	35 431	12 147	0	1	1	34 426
1996	45 953	32 892	13 055	0	1	5	44 483
1997	47 527	34 532	12 973	0	2	20	40 597
1998	47 789	35 596	12 146	0	2	45	43 415
1999	52 192	39 593	12 546	0	2	51	42 465
2000	52 810	41 131	11 609	0	3	67	42 197
2001	53 763	39 681	13 972	0	5	105	44 575
2002	54 385	40 597	13 636	3	9	140	45 056
2003	52 508	34 230	17 888	3	15	372	48 896
2004	56 051	37 700	17 397	2	18	934	51 786
2005	58 518	38 205	18 958	2	21	1 331	54 424
2006	56 225	36 907	17 539	3	22	1 753	54 730
2007	56 153	38 018	16 071	2	24	2 037	54 066
2008	57 842	39 458	16 341	2	30	2 011	60 794
2009	60 515	42 414	16 097	2	49	1 954	63 328
2010	61 571	40 500	18 916	1	89	2 064	70 415
2011	56 270	36 815	17 344	1	174	1 936	70 399
2012	64 030	47 204	14 025	1	337	2 463	74 061
2013	60 239	45 226	11 234	0	626	3 152	75 274
2014	57 742	44 270	8 840	0	785	3 846	69 707
2015	57 455	40 102	11 575	0	937	4 840	72 314
2016	60 429	42 482	11 617	0	1 096	5 235	74 159
2017	63 114	41 697	13 576	0	1 269	6 572	76 620
2018	60 610	40 742	12 400	0	1 438	6 030	74 087
2019	66 268	43 299	13 790	0	1 702	7 477	74 606

[1)] including pumped storage; Source: IEA JQ 2020

As shown in Table 72 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 72: Electricity supply, gross production imports, exports and net imports [GWh].

	Electricity [GWh]				
	Supply[1)]	**Gross production[2)]**	**Imports**	**Exports**	**Net Imports**
1990	46 489	50 294	6 839	7 298	-459
1991	48 793	51 483	8 503	7 738	765
1992	48 197	51 190	9 175	8 621	554
1993	49 073	52 421	8 072	8 804	-732
1994	49 596	53 132	8 219	9 043	-824
1995	50 979	56 225	7 287	9 757	-2 470
1996	52 515	54 880	9 428	8 476	952
1997	53 069	56 704	9 008	9 775	-767
1998	54 039	57 001	10 304	10 467	-163
1999	55 167	60 944	11 608	13 507	-1 899
2000	55 750	61 257	13 824	15 192	-1 368
2001	58 338	62 449	14 467	14 252	215
2002	58 074	62 499	15 375	14 676	699
2003	60 058	60 174	19 003	13 389	5 614
2004	61 320	64 152	16 629	13 548	3 081
2005	62 948	66 833	20 355	17 732	2 623
2006	64 144	64 702	20 925	14 580	6 344
2007	64 762	65 085	21 783	15 767	6 016
2008	65 112	66 852	19 795	14 934	4 862
2009	62 783	69 088	19 542	18 762	780
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	68 597	28 076	19 129	8 947
2019	69 332	74 234	26 047	22 918	3 129

Source: IEA JQ 2020

[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 2020) prepared by *Statistik Austria*. The remaining fuel consumption (= total consumption minus reported boiler consumption) is the activity data of plants < 50 MW_{th} used for emission calculation with a Tier 2 methodology using national emission factors.

Table 73 shows activity data of category 1.A.1.a.

Table 73: 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	1.63	4.66
1991	151.05	19.04	67.33	57.55	2.57	4.55
1992	117.34	18.82	39.97	49.50	3.00	6.05
1993	119.18	26.09	30.81	53.89	3.12	5.27
1994	124.02	24.08	32.97	58.28	3.39	5.29
1995	136.44	19.74	45.49	62.07	4.02	5.13
1996	160.12	19.70	47.52	79.65	6.12	7.12
1997	156.77	24.40	50.96	68.42	6.15	6.85
1998	149.99	28.06	35.81	73.53	6.81	5.78
1999	148.20	22.33	37.88	75.92	6.47	5.60
2000	140.24	14.90	49.16	62.67	8.05	5.46
2001	160.02	19.95	59.76	63.65	11.08	5.59
2002	155.32	10.33	56.12	69.02	13.07	6.77
2003	188.17	14.30	70.88	81.14	14.01	7.85
2004	186.88	14.78	69.06	77.61	15.34	10.09
2005	201.69	14.05	61.63	95.25	20.42	10.33
2006	194.50	12.52	60.20	79.17	29.54	13.08
2007	185.62	8.92	54.48	72.17	37.13	12.92
2008	195.77	8.82	47.87	81.89	44.09	13.11
2009	190.29	8.08	32.45	86.08	46.92	16.77
2010	217.58	8.49	41.47	94.45	55.30	17.86
2011	209.46	4.78	45.64	83.93	55.67	19.44
2012	194.41	2.87	37.18	74.48	60.01	19.88
2013	176.76	2.35	35.78	60.21	58.62	19.80
2014	157.12	2.00	24.74	50.34	58.31	21.73
2015	177.59	3.23	24.98	65.46	61.35	22.57
2016	177.18	4.44	16.91	72.45	59.05	24.32
2017	195.05	2.81	14.55	92.59	62.23	22.87
2018	175.35	1.22	14.78	79.05	58.31	21.99
2019	177.44	0.58	12.49	86.83	55.45	22.08
Trend 1990–2019	24.3%	-96.3%	-79.6%	46.0%	3305.9%	373.8%
Trend 2018–2019	-10.8%	-61.2%	1.6%	-14.2%	-8.1%	-3.8%

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

Table 74: 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%	1.20	0.21	17%	4.37	0.80	18%
2015	10.05	3.55	35%	1.23	0.60	49%	1.10	0.09	8%	4.21	0.58	14%
2016	9.30	2.99	32%	1.02	0.41	41%	1.02	0.05	5%	4.01	0.54	13%
2017	10.05	3.35	33%	0.99	0.36	36%	1.05	0.04	4%	4.21	0.55	13%
2018	9.03	3.02	33%	0.99	0.37	38%	1.02	0.03	3%	4.05	0.48	12%
2019	8.50	2.85	33%	0.81	0.25	31%	0.95	0.02	2%	3.95	0.54	14%

In the approach above different coal types and residual fuel classifications are considered. Table 75 shows some selected aggregated results for 2019. 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 75: NFR 1.A.1.a ≥ 50 MW_{th} default emission factors fuel consumption and emissions ratios for the year 2019.

	Fuel consumption [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	NH3 [kg/TJ]
NFR 1.A.1.a ≥ 50 MWt_h		0.80[(1)]	0.15[(1)]		
SNAP 010101		0.75[(1)]	0.80[(1)]		
Hard Coal	14.781	50.0	1.0	0.9	0.07[(3)]
Oil	2	26.0	3.0	5.0	2.68
Natural gas	60 400	30.0	4.0	0.06	1.0
Sewage sludge	10	100.0	200.0	38.0	0.02
Biomass	882	94.0	72.0	5.0	5.0
SNAP 010102		1.78[(1)]	0.62[(1)]		
Natural gas	3 966	30.0	4.0	0.06	1.0
Waste	9 533	100.0	200.0	0.54[(2)]	0.02
SNAP 010201		11.96[(1)]	17.80[(1)]		
Oil	13	100.0	4.0	5.0	2.68
Natural gas	1 374	25.0	4.0	0.5	1.0
SNAP 010202		0.37[(1)]	0.03[(1)]		
Oil	392	85.0	4.0	5.0	2.68
Natural gas	5 304	25.0	4.0	0.5	1.0
Waste	12 461	48.0	200.0	0.54[(2)]	0.02
Sewage Sludge	640	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 76 shows main pollutant emission factors used for calculation of emissions from boilers < 50 MW_{th} for the year 2017. Increasing biomass consumption of smaller plants is a main source of NO_x emissions from this category in 2018.

Table 76: NFR 1.A.1.a < 50 MW_{th} main pollutant emission factors and fuel consumption for the year 2019.

Fuel	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
Light Fuel Oil	45	159.4	10/45[(1)]	0.8	92	2.7
Heavy Fuel Oil	410	26/317.4[(1)]	3/15[(1)]	8.0	50/398[(1)]	2.7
Gasoil	106	65	10	4.8	0.5	2.7
Diesel oil	0	700	15	0.8	18.8	2.7
Liquified Petroleum Gas	0	150	5	0.5	6	1
Natural Gas/power and CHP	5 809	30	4	0.5	0.3	1
Natural Gas/district heating	1 929	41	5	0.5	0.3	1
Solid Biomass	46 350	94	72	5.0	11	5
Biogas, Sewage Sludge Gas, Landfill Gas	6 828	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 77. The split follows closely (STANZEL et al. 1995).

Table 77: 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 2019). 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 78 shows the fuel consumption of the refinery.

Table 78: 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	0.00	7.88	0.00	0.00
1991	35.65	26.28	0.00	9.37	0.00	0.00
1992	34.85	26.32	0.00	8.53	0.00	0.00
1993	37.68	27.80	0.00	9.88	0.00	0.00
1994	36.05	29.12	0.00	6.93	0.00	0.00
1995	34.20	26.59	0.00	7.61	0.00	0.00
1996	39.39	31.00	0.00	8.38	0.00	0.00
1997	39.71	30.97	0.00	8.74	0.00	0.00
1998	38.70	30.38	0.00	8.32	0.00	0.00
1999	32.87	26.32	0.00	6.55	0.00	0.00
2000	33.18	26.65	0.00	6.53	0.00	0.00
2001	32.91	27.26	0.00	5.66	0.00	0.00
2002	36.16	31.06	0.00	5.10	0.00	0.00
2003	37.66	32.56	0.00	5.10	0.00	0.00
2004	40.45	32.02	0.00	8.43	0.00	0.00
2005	40.45	31.13	0.00	9.32	0.00	0.00
2006	40.72	32.03	0.00	8.68	0.00	0.00
2007	41.30	33.13	0.00	8.18	0.00	0.00
2008	40.62	31.49	0.00	9.13	0.00	0.00
2009	39.16	35.00	0.00	4.16	0.00	0.00
2010	39.41	30.41	0.00	9.00	0.00	0.00
2011	39.88	30.89	0.00	9.00	0.00	0.00
2012	39.75	32.00	0.00	7.75	0.00	0.00
2013	39.37	32.58	0.00	6.79	0.00	0.00
2014	37.71	31.75	0.00	5.96	0.00	0.00
2015	38.83	32.68	0.00	6.15	0.00	0.00
2016	38.14	32.24	0.00	5.90	0.00	0.00
2017	38.33	31.21	0.00	7.12	0.00	0.00
2018	39.64	31.05	0.00	8.59	0.00	0.00
2019	39.62	30.56	0.00	9.06	0.00	0.00
Trend 1990–2019	**12.1%**	**11.3%**		**15.0%**		
Trend 2018–2019	**-0.1%**	**-1.6%**		**5.5%**		

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 79: 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		Liquid	Gaseous	Biomass
		[PJ]		
1990	9.23	0.062	9.13	0.03
1991	9.94	0.040	9.87	0.03
1992	9.45	0.000	9.42	0.03
1993	7.69	0.002	7.65	0.03
1994	8.20	0.001	8.17	0.03
1995	11.06	0.007	11.02	0.03
1996	4.74	-	4.71	0.03
1997	5.03	-	5.00	0.03
1998	6.39	-	6.36	0.03
1999	5.15	-	5.12	0.03
2000	5.10	-	5.07	0.03
2001	4.45	-	4.42	0.03
2002	3.86	-	3.83	0.03
2003	3.07	-	3.04	0.03
2004	4.46	-	4.43	0.03
2005	7.14	-	7.10	0.03
2006	4.76	-	4.73	0.04
2007	4.80	-	4.76	0.04
2008	4.31	-	4.28	0.04
2009	4.81	-	4.77	0.04
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

NFR	1.A.1.c	1.A.1.c	1.A.1.c	1.A.1.c
Fuel		**Liquid**	**Gaseous**	**Biomass**
		[PJ]		
2018	4.36	-	4.32	0.04
2019	5.66	-	5.61	0.04
Trend 1990–2019	**-38.7%**	**-100.0%**	**-38.5%**	**31.0%**
Trend 2018–2019	**29.6%**		**29.8%**	**3.4%**

Emission factors and activity data 2019

Table 80 summarizes the selected emission factors for main pollutants and activity data for the year 2019. It is assumed that emissions are uncontrolled.

Table 80: NFR 1.A.1.c main pollutant emission factors and fuel consumption for the year 2019.

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)	5 655	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 1.4 kt in 2018.

The following Table 81 shows activity data for charcoal.

Table 81: Charcoal production activity.

Year	Charcoal production (t)	Year	Charcoal production (t)
1990	1 000	2005	1 101
1991	1 000	2006	1 220
1992	1 000	2007	1 149
1993	1 000	2008	1 253
1994	1 000	2009	1 365
1995	1 000	2010	1 181
1996	1 000	2011	1 130
1997	1 000	2012	1 377
1998	1 000	2013	1 269
1999	1 000	2014	1 263
2000	1 000	2015	1 447
2001	1 000	2016	1 382
2002	1 000	2017	1 222
2003	1 000	2018	1 379
2004	1 000	2019	1 425

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 82). It is assumed that imported oil products have a similar metal content.

Table 82: Heavy Metal Contents of Fuel Oils in Austria.

[mg/kg]	Cadmium	Mercury	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 emission factors for "other oil products" (which is only used in the refinery) are based on the following assumption: the share of Cd and Pb in crude oil is about 1% and 2%, respectively. 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 0.2% and 0.4% of dust emissions from the refinery. Based on a TSP emission factor of about 5.7 g/GJ, the resulting emission factors for Cd and Pb are 10 mg/GJ and 20 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

Heavy metal emission factors of natural gas are selected from the EMEP/EEA Guidebook 2016, table 3-17.

Table 83: 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
110A Petrol coke 224A Other oil products	20	10	10	10

Cadmium EF [mg/GJ]	1985	1990	1995	2010
Other 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.c Natural gas				
301A Natural gas	0.0012 (all years)			

The following table presents Cd emission factors of several waste categories. Emission factors 2006 are derived from measurements (UMWELTBUNDESAMT 2007).

Table 84: 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 85: 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
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)			
Other 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 (1.A.1.c)	0.1 (all years)			

The following table presents Hg emission factors of several waste categories. Emission factors 2006 are derived from measurements (UMWELTBUNDESAMT 2007).

Table 86: 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 87: 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)			
115A Industrial waste (< 50 MW)	50 (all years)			
Natural gas				
301A Natural gas (1.A.1c)	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 88: 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 2016, 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 89: 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				
Fuel Oil (203B, 203C, 203D, 204A) exc. Gasworks, 110A Petrol coke	0.0004	0.08	0.16	0.00013
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
Gas				
301A, 303A Natural gas and LPG exc. SNAP 010202, 010301	0.0002	0.04	NA	NA
301A, 303A Natural gas and LPG, SNAP 010202, 010301	0.0004	0.08	NA	0.000036
301A 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 90: POP emission factors for Sector 1.A.1 Energy Industries.

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:

- 1A1 - Table 3-2 (1.A.1.a hard coal)
- 1A1 - Table 3-3 (1.A.1.a brown coal)
- 1A1 - Table 3-13 (1.A.1.a wood and wood waste)
- 1A1 - Table 3-5 (1.A.1.a heavy fuel oil)
- 1A1 - Table 3-4 (1.A.1.a, 1A1c gaseous fuels)
- 1A2 - 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[77]) 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 91.

77 http://edm.gv.at

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 91: 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	2019	[%]	[%]
Public Power (0101)(1)	5.51	2.74	1.50	0.17	95	80
District Heating (0102) (1)	3.58	0.73	0.96	0.31	95	80
Petroleum Refining (010301)(2)	4.3	3.3	1.2	1.3	95	80
Wood waste (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 (301)*

(2) *Used fuels: Refinery gas (308A), FCC coke (110A), Residual fuel oil (203D), LPG (303A), Other oil products (224A) and Natural gas (301A)*

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. [78]

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).

78 as of central heating boilers in the residential sector (Hauszentralheizung – HZH)

Table 92: 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	2019	[%]	[%]
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
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).

The most significant recalculation for the year 2018 took place for category 1.A.1.a: +0.03 kt $PM_{2.5}$ (+3.2%)

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)[79]
- Other Stationary Combustion in Manufacturing Industries and Construction (NFR 1.A.2.g.viii).

3.1.4.1 General Methodology

Table 93 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

[79] methodologies for mobile sources are described in Chapter 3.2

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.

Table 93: 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 2005–2019: ETS data.		All pollutants: National studies
1.A.2.b	Non-ferrous Metals	Energy balance 2005–2019: ETS data.		All pollutants: National studies
1.A.2.c	Chemicals	Energy balance 2005–2019: 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 2005–2019: 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 2005–2019: ETS data.		All pollutants: National studies
1.A.2.f	Cement Clinker Production	National Studies 2005–2019: 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 2005–2019: 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 2005–2019: ETS data.		All pollutants: National studies
1.A.2.f	Bricks and Tiles Production	Association of Bricks and Tiles Industry 2005–2019: ETS data.		All pollutants: National studies
1.A.2.g	Other	Energy balance 2005–2019: ETS data.		All pollutants: National studies

The SO_2 emission factor for natural gas is selected from the EMEP 2016 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 http://www.emas.gv.at 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 94: 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 95: 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
1991	4.94	4.75	0.06	185.41
1992	4.14	3.25	0.05	226.91
1993	4.50	3.48	0.05	237.35
1994	4.18	3.79	0.06	250.57
1995	4.44	3.69	0.06	182.09
1996	4.20	4.20	0.06	206.61
1997	4.43	4.43	0.07	211.56
1998	4.45	4.46	0.07	197.77
1999	4.37	4.52	0.07	121.11
2000	4.18	4.06	0.09	164.47
2001	4.04	4.53	0.09	140.79
2002	4.30	4.71	0.09	134.37
2003	4.33	4.89	0.22	147.20
2004	4.10	4.50	0.26	153.14
2005	4.61	4.86	0.29	138.18
2006	4.69	5.31	0.31	147.90
2007	4.74	5.37	0.30	138.79
2008	4.56	4.76	0.27	124.65
2009	3.73	3.83	0.25	116.96

	NO_x (kt)	SO_2 (kt)	NMVOC (kt)	CO (kt)
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

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 2019. It is assumed that emissions are uncontrolled.

Table 96: NFR 1.A.2.a – area source – main pollutant emission factors and fuel consumption for the year 2019.

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)]	0	250.0	150.0	15.0	600.0	0.01
Coke oven coke	(BMWA 1990) [(1)]	86	220.0	150.0	8.0	500.0	0.01
Residual fuel oil < 1% S	(BMWA 1996) [(1)]	0	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA 1996) [(1)]	10	235.0	15.0	8.0	398.0	2.70
Heating oil	(BMWA 1996) [(2)]	0	65.0	15.0	4.8	45.0	2.70
Kerosene	(BMWA 1996) [(3)]	0	118.0	15.0	4.8	92.0	2.70
Natural gas	(BMWA 1996) [(1)]	6 499	41.0	5.0	0.5	0.3[(6)]	1.00
LPG	(BMWA 1996) [(4)]	7	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 2020).

Table 97: 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	0.00	-
1991	1.87	0.49	0.17	1.21	0.00	-
1992	2.11	0.45	0.08	1.58	0.00	-
1993	2.56	0.46	0.19	1.92	0.00	-
1994	4.44	0.57	0.14	3.73	0.00	-
1995	4.36	0.57	0.09	3.70	0.00	-
1996	2.84	0.68	0.15	2.02	0.00	-
1997	3.50	0.94	0.19	2.37	0.00	-
1998	3.29	0.83	0.16	2.30	0.00	-
1999	3.05	0.66	0.21	2.18	0.00	-
2000	3.12	0.64	0.17	2.31	0.00	-
2001	3.41	0.72	0.10	2.60	0.00	-
2002	3.42	0.60	0.16	2.67	0.00	-
2003	3.53	0.56	0.15	2.82	0.00	-
2004	3.67	0.51	0.16	3.01	0.00	-
2005	3.68	0.45	0.13	3.10	0.00	-
2006	3.76	0.45	0.12	3.19	0.00	-
2007	4.28	0.40	0.14	3.74	0.00	-
2008	4.35	0.32	0.14	3.89	0.00	-
2009	4.02	0.26	0.16	3.60	0.00	-
2010	4.10	0.26	0.07	3.77	0.00	-
2011	4.31	0.30	0.07	3.94	0.00	-
2012	4.19	0.28	0.06	3.85	0.00	-
2013	5.08	0.46	0.13	3.99	0.48	0.02
2014	4.93	0.43	0.15	4.31	0.03	0.01
2015	5.09	0.38	0.13	4.54	0.03	0.01
2016	5.30	0.27	0.13	4.85	0.03	0.02
2017	5.18	0.24	0.11	4.80	0.02	0.02

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**
2018	5.79	0.10	0.07	5.57	0.03	0.01
2019	5.18	0.10	0.11	4.95	0.00	0.02
Trend 1990–2019	**149.2%**	**-79.9%**	**-47.1%**	**265.8%**	**-**	**-**
Trend 2018–2019	**-10.5%**	**6.4%**	**54.8%**	**-11.2%**	**-99.8%**	**70.5%**

The following Table 98 shows fuel consumption and main pollutant emission factors of category *1.A.2.b* for the year 2019.

Table 98: NFR 1.A.2.b main pollutant emission factors and fuel consumption for the year 2019.

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)	111	220.0	150.0	8.0	500.0	0.01
Residual fuel oil < 1% S	(BMWA 1996) (1)	3	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA 1996) (1)	1	235.0	15.0	8.0	398.0	2.70
Heating oil	(BMWA 1996) (2)	0	65.0	15.0	4.8	0.5(6)	2.70
Kerosene	(BMWA 1996) (3)	0	118.0	15.0	4.8	92.0	2.70
Other liquid fuels	Similar to 1.A.1.c Other liquid fuels	0	40.0	10.0	0.5	6.0	2.68
Natural Gas	(BMWA 1996) (1)	4 949	41.0	5.0	0.5	0.3(7)	1.00
LPG	(BMWA 1996) (4)	100	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 2016 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. Fuel consumption is taken from the energy balance (IEA JQ 2020). 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 2020).

Table 99: 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
1991	16.09	1.33	1.41	8.33	2.90	2.12
1992	17.45	0.99	1.95	8.83	3.26	2.42
1993	17.81	1.18	1.96	10.89	2.18	1.60
1994	16.56	1.40	1.58	9.97	1.81	1.79
1995	17.11	1.34	1.58	10.33	1.72	2.15
1996	18.97	1.39	1.94	10.35	2.66	2.63
1997	20.38	1.88	2.66	10.87	2.91	2.05
1998	18.62	1.60	2.63	10.48	2.20	1.72
1999	25.64	1.14	3.24	14.76	4.98	1.51
2000	25.45	0.85	2.61	15.78	3.95	2.26
2001	23.96	1.20	2.65	15.47	1.84	2.81
2002	24.26	0.97	2.64	14.95	1.58	4.13
2003	26.72	1.06	2.62	15.11	2.11	5.82
2004	27.73	1.03	2.48	15.28	1.68	7.26
2005	24.81	0.98	1.57	18.40	2.43	1.43
2006	23.59	0.94	1.12	16.95	2.44	2.14
2007	22.56	1.03	0.84	16.40	2.93	1.35
2008	25.64	1.15	0.75	17.30	2.85	3.59
2009	25.85	1.60	0.74	17.82	2.49	3.21
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	27.43	0.43	1.28	19.96	3.00	2.78
2019	29.11	0.38	0.61	21.00	3.42	3.70
Trend 1990–2019	**78.7%**	**-70.3%**	**-43.9%**	**124.3%**	**17.9%**	**121.7%**
Trend 2018–2019	**6.1%**	**-11.5%**	**-52.2%**	**5.2%**	**14.1%**	**33.3%**

Table 100 summarizes activity data and emission factors for 2019. Underlined values indicate non default emission factors.

Table 100: NFR 1.A.2.c main pollutant emission factors and fuel consumption for the year 2019.

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)]	610	80.3[(5)]	150.0	15.0	60.0[(9)]	0.01
Coke oven coke	(BMWA 1990) [(1)]	0	220.0	150.0	8.0	500.0	0.01
Residual fuel oil < 1% S	(BMWA 1996) [(1)]	53	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA 1996) [(1)]	192	235.0	15.0	8.0	398.0	2.70
Heating oil	(BMWA 1996) [(2)]	15	65.0	15.0	4.8	0.5	2.70
Other liquid fuels	Similar to 1.A.1.c Other liquid fuels	122	40.0	10.0	0.5	6.0	2.68
Natural Gas	(BMWA 1996) [(1)]	21 004	41.0	5.0	0.5	0.3[(11)]	1.00
LPG	(BMWA 1996) [(3)]	9	41.0	5.0	0.5	6.0[(4)]	1.00
Industrial waste	(BMWA 1990) [(1)]	3 701	18.3[(6)]	1.6[(6)]	0.54	3.8[(6)]	0.02
Solid biomass	(BMWA 1996) [(1)]	3 001	100.0[(7)]	72.00	5.0	30.0	5.00
Biogas	(BMWA 1990) [(8)]	426	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 2016 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 Chemical*s 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 2002–2019). 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 2020).

Table 101: 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
1991	61.74	14.24	5.53	18.35	23.45	0.19
1992	56.44	8.53	4.71	18.49	24.45	0.26
1993	58.13	8.80	4.45	16.02	28.64	0.23
1994	70.01	8.39	3.81	27.11	30.38	0.32
1995	67.32	6.72	3.97	24.57	31.58	0.48
1996	66.37	5.13	3.87	28.24	28.32	0.81
1997	72.46	6.62	4.69	33.48	27.61	0.07
1998	70.14	5.60	4.68	31.56	28.24	0.07
1999	69.83	2.97	3.79	31.43	31.50	0.14
2000	67.10	2.20	4.70	31.82	28.38	0.00
2001	68.60	2.30	4.02	30.33	31.83	0.11
2002	64.16	1.96	4.83	29.53	27.71	0.12
2003	68.64	2.13	4.42	33.04	28.85	0.20
2004	66.79	1.70	4.63	30.64	29.57	0.25
2005	74.09	1.79	5.02	30.85	36.32	0.11
2006	72.45	1.63	5.23	28.81	36.63	0.15
2007	73.26	1.26	4.01	30.98	36.85	0.17
2008	72.27	1.07	3.68	31.94	35.49	0.10
2009	70.35	1.33	3.80	31.37	33.75	0.10
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	66.33	0.22	4.44	24.90	36.59	0.18
2018	68.69	0.17	4.15	26.60	37.48	0.29
2019	71.81	0.10	4.05	28.10	39.49	0.07
Trend 1990–2019	**29.8%**	**-99.1%**	**-2.1%**	**65.2%**	**71.5%**	**-61.9%**
Trend 2018–2019	**4.5%**	**-41.3%**	**-2.5%**	**5.7%**	**5.4%**	**-74.5%**

Table 102 shows activity data and emission factors for 2019. 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 102: NFR 1.A.2.d main pollutant emission factors and fuel consumption for the year 2019.

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)	4 047	75.0(9)	150.0	15.0	48.2	0.01
Brown coal	(BMWA 1990) (1)	0	170.0	150.0	23.0	39.9	0.02
Brown coal briquettes	(BMWA 1990) (1)	0	170.0	150.0	23.0	39.9	0.02
Coke oven coke	(BMWA 1990) (1)	0	220.0	150.0	8.0	52.7	0.01
Residual fuel oil < 1% S	(BMWA 1996) (1)	17	118.0	10.0	0.8	6.9	2.70
Residual fuel oil ≥ 1% S	(BMWA 1996) (1)	51	235.0	15.0	8.0	30.0	2.70
Heating oil	(BMWA 1996) (2)	16	65.0	15.0	4.8	0.04	2.70
Kerosene	(BMWA 1996) (6)	0	118.0	15.0	4.8	6.9	2.70
LPG	(BMWA 1996) (3)	19	41.0	5.0	0.5	IE	1.00
Natural Gas (including lime kilns)	(BMWA 1996) (1)	28 102	46.9(9)	5.0	0.5	IE	1.00
Industrial waste	(BMWA 1990) (1)	74	100.0	200.0	0.54	9.8	0.02
Black liquor	(BMWA 1990) (1)	29 958	68.0(9)	20.0	4.0	9.8	0.02
Fuel wood	(BMWA 1996) (8)	0	110.0	370.0	5.00	4.5	5.00
Solid biomass + Sewage sludge	(BMWA 1996) (1)	7 403	86.0(9)	72.00	5.0	4.5	5.00
Biogas	(BMWA 1990) (5)	1 248	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 2020).

Table 103: 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	-
1991	14.76	5.11	0.20	9.33	0.12	-
1992	13.65	4.43	0.10	9.03	0.09	-
1993	13.97	4.99	0.20	8.62	0.15	-
1994	14.67	4.55	0.18	9.84	0.10	-
1995	15.10	4.40	0.06	10.53	0.10	-
1996	14.63	3.27	0.11	11.22	0.03	0.006
1997	17.08	4.02	0.13	12.91	0.02	0.006
1998	15.64	3.21	0.11	12.31	0.01	0.006
1999	14.36	2.14	0.08	11.92	0.22	-
2000	15.16	2.18	0.21	12.53	0.24	-
2001	15.74	3.13	0.12	12.22	0.27	-
2002	19.12	2.35	0.15	16.36	0.27	-
2003	16.03	2.94	0.15	12.71	0.23	-
2004	15.97	3.34	0.12	12.28	0.23	-
2005	16.51	3.19	0.13	12.71	0.48	-
2006	16.22	3.23	0.10	12.27	0.63	-
2007	15.61	2.77	0.11	12.02	0.72	-
2008	15.56	2.50	0.12	12.19	0.75	-
2009	15.98	2.71	0.14	12.44	0.69	0.0003
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	14.08	0.43	0.13	12.98	0.53	0.0049
2019	13.49	0.24	0.12	12.67	0.46	-
Trend 1990–2019	**-3.0%**	**-94.6%**	**-32.5%**	**38.5%**	**252.1%**	**-**
Trend 2018–2019	**-4.2%**	**-43.6%**	**-9.3%**	**-2.4%**	**-13.6%**	**-100.0%**

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 104 summarizes activity data and emission factors for 2019.

Table 104: NFR 1.A.2.e main pollutant emission factors and fuel consumption for the year 2019.

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)]	0	250.0	150.0	15.0	600.0	0.01
Brown coal	(BMWA 1990) [(1)]	0	170.0	150.0	23.0	630.0	0.02
Brown coal briquettes	(BMWA 1990) [(1)]	0	170.0	150.0	23.0	630.0	0.02
Coke oven coke	(BMWA 1990) [(1)]	119	220.0	150.0	8.0	500.0	0.01
Residual fuel oil < 1% S	(BMWA 1996) [(1)]	39	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA 1996) [(1)]	2	235.0	15.0	8.0	398.0	2.70
Heating oil	(BMWA 1996) [(2)]	73	65.0	15.0	4.8	0.5	2.70
Kerosene	(BMWA 1996) [(6)]	0	118.0	15.0	4.8	92.0	2.7
LPG	(BMWA 1996) [(3, 8)]	127	41.0	5.0	0.5	6.0[(4)]	1.00
Natural Gas	(BMWA 1996) [(1)]	12 667	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)]	0	110.0	370.0	5.00	11.0	5.00
Solid biomass	(BMWA 1996) [(1)]	319	143.0	72.00	5.0	60.0	5.00
Biogas	(BMWA 1990) [(5)]	64	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 2016 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 105: 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
1991	23.58	6.59	5.05	10.28	-	1.67
1992	23.29	5.76	6.28	9.37	-	1.88
1993	23.50	6.89	5.07	9.73	-	1.82
1994	23.97	7.82	3.98	10.22	-	1.94
1995	22.07	4.37	4.63	11.10	-	1.98
1996	22.97	3.32	5.55	11.93	-	2.17

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**
1997	24.60	3.40	5.85	13.25	-	2.10
1998	24.58	3.41	5.63	12.87	-	2.66
1999	21.55	3.81	3.80	11.07	-	2.88
2000	22.79	2.32	5.34	11.57	-	3.56
2001	23.33	1.93	4.89	11.97	-	4.55
2002	25.06	3.29	3.62	13.59	-	4.56
2003	24.80	3.37	3.26	14.01	-	4.16
2004	27.60	4.46	3.03	14.77	-	5.34
2005	25.77	3.39	3.92	11.90	1.74	4.82
2006	27.23	2.54	5.71	11.54	1.56	5.89
2007	28.84	2.66	6.50	11.94	1.59	6.16
2008	28.61	2.45	6.13	11.59	3.34	5.10
2009	24.43	1.97	4.61	9.67	3.11	5.08
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
Trend 1990–2019	**18.6%**	**-81.6%**	**-56.8%**	**25.0%**	**-**	**501.5%**
Trend 2018–2019	**-0.4%**	**-18.1%**	**2.0%**	**4.2%**	**-2.9%**	**-3.9%**

Table 106 shows total fuel consumption and emissions of main pollutants for sub categories of *1.A.2.f Non-metallic Minerals* for the year 2018.

Table 106: NFR 1.A.2.f Non-metallic Minerals - Fuel consumption and emissions of main pollutants by sub category for the year 2019.

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	13 667	2.04	3.48	0.15	0.21	0.151	IE in 2A1
SNAP 030312 Lime Production	2 966	0.84	0.12	0.01	0.17	0.003	IE in 2A2
SNAP 030317 Glass Production	3 472	0.58	0.02	0.00	0.16	0.003	0.001
SNAP 030319 Bricks and Tiles Production	3 161	0.80	0.09	0.01	0.19	0.005	0.039
SNAP 030323 Magnesia Production	4 427	1.24	0.11	0.01	0.05	0.005	0.025
Total	**27 692**	**5.50**	**3.82**	**0.17**	**0.79**	**0.167**	**0.065**

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, 2010–2020). Table 107 shows detailed fuel consumption data for 2019.

Table 107: Cement clinker manufacturing industry. Fuel consumption for the year 2019.

Fuel	Activity [TJ]
Hard coal	856
Brown coal	1 195
Petrol coke	415
Residual fuel oil < 1% S	10
Residual fuel oil 0.5% S	0
Residual fuel oil ≥ 1% S	56
Heating oil	22
Natural Gas	441
Industrial waste	7 805
Pure biogenic residues	2 868
Total	**13 667**

HCB accidental release

Within the period, 2012 to 2014 high amounts of HCB were released from a cement plant unintentionally[80]. 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 108: 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 109. Heavy metals emission factors are presented in the following subchapter. Fuel consumption and main pollutant emission factors are presented in Table 111.

Table 109: Lime production.

Year	Lime [kt]	Year	Lime [kt]
1990	513	2005	788
1991	477	2006	781
1992	462	2007	816
1993	480	2008	846
1994	519	2009	695
1995	523	2010	765
1996	505	2011	810
1997	550	2012	761
1998	595	2013	779
1999	596	2014	787
2000	654	2015	772
2001	667	2016	773
2002	719	2017	775
2003	754	2008	735
2004	786	2019	783

80 http://www.ktn.gv.at/302524_DE-HCB-Messberichte

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 111. Table 110 shows the sum of flat and packaging glass production data. The share of flat glass in total glass production is about 5%.

Table 110: Glass production.

Year	Glass [kt]	Year	Glass [kt]
1990	399	2005	418
1991	459	2006	448
1992	406	2007	497
1993	406	2008	504
1994	435	2009	443
1995	435	2010	498
1996	435	2011	474
1997	406	2012	472
1998	406	2013	487
1999	445	2014	497
2000	375	2015	497
2001	441	2016	481
2002	389	2017	502
2003	477	2018	487
2004	357	2019	526

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 2019 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 111 presents fuel consumption and main pollutant emission factors.

1.A.2.f Fuel consumption and main pollutant emission factors

Table 111 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 111: NFR 1.A.2.f main pollutant emission factors and fuel consumption for the year 2019 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)]	270	170.0	150.0	23.0	630.0	0.02
Petrol coke	(BMWA 1990) [(1)]	0	220.0	150.0	8.0	323.0[(8)]	0.01
Residual fuel oil < 1% S	(BMWA 1996) [(1)]	0	235.0	15.0	8.0	398.0	2.70
Heating oil	(BMWA 1996) [(2)]	2	65.0	15.0	4.8	0.5	2.70
Natural Gas	(BMWA 1996) [(1)]	2 694	294.0[(5)]	30.0[(6)]	0.5	0.3[(10)]	1.00
Industrial waste	(BMWA 1990) [(1)]	0	100.0	200.0	38.0	130.0	0.02
SNAP 030317 Glass manufacturing							
Residual fuel oil	(BMWA 1996) [(1)]	1	299.1[(11)]	15.0	8.0	442.9[(7)]	2.70
LPG	(BMWA 1996) [(3)]	0		5.0	0.5	44.9[(7)]	1.00
Natural Gas	(BMWA 1996) [(1)]	3 470	167.2[(12)]	5.0	0.5	44.9[(7)]	1.00
SNAP 030319 Bricks and tiles manufacturing							
Brown coal	(BMWA 1990) [(1)]	133	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)]	53	220.0	150.0	8.0	323.0[(8)]	0.01
Residual fuel oil < 1% S	(BMWA 1996) [(1)]	1	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA 1996) [(1)]	106	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)]	0	41.0	5.0	0.5	6.0[(4)]	1.00
Natural Gas	(BMWA 1996) [(1)]	2 229	294.0[(5)]	5.0	0.5	0.3[(10)]	1.00
Industrial waste	(BMWA 1990) [(1)]	61	100.0	200.0	38.0	130.0	0.02
Solid biomass	(BMWA 1996) [(1)]	571	143.0	72.00	5.0	60.0	5.00
SNAP 030323 Magnesia Production							
Petrol coke	(BMWA 1990) [(1)]	478	220.0	150.0	8.0	81.0[(9)]	0.01
Natural Gas	(BMWA 1996) [(1)]	3 776	294.0[(5)]	5.0	0.5	0.3[(10)]	1.00
Industrial waste	(BMWA 1990) [(1)]	21	100.0	200.0	38.0	130.0	0.02
Solid biomass	(BMWA 1996) [(1)]	150	143.0	72.00	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 SO2(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 2016 Guidebook 1.A.4.b.i – table 3-13.

(11) Implied emission factor 2002.

(12) Implied emission factor 2018.

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 112 presents the industrial branches, which are considered in category 1.A.2.g.viii

Table 112: 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 113 presents the fuel consumption of category 1.A.2.g.viii by type of fuel.

Table 113: 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
1991	33.06	8.95	0.84	19.16	3.52	0.58
1992	34.04	6.96	0.35	22.92	3.09	0.71
1993	34.36	10.65	0.64	19.59	2.96	0.52
1994	35.88	8.72	0.34	23.39	2.74	0.68
1995	39.32	10.55	0.17	25.68	2.24	0.67
1996	41.84	12.96	0.23	24.39	3.51	0.74
1997	41.07	18.44	0.49	16.91	3.77	1.46
1998	36.38	15.28	0.42	16.72	2.53	1.44
1999	35.18	8.26	1.17	15.77	9.10	0.87
2000	36.45	8.15	0.29	19.31	8.26	0.44
2001	35.66	9.12	0.07	17.29	8.38	0.80
2002	32.98	6.90	0.13	17.16	8.21	0.58
2003	37.31	8.66	0.12	18.18	9.64	0.72
2004	38.55	8.86	0.13	18.38	10.07	1.11
2005	51.77	9.47	0.33	23.29	17.16	1.52
2006	53.09	9.69	0.38	23.53	17.94	1.55
2007	55.41	7.85	0.30	23.07	22.56	1.62
2008	53.26	6.69	0.31	24.25	20.67	1.34
2009	56.58	6.73	0.00	25.72	22.94	1.20
2010	59.51	6.86	-	27.93	22.87	1.85

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**
2011	58.13	7.06	-	24.40	23.75	2.92
2012	61.47	7.82	-	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	46.44	1.96	0.00	24.72	18.96	0.80
2019	39.91	1.21	-	21.09	16.32	1.29
Trend 1990–2019	**29.5%**	**-85.3%**	**-100.0%**	**15.3%**	**380.8%**	**2701.6%**
Trend 2018–2019	**-14.1%**	**-38.3%**	**-100.0%**	**-14.7%**	**-13.9%**	**60.2%**

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. 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 111.

Table 114 shows activity data and main pollutant emission factors of category 1.A.2.g.viii.

Table 114: NFR 1.A.2.g.viii main pollutant default emission factors and fuel consumption for the year 2019.

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
Residual fuel oil < 1% S	(BMWA 1996)(1)	126	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA 1996)(1)	5	235.0	15.0	8.0	398.0	2.70
Heating oil, Diesel oil	(BMWA 1996)(2)	197	65.0	15.0	4.8	0.5	2.70
LPG	(BMWA 1996)(3)	880	41.0	5.0	0.5	6.0(4)	1.00
Natural gas	(BMWA 1996)(1)	21 093	41.0	5.0	0.5	0.3(7)	1.00
Industrial waste	(BMWA 1990)(1)	1 289	100.0	200.0	0.54	11.0	0.02
Fuel wood	(BMWA 1996)(6)	13	110.0	370.0	5.00	11.0	5.00
Solid biomass	(BMWA 1996)(1)	15 977	143.0	72.00	5.0	60.0	5.00
Sewage sludge	(BMWA 1996)(1)	180	100.0	200.0	38.00	NA	0.02
Biogas	(BMWA 1990)(5)	150	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 2016 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 115: Wood processing and chipboard manufacturing emission factors and fuel consumption for the year 2018.

Fuel	Activity [TJ]	NO_x [kg/TJ]	TSP [kg/TJ]	PM_{10} [kg/TJ]	$PM_{2.5}$ [kg/TJ]
Solid biomass	18 932	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_X emission 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, 2020); in the Tables presented below implied emission factors (IEF) are given.

For the other sub categories emission factors were applied, references are provided below.

Coal

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 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 116: Cd emission factors for NFR 1.A.2 Manufacturing Industries and Construction.

Cadmium EF [mg/GJ]	**1990**	**1995**	**2019**
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)	
203C medium fuel oil		0.50 (all years)	
203D heavy fuel oil	0.75	0.50	0.50
110A petrol coke		0.1 (all years)	
Other Fuels			
111A Fuel wood 215A Black liquor	6.10	2.50	2.50
116A Wood waste 115A Industrial waste	6.10	2.35	2.35

Table 117: Hg emission factors for NFR 1.A.2 Manufacturing Industries and Construction.

Mercury EF [mg/GJ]	**1990**	**1995**	**2019**
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)	
203C medium fuel oil		0.04 (all years)	
203D heavy fuel oil		0.75 (all years)	
110A petrol coke		1.70 (all years)	
Other Fuels			
111A Fuel wood 215A Black liquor 116A Wood waste 115A Industrial waste	1.90	1.25	1.25

Table 118: Pb emission factors for NFR 1.A.2 Manufacturing Industries and Construction.

LEAD EF [mg/GJ]	**1990**	**1995**	**2019**
Coal			
102A Hard coal 107A Coke oven coke	9.00	6.00	6.00
105A Brown coal 106A brown coal briquettes	5.85	3.90	3.90

LEAD EF [mg/GJ]	1990	1995	2019
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		1.20 (all years)	
203D heavy fuel oil	0.19	0.13	0.13
110A petrol coke		6.00 (all years)	
Other Fuels			
111A Fuel wood 215A Black liquor 116A Wood waste	26.3	21.15	21.15
115A Industrial waste		72.00 (all years)	

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 119: Non-ferrous metals *production [t].*

Year	Nickel Production (SNAP 030324)
	[t]
1990	638
1995	822
2000	2 000
2010	2 000
2019	2 000

Nickel Production is taken from (ÖSTAT INDUSTRIE- UND GEWERBESTATISTIK), (EUROPEAN COMMISSION IPPC BUREAU 2000) and the nickel-institute (www.nickelinstitute.org).

Table 120: 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
1991	101	3 635
1992	83	3 820
1993	65	3 678
1994	68	3 791
1995	69	2 930
1996	65	2 916
1997	66	3 103
1998	74	2 869
1999	71	2 892
2000	75	3 053

Year	Cast Iron Production [kt]	Cement clinker [kt]
2001	75	3 061
2002	71	3 118
2003	69	3 120
2004	76	3 223
2005	76	3 221
2006	81	3 653
2007	87	3 992
2008	87	3 996
2009	54	3 428
2010	65	3 097
2011	67	3 176
2012	63	3 206
2013	67	3 156
2014	65	3 143
2015	61	3 257
2016	56	3 300
2017	61	3 313
2018	64	3 552
2019	62	3 423

Table 121: Asphalt concrete production.

Year	Asphalt concrete [kt]
1990	403
2019	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 122: 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[81]	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

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 124.

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.

[81] upper value for 1985, lower value for 2000; years in between were linearly interpolated

Table 123: 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[82].

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 gas were used.

PCB emission factors have been selected as outlined in chapter 3.1.3.

Table 124: 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 ind.	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

[82] 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.

	PCDD/F [µg/GJ]	HCB [µg/GJ]	PAK4 [mg/GJ]	PCB [µg/GJ]
Gas				
Natural gas	0.0006	0.072	0.0032 (for iron and steel) 0.055 (for pulp and paper) NA (other sub 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 125: 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 (2017 value)	0.039	5.83	1.09
030313 Asphalt concrete plants	0.014	2.8	0.15
030324 Nickel production	13	2 600–2.25[83]	–

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 1995/1997/2001/2003/2007-2011) are included in category 2.A.1.
- NFR 1.A.2.d pulp, paper and print: emission values until 2017 were taken from (AUSTROPAPIER 2002–2019) 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).

Table 126: PM emission factors for NFR 1.A.2 for the years where values have been updated and 2019.

	TSP Emission Factors [g/GJ]				PM_{10}	$PM_{2.5}$
	1990	1995	2000	2019	[%]	[%]
Gas						
Natural gas & LPG		0.5			90	75
Natural gas – Pulp & Paper (IEF)	0.20	0.10	0.06	0.78	90	75

[83] Higher value for 1995/1990, lower value for 2000

	TSP Emission Factors [g/GJ]				PM_{10}	$PM_{2.5}$
	1990	1995	2000	2019	[%]	[%]
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	6.57	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).

The most significant recalculation for the year 2018 took place for the category 1.A.2.g.viii: -0.3 kt NO_x, -0.1 kt SO_2

3.1.5 NFR 1.A.3.e.1 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 127 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 2016 table 3-17. The PCB emission factor is derived from the PCCD/F factor (see Table 89)

Table 127: NFR 1.A.3 e main pollutant emission factors and fuel consumption for the year 2019.

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]	10 870	150.0[2] 32.2[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 2019.*

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 2007–2015 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 75 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 is cross-checked with reported flue gas concentrations or mandatory limits.

3.1.7 Planned improvements

Currently no specific improvements are planned.

3.1.8 Recalculations

This chapter presents the recalculation based on revised fuel combustion activity data expressed as the difference to the previous submission.

Revision of the energy balance

The Austrian Federal statistics office ("Statistik Austria") has revised the energy balance for the years 1990 to 2018 with the following main implications for energy consumption as shown in the inventory:

- Natural gas gross inland consumption has been revised for 1999–2004 (between – 0.3 and 1.3 PJ), 2014–2016 (between 1 and 5.2 PJ) and 2018 (– 1.3 PJ). In addition, natural gas consumption has been shifted from 'energy sector use' to 'final energy consumption' for the years 1994–1996 (between 0.1 to 1.3 PJ) and 1999–2018 (up to 2.6 PJ in 2018). Final energy consumption has also been shifted to different sectors.

  For liquid fuels, gross inland consumption has been revised for the year 2018 for motor gasoline only (by – 0.2 PJ).

  In the inventory, considerable amounts of LPG fuel consumed in the period 1990–2018 have been removed from category 1.A.1.a and included in 'oil refinery' instead (use of energy sector).
- For solid fuels, gross inland consumption has been revised for the years 2017 (+ 0.2 PJ) and 2018 (+ 0.7 PJ), mainly because of an increased amount of hard coal having been moved to category 1.A.2 manufacturing industries.
- For solid biomass fuels, gross inland consumption has been revised for 2005–2018 (between – 1.7 and + 1.6 PJ). The main revisions for 2018 affect category 1.A.1.a (+ 1.1PJ from wood waste), category 1.A.2 (– 1.4 PJ from wood waste) and 1.A.4.b (– 2.6 PJ from wood waste, + 3.6 PJ from wood pellets).

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. For 1.A.1.a, a double counting of emissions from LPG has been corrected for the whole time series, mainly affecting NO_X emissions. Changes to NO_X and $PM_{2.5}$ emissions 2018 are mainly due to a revision of biomass consumption data. Changes to SO_2 emissions are mainly due to a revision of residual fuel oil as well as biomass consumption data.

3.1.9 NFR 1.A.4 Other sectors

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.

Source Description

Category *1.A.4 Oher Sectors* includes emissions from stationary fuel combustion in the small combustion sector as well as from some mobile machinery. 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 *1.A.2 Manufacturing Industries and Construction*. Information about type of heating is derived from an energy demand model for space heating based on heating market surveys 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 same ownership cannot always be made by the interviewed person or interviewers.

Table 128 presents non-combustion PM emission sources.

Table 128: $PM_{2.5}$ emissions from non-combustion sources in 2019.

Source	NFR	$PM_{2.5}$ [t]
Bonfire	1.A.4.a.i	150
Open fire pits	1.A.4.a.i	16
Barbecue	1.A.4.b.i	763
Total		**929**

Table 129 shows NFR 1.A.4 category definitions partly taken from the IPCC 2006 Guidelines.

Table 129: NFR 1.A.4 category definitions.

Code Number and Name				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 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	1	Residential: stationary	Fuel combustion in buildings. *Barbecue.*
1.A.4	b	2	Residential: Household and gardening (mobile) [84]	Fuel combusted in non-commercial mobile machinery such as for gardening and other off road vehicles.
1.A.4	c	Agriculture/Forestry/Fishing		Fuel combustion in agriculture, forestry, fishing and fishing industries such as fish farms. Activities included in ISIC Divisions 01, 02.And 05. Highway agricultural transportation is excluded.
1.A.4	c	1	Stationary	Fuels combusted in pumps, grain drying, horticultural greenhouses and other agriculture, forestry or stationary combustion in the fishing industry.
1.A.4	c	2	Off-road Vehicles and Other Machinery [84]	Fuels combusted in traction vehicles and other mobile machinery on farm land and in forests.
1.A.4	c	3	National Fishing [84]	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).

3.1.9.1 Methodology

A country specific tier 2 methodology is applied.

There are twenty-two technology and fuel dependent main sub categories (heating types) for category *1.A.4 Other sectors – stationary sources* as presented in the following table:

[84] methodologies for mobile sources are described in Chapter 3.2

Table 130: Heating types of category 1.A.4. Other sectors – stationary sources.

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, sewage sludge gas, biogas and landfill gas
#9	Forced-draft natural gas burners	Natural gas, sewage sludge gas, biogas and landfill gas
#10	LPG stoves	LPG and gas works gas
#11	LPG boilers	LPG and gas works gas
#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 wood stoves and cooking stoves and calculated separately.

For each technology fuel dependent emission factors are applied.

Activity data

Total fuel consumption for each of the sub categories of *1.A.4* is taken from the national energy balance. 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, which 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) (BMLRT 2020b, STATCUBE 2014a, 2014b, 2014c, 2020a, 2020b STATISTIK AUSTRIA 1973, 1982, 1992a, 2004, 2013, 2020a, 2020b)
- 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)
- 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) (UMWELTBUNDESAMT 2014d, E7 ENERGIE MARKT ANALYSE GMBH 2009, 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 2014)
- 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 (ZAMG 2020) and calibrated according to the energy statistics supplier to maintain consistency with fuel demand reported in (IEA JQ 2020)

Activity data by type of heating is selected as the following:

1.A.4.a.1 Commercial/Institutional: stationary

The fuel consumption reported in (IEA JQ 2020) is assigned to twenty-two heating types derived from an energy demand model for space heating based on heating market surveys and calibrated according to the energy statistics supplier (see section *Activity data* above).

Table 131: Fuel consumption from NFR 1.A.4.a.1 Commercial/Institutional: Stationary *1990–2019.*

NFR	1.A.4.a.1	1.A.4.a.1	1.A.4.a.1	1.A.4.a.1	1.A.4.a.1	1.A.4.a.1
Fuel	**(PJ)**	**liquid**	**solid**	**gaseous**	**biomass**	**other**
1990	35.39	18.66	0.96	12.60	2.06	1.11
1991	37.60	17.91	1.27	15.37	2.08	0.97
1992	45.67	18.29	0.92	23.84	1.93	0.69
1993	49.89	17.69	0.86	28.43	2.59	0.33
1994	41.22	15.57	0.80	21.83	2.50	0.51
1995	50.64	17.64	0.64	29.29	2.55	0.52
1996	50.95	23.72	0.67	23.61	2.40	0.55
1997	51.47	27.53	0.92	19.72	2.73	0.58
1998	49.02	24.73	0.74	20.23	2.71	0.61
1999	58.41	27.78	0.92	25.10	4.00	0.61
2000	47.43	17.84	1.10	23.67	4.26	0.56
2001	62.22	23.65	1.23	33.44	3.29	0.63
2002	59.20	24.92	0.86	29.67	3.13	0.62
2003	68.24	30.58	1.18	32.21	3.62	0.65

NFR	1.A.4.a.1	1.A.4.a.1	1.A.4.a.1	1.A.4.a.1	1.A.4.a.1	1.A.4.a.1
Fuel	**(PJ)**	**liquid**	**solid**	**gaseous**	**biomass**	**other**
2004	67.54	23.40	0.83	38.51	4.27	0.52
2005	54.73	26.86	0.72	23.16	2.92	1.07
2006	58.38	28.67	0.52	24.80	3.66	0.72
2007	43.90	19.87	0.41	19.38	3.91	0.33
2008	46.96	20.92	0.25	21.39	4.34	0.05
2009	37.59	16.92	0.19	16.87	3.56	0.05
2010	31.09	9.49	0.22	17.19	4.13	0.06
2011	27.33	8.83	0.15	14.99	3.32	0.05
2012	25.60	6.04	0.00	16.90	2.66	NO
2013	25.78	5.87	0.01	17.01	2.82	0.07
2014	22.72	6.01	0.00	14.27	2.36	0.08
2015	24.24	5.95	0.00	15.25	2.96	0.08
2016	22.56	5.60	NO	14.37	2.49	0.09
2017	26.08	7.73	NO	14.54	3.73	0.08
2018	26.01	6.73	NO	15.43	3.75	0.09
2019	26.92	6.72	NO	16.04	4.06	0.10
Trend 1990–2019	**-23.9%**	**-64.0%**	**-100.0%**	**27.3%**	**96.9%**	**-91.0%**
Trend 2018–2019	**3.5%**	**-0.2%**	**NO**	**3.9%**	**8.3%**	**6.5%**

Table 132: Share of 1.A.4.a heating type on fuel category for the year 2019.

Fuel	No.	Heating type	Share of heating type [% TJ]
			1.A.4.a
Light fuel oil	#1	Fuel oil boilers	100.0%
Medium fuel oil	#1	Fuel oil boilers	NO
Heavy fuel oil	#1	Fuel oil boilers	NO
Diesel	#1	Fuel oil boilers	100.0%
Petroleum	#1	Fuel oil boilers	NO
Gas oil	#2	Gas oil stoves	3.2%
	#3	Vaporizing burners	2.0%
	#4	Yellow burners	42.4%
	#5	Blue burners with conventional technology	1.5%
	#6	Blue burners with low temperature or condensing technology	50.9%
Natural gas	#7	Natural gas convectors	16.1%
	#8	Atmospheric burners	48.9%
	#9	Forced-draft natural gas burners	35.0%
Biogas and landfill gas	#8	Atmospheric burners	58.3%
	#9	Forced-draft natural gas burners	41.7%
LPG and gas works gas	#10	LPG stoves	60.2%
	#11	LPG boilers	39.8%
Fuel wood	#12	Wood stoves and cooking stoves	3.9%
	#13	Tiled wood stoves and masonry	96.1%

Fuel	No.	Heating type	Share of heating type [% TJ]
			1.A.4.a
		heaters	
	#14	Mixed-fuel wood boilers	NO
	#15	Natural-draft wood boilers	NO
	#16	Forced-draft wood boilers	NO
Wood waste	#17	Wood chips boilers with conventional technology	4.7%
	#18	Wood chips boilers with oxygen sensor emission control	42.7%
	#19	Pellet stoves	3.8%
	#20	Pellet boilers	48.8%
Hard coal and hard coal briquettes	#21	Coal stoves	NO
	#22	Coal boilers	NO
Lignite and brown coal	#21	Coal stoves	NO
	#22	Coal boilers	NO
Brown coal briquettes	#21	Coal stoves	NO
	#22	Coal boilers	NO
Coke	#21	Coal stoves	NO
	#22	Coal boilers	NO
Peat	#21	Coal stoves	NO
	#22	Coal boilers	NO
Industrial waste	#22	Coal boilers	100.0%
Charcoal	BBQ	Barbecue	100.0%

NO…not occurring (in 2019)

Table 133: NFR 1.A.4.a.1 percentual consumption by type of heating.

Fuel group	Natural Gas			Fuel Oil, LPG			Gasoil				
Heating type No.	#7	#8	#9	#1	#10	#11	#2	#3	#4	#5	#6
Year	[% TJ]			[%TJ]			[%TJ]				
1990	26.8	59.6	13.7	91.5	7.4	1.1	10.3	1.5	78.6	1.7	7.9
1991	24.8	60.0	15.2	84.6	13.3	2.1	10.3	1.5	77.1	1.8	9.4
1992	23.4	59.7	16.8	74.9	21.6	3.5	10.2	1.4	75.0	2.2	11.2
1993	21.9	59.7	18.5	72.2	23.8	4.0	10.1	1.4	73.1	2.8	12.6
1994	20.7	58.8	20.5	71.4	24.4	4.2	9.9	1.4	70.5	3.8	14.4
1995	19.3	58.1	22.5	79.2	17.6	3.1	9.8	1.3	68.0	4.9	16.0
1996	18.0	57.5	24.5	89.0	9.3	1.7	9.7	1.2	64.5	6.3	18.3
1997	17.1	56.5	26.4	80.5	16.4	3.1	9.5	1.2	61.8	7.3	20.1
1998	16.1	55.6	28.2	78.8	17.7	3.5	9.4	1.1	58.7	8.4	22.4
1999	15.3	54.6	30.1	83.4	13.8	2.8	9.2	1.1	57.2	8.9	23.6
2000	14.6	53.8	31.7	82.8	14.2	3.0	8.9	1.1	56.2	9.2	24.6
2001	14.4	52.8	32.8	85.9	11.3	2.8	8.6	1.1	55.3	9.6	25.5
2002	14.6	51.7	33.7	75.5	19.2	5.3	8.1	1.1	54.6	9.8	26.4
2003	14.5	50.9	34.6	71.1	22.1	6.8	7.6	1.1	54.5	10.0	26.9
2004	14.6	50.1	35.3	49.8	37.5	12.7	7.1	1.1	53.6	10.2	28.0
2005	14.6	49.6	35.8	51.4	35.5	13.1	6.7	1.1	53.5	9.7	29.0

Fuel group	Natural Gas			Fuel Oil, LPG			Gasoil				
Heating type No.	#7	#8	#9	#1	#10	#11	#2	#3	#4	#5	#6
Year	[% TJ]			[%TJ]			[%TJ]				
2007	14.8	49.0	36.2	68.2	22.7	9.1	6.3	1.2	53.5	9.3	29.8
2007	15.1	48.5	36.4	54.3	31.8	13.9	5.9	1.2	53.1	8.7	31.1
2008	15.1	48.2	36.7	42.0	39.5	18.4	5.5	1.3	52.6	8.1	32.5
2009	15.2	48.0	36.9	46.5	35.7	17.8	5.1	1.3	52.1	7.5	34.0
2010	15.0	47.9	37.1	7.4	60.6	32.0	4.8	1.4	51.4	6.9	35.5
2011	15.4	47.6	37.0	24.4	48.3	27.3	4.4	1.5	50.6	6.1	37.4
2012	15.4	47.6	37.0	71.1	18.1	10.8	4.1	1.5	49.8	5.3	39.2
2013	15.4	47.6	36.9	74.6	15.6	9.8	3.8	1.6	49.0	4.4	41.2
2014	16.1	47.4	36.5	82.4	10.6	7.1	3.6	1.7	48.0	3.4	43.3
2015	15.9	47.7	36.4	79.5	12.1	8.4	3.3	1.8	47.0	2.3	45.7
2016	15.8	48.9	35.4	90.2	5.8	4.0	3.2	2.2	45.7	1.7	47.1
2017	15.8	48.7	35.5	65.8	20.4	13.7	3.2	2.1	44.6	1.7	48.4
2018	16.1	48.8	35.1	49.2	30.5	20.3	3.2	2.0	43.5	1.6	49.6
2019	16.1	48.9	35.0	1.0	59.7	39.4	3.2	2.0	42.4	1.5	50.9

NO…not occurring

Table 134: NFR 1.A.4.a.1 percentual consumption by type of heating (continued).

Fuel (group)	Fuel Wood (log wood)					Wood chips, pellets and other biomass				Coal (+ Briquettes)	
Heating type No.	#12	#13	#14	#15	#16	#17	#18	#19	#20	#21	#22*
Year	[% TJ]					[%TJ]				[%TJ]	
1990	1.5	65.1	32.3	NO	1.2	89.3	10.7	NO	NO	37.8	62.2
1991	1.4	64.4	32.6	NO	1.6	77.2	11.0	0.0	11.8	44.5	55.5
1992	1.5	63.4	33.0	NO	2.2	65.0	12.8	0.0	22.2	45.0	55.0
1993	1.5	62.5	33.3	NO	2.7	55.8	13.3	0.1	30.8	54.5	45.5
1994	1.6	61.5	33.7	NO	3.3	47.4	13.9	0.4	38.2	48.2	51.8
1995	1.5	60.7	33.9	NO	3.9	40.5	14.2	0.9	44.4	44.9	55.1
1996	1.4	59.9	34.2	NO	4.5	35.2	13.7	1.5	49.6	45.2	54.8
1997	1.5	58.8	34.5	NO	5.2	30.5	13.3	2.1	54.1	50.2	49.8
1998	1.6	57.7	34.8	NO	5.8	26.3	13.0	2.6	58.1	46.4	53.6
1999	1.7	56.6	35.2	NO	6.5	22.8	12.6	3.1	61.5	51.6	48.4
2000	1.9	55.3	35.5	NO	7.3	19.5	12.4	3.6	64.6	57.2	42.8
2001	1.8	58.4	32.6	NO	7.3	21.9	16.0	3.7	58.4	57.2	42.8
2002	1.9	60.9	29.9	0.0	7.3	22.1	18.5	3.7	55.7	51.0	49.0
2003	1.8	63.7	27.2	0.1	7.2	21.6	20.5	3.7	54.3	55.7	44.3
2004	2.0	66.3	24.5	0.2	7.0	20.7	22.2	3.7	53.4	53.1	46.9
2005	1.9	69.1	22.4	0.2	6.4	10.9	14.4	4.9	69.8	36.3	63.7
2007	2.1	71.6	20.3	0.2	5.8	14.5	23.5	4.0	57.9	37.9	62.1

Fuel (group)	Fuel Wood (log wood)					Wood chips, pellets and other biomass				Coal (+ Briquettes)	
Heating type No.	#12	#13	#14	#15	#16	#17	#18	#19	#20	#21	#22*
Year	[% TJ]					[%TJ]				[%TJ]	
2007	2.4	74.0	18.2	0.2	5.2	14.7	27.5	3.8	54.0	48.3	51.7
2008	2.4	76.8	16.0	0.1	4.6	17.1	38.7	2.9	41.3	66.9	33.1
2009	2.5	79.6	13.8	0.1	3.9	13.9	38.1	3.2	44.9	63.4	36.6
2010	2.3	82.8	11.5	0.1	3.3	13.4	43.3	2.9	40.4	62.8	37.2
2011	2.8	85.4	9.2	0.1	2.6	10.6	40.4	3.2	45.8	59.9	40.1
2012	2.8	88.4	6.8	0.1	2.0	11.3	50.1	2.6	36.1	73.1	26.9
2013	2.9	91.3	4.5	0.0	1.3	9.1	45.8	3.0	42.1	9.5	90.5
2014	3.7	93.3	2.3	0.0	0.7	6.5	36.8	3.7	53.0	1.0	99.0
2015	3.5	96.5	NO	NO	NO	8.5	53.7	2.5	35.4	0.7	99.3
2016	3.4	96.6	NO	NO	NO	5.2	37.7	3.9	53.2	NO	100.0
2017	3.4	96.6	NO	NO	NO	4.3	33.7	4.5	57.5	NO	100.0
2018	3.8	96.2	NO	NO	NO	5.1	42.3	3.7	48.8	NO	100.0
2019	3.9	96.1	NO	NO	NO	4.7	42.7	3.8	48.8	NO	100.0

NO…not occurring

** including industrial waste*

1.A.4.b.1 Residential: stationary

Energy consumption by type of fuel and by type of heating is derived from an energy demand model for space heating based on heating market surveys validated with a statistical evaluation of micro census data 1990, 1992, 1999/2000, 2004, 2006, 2008, 2010, 2012, 2014, 2016 and 2018 (STATISTIK AUSTRIA 1990, 1992b, 2002, 2019). 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 *Activity data* above).

Table 135: Fuel consumption from NFR 1.A.4.b.1 Residential: stationary 1990–2019.

NFR	1.A.4.b.1	1.A.4.b.1	1.A.4.b.1	1.A.4.b.1	1.A.4.b.1	1.A.4.b.1
Fuel	(PJ)	liquid	solid	gaseous	biomass	other
1990	191.02	72.50	26.62	33.50	58.40	NO
1991	213.40	79.16	29.12	40.08	65.04	NO
1992	198.42	72.69	25.06	39.17	61.50	NO
1993	200.39	73.98	20.81	42.80	62.79	NO
1994	186.59	69.12	18.52	40.79	58.16	NO
1995	200.23	75.59	17.56	44.28	62.80	NO
1996	217.93	83.89	16.64	48.46	68.94	NO
1997	194.75	68.05	12.58	49.73	64.39	NO
1998	197.75	71.31	11.05	52.50	62.89	NO
1999	200.25	73.12	10.22	52.85	64.06	NO

NFR	1.A.4.b.1	1.A.4.b.1	1.A.4.b.1	1.A.4.b.1	1.A.4.b.1	1.A.4.b.1
Fuel	**(PJ)**	**liquid**	**solid**	**gaseous**	**biomass**	**other**
2000	190.62	72.60	9.05	48.90	60.07	NO
2001	198.47	71.55	8.57	54.56	63.79	NO
2002	187.16	68.92	6.87	51.63	59.73	NO
2003	189.06	69.07	5.78	55.09	59.11	NO
2004	183.09	66.55	5.49	54.16	56.89	NO
2005	192.43	63.88	3.97	65.71	58.86	0.00
2006	190.56	61.36	3.77	63.49	61.93	0.00
2007	177.58	53.50	3.22	57.59	63.27	0.00
2008	181.47	54.33	3.28	59.16	64.69	0.00
2009	180.26	50.63	2.39	60.39	66.85	0.00
2010	199.36	55.88	2.63	65.47	75.38	0.00
2011	179.92	48.34	1.69	58.18	71.71	0.00
2012	180.81	44.01	1.77	59.22	75.81	0.00
2013	186.20	47.32	1.35	59.83	77.69	0.00
2014	163.15	41.46	1.11	52.40	68.18	0.00
2015	173.49	43.18	0.91	56.84	72.55	0.00
2016	181.09	42.84	0.87	62.82	74.56	0.00
2017	180.66	43.35	0.96	61.50	74.85	0.00
2018	165.13	39.10	0.79	56.28	68.95	0.00
2019	169.98	39.58	0.82	59.05	70.54	0.00
Trend 1990–2019	**-11.0%**	**-45.4%**	**-96.9%**	**76.3%**	**20.8%**	**NO**
Trend 2018–2019	**2.9%**	**1.2%**	**2.8%**	**4.9%**	**2.3%**	**-5.1%**

Table 136: Share of 1.A.4.b heating type on fuel category for the year 2019.

Fuel	No.	Heating type	Share of heating type [% TJ]
			1.A.4.b
Light fuel oil	#1	Fuel oil boilers	NO
Medium fuel oil	#1	Fuel oil boilers	NO
Heavy fuel oil	#1	Fuel oil boilers	NO
Diesel	#1	Fuel oil boilers	NO
Petroleum	#1	Fuel oil boilers	NO
Gas oil	#2 #3 #4 #5 #6	Gas oil stoves Vaporizing burners Yellow burners Blue burners with conventional technology Blue burners with low temperature or condensing technology	1.7% 0.3% 44.8% 1.6% 51.6%
Natural gas	#7 #8 #9	Natural gas convectors Atmospheric burners Forced-draft natural gas burners	9.9% 46.8% 43.3%

Fuel	No.	Heating type	Share of heating type [% TJ]
			1.A.4.b
Biogas and landfill gas	#8 #9	Atmospheric burners Forced-draft natural gas burners	NO NO
LPG and gas works gas	#10 #11	LPG stoves LPG boilers	12.7% 87.3%
Fuel wood	#12 #13 #14 #15 #16	Wood stoves and cooking stoves Tiled wood stoves and masonry heaters Mixed-fuel wood boilers Natural-draft wood boilers Forced-draft wood boilers	9.0% 7.8% 46.3% 6.0% 30.9%
Wood waste	#17 #18 #19 #20	Wood chips boilers with conventional technology Wood chips boilers with oxygen sensor emission control Pellet stoves Pellet boilers	1.6% 12.6% 3.2% 82.5%
Hard coal and hard coal briquettes	#21 #22	Coal stoves Coal boilers	22.9% 77.1%
Lignite and brown coal	#21 #22	Coal stoves Coal boilers	22.9% 77.1%
Brown coal briquettes	#21 #22	Coal stoves Coal boilers	22.9% 77.1%
Coke	#21 #22	Coal stoves Coal boilers	22.9% 77.1%
Peat	#21 #22	Coal stoves Coal boilers	NO NO
Industrial waste	#22	Coal boilers	NO
Charcoal	BBQ	Barbecue	100.0%

NO…not occurring (in 2019)

Table 137: NFR 1.A.4.b.1 percentual consumption by type of heating.

Fuel (group)	Natural Gas			Fuel Oil, LPG			Gasoil				
Heating type No.	#7	#8	#9	#1	#10	#11	#2	#3	#4	#5	#6
Year	[% TJ]			[%TJ]			[%TJ]				
1990	39.1	53.5	7.5	96.3	0.8	2.8	15.0	11.0	64.8	1.5	7.7
1991	37.6	53.9	8.5	95.1	1.0	3.9	15.0	10.8	63.0	1.6	9.5
1992	36.1	54.3	9.7	94.6	1.0	4.4	14.4	10.7	61.6	1.9	11.5
1993	34.6	54.5	10.9	90.9	1.6	7.5	13.8	10.4	60.0	2.3	13.4
1994	33.0	54.7	12.2	87.6	2.1	10.4	13.3	10.1	58.4	3.0	15.2
1995	31.5	54.9	13.6	86.7	1.9	11.4	12.7	9.7	56.8	3.8	17.0
1996	30.0	55.0	15.0	85.8	1.8	12.4	12.1	9.3	55.2	4.8	18.6
1997	28.5	55.0	16.5	84.6	1.9	13.6	11.5	8.8	53.6	5.8	20.2
1998	27.0	55.0	17.9	84.2	1.8	14.0	10.9	8.4	52.6	6.5	21.5
1999	25.5	55.0	19.5	84.3	1.7	14.0	10.4	8.1	51.7	7.1	22.7
2000	24.0	55.1	20.9	80.5	2.0	17.5	10.4	7.7	50.7	7.6	23.6

Fuel (group)	Natural Gas			Fuel Oil, LPG			Gasoil				
Heating type No.	#7	#8	#9	#1	#10	#11	#2	#3	#4	#5	#6
Year	[% TJ]			[%TJ]			[%TJ]				
2001	22.5	55.3	22.2	82.9	1.6	15.5	9.1	7.6	50.6	8.0	24.7
2002	21.0	55.5	23.5	81.6	1.8	16.6	7.9	7.5	50.9	8.2	25.5
2003	19.5	55.9	24.6	85.2	1.3	13.4	6.7	7.4	51.3	8.5	26.1
2004	18.0	56.2	25.8	84.9	1.4	13.7	4.6	7.5	52.2	8.7	26.9
2005	15.8	56.7	27.5	70.1	2.6	27.3	4.0	7.2	52.3	8.3	28.1
2007	15.6	55.8	28.6	68.3	2.8	29.0	3.5	6.9	52.5	8.0	29.2
2007	15.6	54.8	29.6	59.3	3.7	37.0	2.9	6.5	52.5	7.6	30.6
2008	15.0	54.1	30.9	59.0	4.3	36.7	2.8	6.1	52.0	7.1	32.1
2009	14.5	53.3	32.2	53.5	5.9	40.6	2.7	5.6	51.5	6.6	33.7
2010	14.2	52.3	33.5	45.1	6.7	48.2	2.5	5.1	51.1	6.0	35.3
2011	14.6	50.8	34.6	32.2	9.6	58.2	2.3	4.5	50.4	5.4	37.3
2012	12.4	50.7	36.9	19.1	10.6	70.2	2.2	3.9	49.9	4.8	39.2
2013	10.4	50.3	39.3	12.3	10.9	76.8	2.2	3.3	49.2	4.1	41.2
2014	11.3	48.3	40.5	NO	15.9	84.1	2.2	2.6	48.5	3.3	43.4
2015	10.9	47.3	41.8	NO	16.8	83.2	2.0	1.8	47.8	2.5	45.9
2016	10.3	46.1	43.6	NO	14.4	85.6	2.0	0.3	47.6	1.8	48.3
2017	10.0	46.3	43.7	NO	13.3	86.7	1.9	0.3	46.7	1.7	49.4
2018	10.2	46.4	43.4	NO	13.5	86.5	1.8	0.3	45.7	1.6	50.5
2019	9.9	46.8	43.3	NO	12.7	87.3	1.7	0.3	44.8	1.6	51.6

NO…not occurring

Table 138: NFR 1.A.4.b.1 percentual consumption by type of heating (continued).

Fuel (group)	Fuel Wood (log wood)					Wood chips, pellets and other biomass				Coal (+ Briquettes)	
Heating type No.	#12	#13	#14	#15	#16	#17	#18	#19	#20	#21	#22
Year	[% TJ]					[%TJ]				[%TJ]	
1990	27.5	3.8	66.2	NO	2.5	87.9	12.1	NO	NO	30.0	70.0
1991	25.8	5.1	65.7	NO	3.4	69.9	11.8	NO	18.2	29.3	70.7
1992	23.6	6.5	65.4	NO	4.5	57.9	12.3	NO	29.8	28.6	71.4
1993	21.4	7.9	65.0	NO	5.7	49.5	13.1	NO	37.4	27.8	72.2
1994	19.7	8.8	64.5	NO	7.0	43.2	13.9	NO	42.9	27.1	72.9
1995	18.0	9.6	64.1	NO	8.2	38.6	14.5	NO	47.0	26.3	73.7
1996	16.5	10.4	63.6	NO	9.6	34.8	15.1	NO	50.1	25.6	74.4
1997	15.2	10.8	63.1	NO	10.9	31.4	15.9	NO	52.7	24.9	75.1
1998	14.1	11.0	62.6	NO	12.2	28.5	16.7	NO	54.8	24.1	75.9
1999	13.1	11.2	62.1	NO	13.6	26.0	17.5	NO	56.6	23.4	76.6
2000	13.0	11.3	60.8	NO	14.9	23.6	18.4	NO	58.1	22.7	77.3
2001	12.4	9.5	61.5	NO	16.6	27.9	25.3	0.3	46.5	21.9	78.1

Fuel (group)	Fuel Wood (log wood)					Wood chips, pellets and other biomass				Coal (+ Briquettes)	
Heating type No.	#12	#13	#14	#15	#16	#17	#18	#19	#20	#21	#22
Year	[% TJ]					[%TJ]				[%TJ]	
2002	11.5	8.0	62.2	0.1	18.2	30.9	32.1	1.2	35.9	21.2	78.8
2003	10.3	6.7	62.9	0.3	19.8	32.7	38.6	1.7	27.0	20.5	79.5
2004	10.0	6.5	62.1	0.5	20.8	28.4	38.2	1.9	31.5	19.7	80.3
2005	9.0	6.4	61.2	0.9	22.5	23.4	38.1	2.1	36.4	17.5	82.5
2007	9.5	6.9	58.4	1.6	23.7	18.4	35.6	2.4	43.6	17.6	82.4
2007	10.0	7.5	56.3	2.1	24.1	15.1	33.3	2.6	49.0	17.8	82.2
2008	9.5	7.6	55.7	2.7	24.5	13.4	34.7	2.6	49.2	15.8	84.2
2009	8.9	7.7	54.8	3.2	25.5	10.6	32.3	2.9	54.2	12.8	87.2
2010	8.7	7.8	53.7	3.6	26.2	8.4	29.1	3.2	59.3	16.9	83.1
2011	8.3	7.5	52.9	4.0	27.2	6.5	25.8	2.9	64.9	22.9	77.1
2012	8.5	7.8	51.5	4.3	27.9	4.9	22.3	2.5	70.2	22.8	77.2
2013	8.8	8.2	50.1	4.6	28.4	6.7	33.4	1.9	58.0	22.4	77.6
2014	9.1	8.6	48.8	4.8	28.7	6.0	32.9	1.9	59.1	20.6	79.4
2015	8.7	8.3	48.2	5.1	29.7	3.7	22.7	1.6	72.0	15.5	84.5
2016	9.3	8.5	47.3	5.0	29.9	3.3	23.0	2.4	71.3	19.3	80.7
2017	9.1	8.3	46.9	5.3	30.3	4.1	29.2	2.3	64.4	20.8	79.2
2018	9.0	8.1	46.7	5.6	30.6	2.5	18.3	2.8	76.4	21.8	78.2
2019	9.0	7.8	46.3	6.0	30.9	1.6	12.6	3.2	82.5	22.9	77.1

NO…not occurring

Figure 45 shows activity data of *1.A.4.b.1 Residential: stationary* by type of fuel together with the correlating heating degree days for the years 1990 to 2019 (ZAMG 2020).

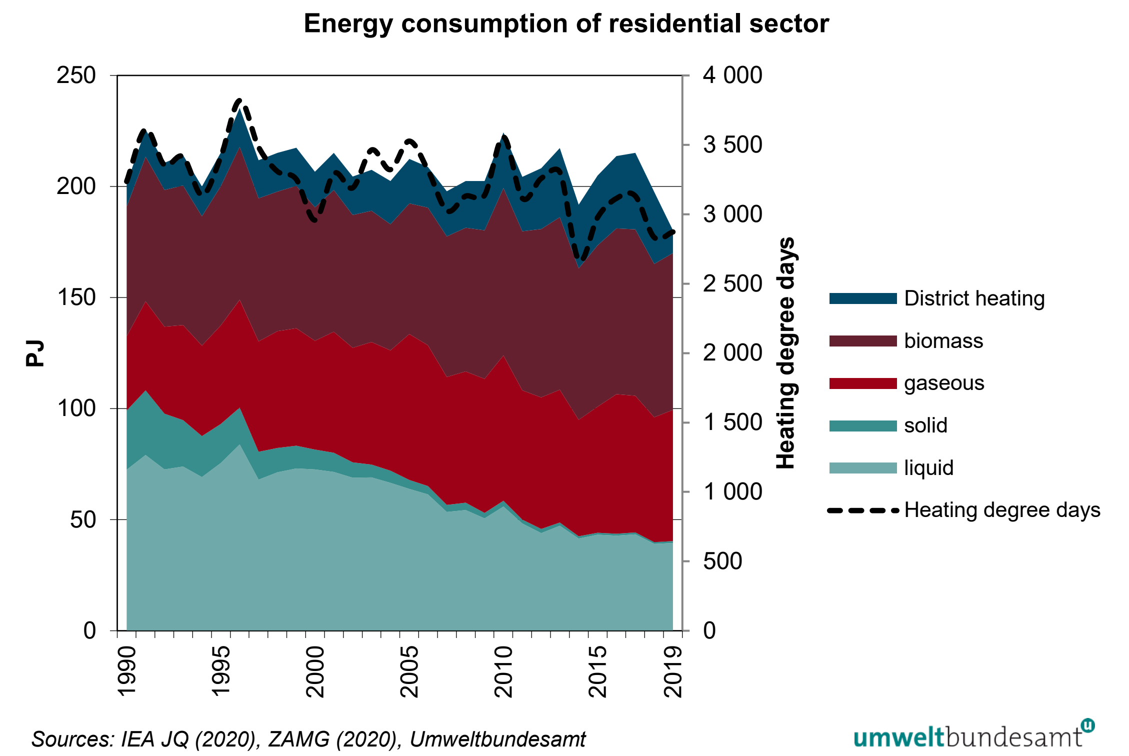


Figure 45: Energy consumption [PJ] of residential sector by type of fuel and number of heating degree days 1990–2019.

1.A.4.c.1 Agriculture/Forestry/Fishing: stationary

The fuel consumption reported in (IEA JQ 2020) for category *1.A.4.c.1* is predominantly assigned to implied emission factors derived from category *1.A.4.a.1* assuming similar structure of heating types in both categories (see section *Activity data* above).

Table 139: Fuel consumption from NFR 1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary 1990–2019.

NFR	1.A.4.c 1	1.A.4.c 1	1.A.4.c 1	1.A.4.c 1	1.A.4.c 1	1.A.4.c 1
Fuel	**(PJ)**	**liquid**	**solid**	**gaseous**	**biomass**	**other**
1990	10.26	5.34	0.55	0.37	4.01	NO
1991	10.25	4.71	0.61	0.44	4.49	NO
1992	9.50	4.21	0.56	0.43	4.29	NO
1993	8.23	2.89	0.44	0.47	4.42	NO
1994	6.96	2.10	0.39	0.45	4.01	NO
1995	7.68	2.30	0.39	0.49	4.49	NO
1996	8.46	2.60	0.37	0.55	4.95	NO
1997	8.40	2.70	0.30	0.56	4.83	NO
1998	8.28	2.87	0.24	0.61	4.56	NO
1999	9.08	3.17	0.23	0.58	5.10	NO
2000	8.46	2.79	0.18	0.54	4.95	NO
2001	9.09	2.73	0.16	0.60	5.60	NO
2002	8.32	2.28	0.12	0.56	5.36	NO
2003	8.90	2.56	0.09	0.59	5.66	NO

NFR	1.A.4.c 1	1.A.4.c 1	1.A.4.c 1	1.A.4.c 1	1.A.4.c 1	1.A.4.c 1
Fuel	**(PJ)**	**liquid**	**solid**	**gaseous**	**biomass**	**other**
2004	9.13	2.44	0.09	0.58	6.03	NO
2005	8.11	1.47	0.12	0.77	5.75	NO
2006	7.84	1.34	0.11	0.73	5.67	NO
2007	7.29	1.02	0.13	0.74	5.40	NO
2008	7.48	1.04	0.14	0.75	5.54	NO
2009	7.06	0.62	0.05	0.74	5.64	NO
2010	7.80	0.53	0.06	0.84	6.37	NO
2011	7.30	0.42	0.04	0.72	6.13	NO
2012	7.56	0.42	0.04	0.46	6.64	NO
2013	8.34	0.53	0.03	0.51	7.28	NO
2014	7.84	0.56	0.02	0.56	6.70	NO
2015	8.02	0.50	0.02	0.62	6.88	NO
2016	8.41	0.60	0.02	0.74	7.05	NO
2017	8.68	0.28	0.03	1.01	7.37	NO
2018	7.86	0.25	0.02	0.90	6.68	NO
2019	7.46	0.17	0.02	1.08	6.20	NO
Trend 1990–2019	**-27.3%**	**-96.9%**	**-96.9%**	**195.9%**	**54.7%**	**NO**
Trend 2018–2019	**-5.0%**	**-33.0%**	**-29.0%**	**19.5%**	**-7.2%**	**NO**

3.1.9.2 Emission factors for main pollutants

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.

Country specific main pollutant emission factors from national studies (BMWA 1990, 1996 and 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.

Natural gas and heating oil 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 140. The split follows closely (STANZEL et al. 1995).

Table 140: Share of CH_4 and NMVOC in VOC for small combustion devices.

	CH_4	NMVOC	VOC
Coal	25%	75%	100%
Gas oil; Kerosene	20%	80%	100%
Residual fuel oil	25%	75%	100%
Natural gas; LPG	80%	20%	100%
Biomass	25%	75%	100%

Additional literature research based on (UMWELTBUNDESAMT 2017b) was done to reflect the twenty-two technology and fuel dependent main sub categories (heating types):

- Supplemental CO emission factors are taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, 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 2013 and 2016 (EEA 2013, EEA 2016), (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 2016, 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 2016 and (LEUTGÖB et al. 2003).
- Supplemental NH_3 emission factors are taken from the EMEP/CORINAIR Emission Inventory Guidebook – 2006 and (UMWELTBUNDESAMT 1993).

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.

Table 141: Share of wood stoves and cooking stoves stock 2001–2019.

Year	Wood stoves and cooking stoves (new)		Wood stoves and cooking stoves (conventional)	
	1.A.4.a	1.A.4.b	1.A.4.a	1.A.4.b
2001	0.5%	0.4%	99.5%	99.6%
2002	1.6%	2.6%	98.4%	97.4%
2003	2.8%	4.1%	97.2%	95.9%
2004	4.2%	5.2%	95.8%	94.8%
2005	5.6%	6.4%	94.4%	93.6%
2006	6.9%	8.3%	93.1%	91.7%
2007	8.3%	10.1%	91.7%	89.9%
2008	9.7%	12.0%	90.3%	88.0%
2009	11.1%	13.8%	88.9%	86.2%
2010	12.5%	15.7%	87.5%	84.3%
2011	13.8%	17.5%	86.2%	82.5%
2012	15.2%	19.3%	84.8%	80.7%
2013	16.6%	21.2%	83.4%	78.8%
2014	18.0%	23.0%	82.0%	77.0%

Year	Wood stoves and cooking stoves (new)		Wood stoves and cooking stoves (conventional)	
	1.A.4.a	1.A.4.b	1.A.4.a	1.A.4.b
2015	19.4%	24.9%	80.6%	75.1%
2016	20.7%	26.7%	79.3%	73.3%
2017	22.1%	28.6%	77.9%	71.4%
2018	23.5%	30.4%	76.5%	69.6%
2019	24.9%	32.3%	75.1%	67.7%

Table 142: NMVOC, CH_4 and CO emission factors of category 1.A.4 new wood stoves and cooking stoves (Source: LANG et al. 2003).

Fuel	No.	NMVOC [kg/TJ]	CH_4 [kg/TJ]	CO [kg/TJ]
		1.A.4.a/b	1.A.4.a/b	1.A.4.a/b
Fuel wood	#12	338.00	115.61	2 345.30

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 and CH_4 emissions than conventional equipment. The selected factors are derived from the energy demand model for space heating.

Table 143: Share of mixed-fuel wood boilers stock 1990–2019.

Year	Mixed-fuel wood boilers (advanced)		Mixed-fuel wood boilers (conventional)	
	1.A.4.a	1.A.4.b	1.A.4.a	1.A.4.b
1990	3.8%	3.7%	96.2%	96.3%
1991	4.3%	4.2%	95.7%	95.8%
1992	4.7%	4.7%	95.3%	95.3%
1993	5.2%	5.3%	94.8%	94.7%
1994	5.7%	5.9%	94.3%	94.1%
1995	6.1%	6.4%	93.9%	93.6%
1996	6.5%	7.0%	93.5%	93.0%
1997	7.0%	7.7%	93.0%	92.3%
1998	7.4%	8.3%	92.6%	91.7%
1999	7.8%	8.8%	92.2%	91.2%
2000	8.1%	9.3%	91.9%	90.7%
2001	8.5%	9.8%	91.5%	90.2%
2002	8.7%	10.0%	91.3%	90.0%
2003	8.8%	10.2%	91.2%	89.8%
2004	8.8%	10.3%	91.2%	89.7%
2005	9.1%	10.3%	90.9%	89.7%
2006	9.2%	10.5%	90.8%	89.5%
2007	9.3%	10.6%	90.7%	89.4%
2008	9.5%	10.6%	90.5%	89.4%
2009	9.7%	10.7%	90.3%	89.3%
2010	9.8%	10.8%	90.2%	89.2%
2011	9.9%	10.9%	90.1%	89.1%

Year	Mixed-fuel wood boilers (advanced)		Mixed-fuel wood boilers (conventional)	
	1.A.4.a	1.A.4.b	1.A.4.a	1.A.4.b
2012	10.1%	11.0%	89.9%	89.0%
2013	10.2%	11.1%	89.8%	88.9%
2014	10.4%	11.2%	89.6%	88.8%
2015	10.5%	11.2%	89.5%	88.8%
2016	10.7%	11.3%	89.3%	88.7%
2017	10.8%	11.4%	89.2%	88.6%
2018	10.9%	11.4%	89.1%	88.6%
2019	11.1%	11.5%	88.9%	88.5%

Table 144: NO_x, NMVOC, CH_4 and CO emission factors of category 1.A.4 advanced mixed-fuel wood boilers (Source: BMWA 1999, EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016).

Fuel	No.	NO_x [kg/TJ]	NMVOC [kg/TJ]	CH_4 [kg/TJ]	CO [kg/TJ]
		1.A.4.a/b	1.A.4.a/b	1.A.4.a/b	1.A.4.a/b
Fuel wood	#14	107.0	350.00	121.4	3 483.00

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.

Table 145: Share of new blue burners with low temperature or condensing technology stock 2001–2019.

Year	Blue burners with low temperature or condensing technology (new)		Blue burners with low temperature or condensing technology (conventional)	
	1.A.4.a	1.A.4.b	1.A.4.a	1.A.4.b
2001	0.4%	2.5%	99.6%	97.5%
2002	1.4%	3.5%	98.6%	96.5%
2003	2.4%	4.5%	97.6%	95.5%
2004	3.8%	5.6%	96.2%	94.4%
2005	5.1%	6.6%	94.9%	93.4%
2006	6.5%	7.6%	93.5%	92.4%
2007	7.9%	8.7%	92.1%	91.3%
2008	9.3%	9.7%	90.7%	90.3%
2009	10.7%	10.7%	89.3%	89.3%
2010	12.1%	11.8%	87.9%	88.2%
2011	13.5%	12.8%	86.5%	87.2%
2012	14.8%	13.9%	85.2%	86.1%
2013	16.2%	14.9%	83.8%	85.1%
2014	17.6%	15.9%	82.4%	84.1%
2015	19.0%	17.0%	81.0%	83.0%
2016	20.4%	18.0%	79.6%	82.0%
2017	21.8%	19.1%	78.2%	80.9%
2018	23.2%	20.1%	76.8%	79.9%

Year	Blue burners with low temperature or condensing technology (new)		Blue burners with low temperature or condensing technology (conventional)	
	1.A.4.a	1.A.4.b	1.A.4.a	1.A.4.b
2019	24.6%	21.1%	75.4%	78.9%

Table 146: NO_x emission factors of category 1.A.4 new blue burners with low temperature or condensing technology (Source: LEUTGÖB et al. 2003).

Fuel	No.	NO_x [kg/TJ]
		1.A.4.a/b
Gas oil	#6	20.0

Desulphurisation of gas oil reduced the organic nitrogen content down to 10 ppm from 2009 onwards. This is reflected by lowering NO_x emission factors for all boilers burning gas oil by about 10.7% in the year 2009.

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.

Table 147: Share of new forced-draft natural gas burners stock 2001–2019.

Year	Forced-draft natural gas burners (new)		Forced-draft natural gas burners (conventional)	
	1.A.4.a	1.A.4.b	1.A.4.a	1.A.4.b
2001	0.2%	1.4%	99.8%	98.6%
2002	1.3%	2.6%	98.7%	97.4%
2003	2.2%	3.8%	97.8%	96.2%
2004	3.7%	5.5%	96.3%	94.5%
2005	5.1%	6.2%	94.9%	93.8%
2006	6.5%	7.5%	93.5%	92.5%
2007	8.0%	8.7%	92.0%	91.3%
2008	9.4%	9.9%	90.6%	90.1%
2009	10.8%	11.1%	89.2%	88.9%
2010	12.3%	12.3%	87.7%	87.7%
2011	13.7%	13.6%	86.3%	86.4%
2012	15.1%	14.8%	84.9%	85.2%
2013	16.6%	16.1%	83.4%	83.9%
2014	18.0%	17.3%	82.0%	82.7%
2015	19.4%	18.5%	80.6%	81.5%
2016	20.9%	19.7%	79.1%	80.3%
2017	22.3%	21.0%	77.7%	79.0%
2018	23.7%	22.3%	76.3%	77.7%
2019	25.2%	23.5%	74.8%	76.5%

Table 148: NO_x emission factors of category 1.A.4 new forced-draft natural gas burners (Source: LEUTGÖB et al. 2003).

Fuel	No.	NO_x [kg/TJ]
		1.A.4.a/b
Natural gas	#9	16.0

For category *1.A.4.c.1* fuel consumption reported in (IEA JQ 2020) is assigned to implied emission factors derived from category *1.A.4.a.1* assuming similar structure of heating types in both categories. Supplemental implied emission factors derived from category *1.A.4.b.1* were assigned, if no activity data for the specific fuel in category *1.A.4.a.1* occurred.

The following tables show the main pollutant emission factors by type of heating.

Table 149: NFR 1.A.4. NO_x emission factors for the year 2019.

No.	Heating type	Fuel	Emission factors NO_x [kg/TJ]		
			1.A.4.a	**1.A.4.b**	**1.A.4.c**
#1	Fuel oil boilers	Residual fuel oil Diesel Petroleum, other petroleum products	115.0 700.0 NO	NO NO NO	115.0 NO NO
#2	Gas oil stoves	Gas oil	48.0	48.0	35.8(1)
#3	Vapourizing burners	Gas oil	61.6	61.6	
#4	Yellow burners	Gas oil	37.5	37.5	
#5	Blue burners with conventional technology	Gas oil	36.6	36.6	
#6	Blue burners with low temperature or condensing technology	Gas oil	32.5	33.1	
#7	Natural gas convectors	Natural gas	51.0	51.0	41.2(1)
#8	Atmospheric burners	Natural gas Biogas and landfill gas	42.0 150.0	42.0 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	35.5 150.0	35.9 NO	
#10	LPG stoves	LPG and gas works gas	51.0	51.0	48.2(1)
#11	LPG boilers	LPG and gas works gas	44.0	44.0	
#12	Wood stoves and cooking stoves	Fuel wood Charcoal	106.0 40.0	106.0 40.0	81.0(1)
#13	Tiled wood stoves and masonry heaters	Fuel wood	80.0	80.0	
#14	Mixed-fuel wood boilers	Fuel wood	NO	122.0	
#15	Natural-draft wood boilers	Fuel wood	NO	107.0	
#16	Forced-draft wood boilers	Fuel wood	NO	80.0	
#17	Wood chips boilers with conventional technology	Wood waste	107.0	107.0	70.8(1)
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	80.0	80.0	
#19	Pellet stoves	Wood waste	60.0	60.0	
#20	Pellet boilers	Wood waste	60.0	60.0	

No.	Heating type	Fuel	Emission factors NO_x [kg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#21	Coal stoves	Hard coal and hard coal briquettes	NO	132.0	
		Lignite and brown coal	NO	132.0	
		Brown coal briquettes	NO	132.0	
		Coke	NO	132.0	
		Peat	NO	NO	90.4[1]
#22	Coal boilers	Hard coal and hard coal briquettes	NO	78.0	
		Lignite and brown coal	NO	78.0	
		Brown coal briquettes	NO	78.0	
		Coke	NO	78.0	
		Industrial waste	100.0	NO	

NO…not occurring (in 2019)

[1] Implied emission factor

Table 150: NFR 1.A.4. NMVOC emission factors for the year 2019.

No.	Heating type	Fuel	Emission factors NMVOC [kg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#1	Fuel oil boilers	Residual fuel oil	0.75	NO	0.75
		Diesel	0.80	NO	NO
		Petroleum, other petroleum products	NO	NO	NO
#2	Gas oil stoves	Gas oil	1.50	1.50	
#3	Vapourizing burners	Gas oil	0.80	0.80	
#4	Yellow burners	Gas oil	0.80	0.80	0.80
#5	Blue burners with conventional technology	Gas oil	0.51	0.51	
#6	Blue burners with low temperature or condensing technology	Gas oil	0.17	0.17	
#7	Natural gas convectors	Natural gas	2.00	2.00	
#8	Atmospheric burners	Natural gas	0.51	0.51	
		Biogas and landfill gas	0.51	NO	0.65[1]
#9	Forced-draft natural gas burners	Natural gas	0.20	0.20	
		Biogas and landfill gas	0.20	NO	
#10	LPG stoves	LPG and gas works gas	2.00	2.00	1.40[1]
#11	LPG boilers	LPG and gas works gas	0.50	0.50	
#12	Wood stoves and cooking stoves	Fuel wood	567.28	544.76	
		Charcoal	2 000.00	2 000.00	
#13	Tiled wood stoves and masonry heaters	Fuel wood	338.00	338.00	346.86[1]
#14	Mixed-fuel wood boilers	Fuel wood	NO	422.94	
#15	Natural-draft wood boilers	Fuel wood	NO	350.00	
#16	Forced-draft wood boilers	Fuel wood	NO	325.00	

No.	Heating type	Fuel	Emission factors NMVOC [kg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#17	Wood chips boilers with conventional technology	Wood waste	432.40	432.40	71.03(1)
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	78.00	78.00	
#19	Pellet stoves	Wood waste	39.00	39.00	
#20	Pellet boilers	Wood waste	32.50	32.50	
#21	Coal stoves	Hard coal and hard coal briquettes	NO	333.30	295.61(1)
		Lignite and brown coal	NO	333.30	
		Brown coal briquettes	NO	333.30	
		Coke	NO	333.30	
		Peat	NO	NO	
#22	Coal boilers	Hard coal and hard coal briquettes	NO	284.40	
		Lignite and brown coal	NO	284.40	
		Brown coal briquettes	NO	284.40	
		Coke	NO	284.40	
		Industrial waste	0.54	NO	

NO…not occurring (in 2019)

(1) Implied emission factor

Table 151: NFR 1.A.4. CO emission factors for the year 2019.

No.	Heating type	Fuel	Emission factors CO [kg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#1	Fuel oil boilers	Residual fuel oil	45.0	NO	45.0
		Diesel	15.0	NO	NO
		Petroleum, other petroleum products	NO	NO	NO
#2	Gas oil stoves	Gas oil	150.0	150.0	67.0
#3	Vapourizing burners	Gas oil	67.0	67.0	
#4	Yellow burners	Gas oil	13.0	13.0	
#5	Blue burners with conventional technology	Gas oil	5.0	5.0	
#6	Blue burners with low temperature or condensing technology	Gas oil	3.0	3.0	
#7	Natural gas convectors	Natural gas	80.0	80.0	37.0
#8	Atmospheric burners	Natural gas	48.0	48.0	
		Biogas and landfill gas	48.0	NO	
#9	Forced-draft natural gas burners	Natural gas	37.0	37.0	
		Biogas and landfill gas	37.0	NO	
#10	LPG stoves	LPG and gas works gas	80.0	80.0	37.0
#11	LPG boilers	LPG and gas works gas	50.0	50.0	

No.	Heating type	Fuel	Emission factors CO [kg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#12	Wood stoves and cooking stoves	Fuel wood	3 816.0(1)	3 671.6(1)	
		Charcoal	8 100.0	8 100.0	
#13	Tiled wood stoves and masonry heaters	Fuel wood	2 345.3(1)	2 345.3(1)	
#14	Mixed-fuel wood boilers	Fuel wood	NO	4 208.8	2 402.1(2)
#15	Natural-draft wood boilers	Fuel wood	NO	3 483.0(1)	
#16	Forced-draft wood boilers	Fuel wood	NO	3 234.2(1)	
#17	Wood chips boilers with conventional technology	Wood waste	2 400.0	2 400.0	
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	776.2(1)	776.2(1)	547.9(2)
#19	Pellet stoves	Wood waste	402.5(1)	402.5(1)	
#20	Pellet boilers	Wood waste	180.4(1)	180.4(1)	
#21	Coal stoves	Hard coal and hard coal briquettes	NO	3 705.0	
		Lignite and brown coal	NO	3 705.0	
		Brown coal briquettes	NO	3 705.0	
		Coke	NO	3 705.0	
		Peat	NO	NO	4 206.0
#22	Coal boilers	Hard coal and hard coal briquettes	NO	4 206.0	
		Lignite and brown coal	NO	4 206.0	
		Brown coal briquettes	NO	4 206.0	
		Coke	NO	4 206.0	
		Industrial waste	200.0	NO	

NO…not occurring (in 2019)

(1) CO from new biomass heatings is calculated by means of ratio of NMVOC from new by conventional heatings

(2) Implied emission factor

Table 152: NFR 1.A.4. SO_2 emission factors for the year 2019.

No.	Heating type	Fuel	Emission factors SO_2 [kg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#1	Fuel oil boilers	Residual fuel oil	90.00	NO	90.0
		Diesel	18.76	NO	NO
		Petroleum, other petroleum products	NO	NO	NO
#2	Gas oil stoves	Gas oil	0.47	0.47	
#3	Vapourizing burners	Gas oil	0.47	0.47	
#4	Yellow burners	Gas oil	0.47	0.47	0.47
#5	Blue burners with conventional technology	Gas oil	0.47	0.47	
#6	Blue burners with low temperature or condensing technology	Gas oil	0.47	0.47	

No.	Heating type	Fuel	Emission factors SO_2 [kg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#7	Natural gas convectors	Natural gas	0.30	0.30	
#8	Atmospheric burners	Natural gas Biogas and landfill gas	0.30 NA	0.30 NO	0.30
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	0.30 NA	0.30 NO	
#10	LPG stoves	LPG and gas works gas	6.00	6.00	6.00
#11	LPG boilers	LPG and gas works gas	6.00	6.00	
#12	Wood stoves and cooking stoves	Fuel wood Charcoal	11.00	11.00	
#13	Tiled wood stoves and masonry heaters	Fuel wood	11.00	11.00	11.00
#14	Mixed-fuel wood boilers	Fuel wood	NO	11.00	
#15	Natural-draft wood boilers	Fuel wood	NO	11.00	
#16	Forced-draft wood boilers	Fuel wood	NO	11.00	
#17	Wood chips boilers with conventional technology	Wood waste	11.00	11.00	
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	11.00	11.00	11.00
#19	Pellet stoves	Wood waste	11.00	11.00	
#20	Pellet boilers	Wood waste	11.00	11.00	
#21	Coal stoves	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	543.00 543.00 543.00 543.00 NO	543.00
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 130.00	543.00 543.00 543.00 543.00 NO	

NA…not applicable

NO…not occurring (in 2019)

Table 153: NFR 1.A.4. NH_3 emission factors for the year 2019.

No.	Heating type	Fuel	Emission factors NH_3 [kg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#1	Fuel oil boilers	Residual fuel oil Diesel Petroleum, other petroleum products	2.68 2.68 NO	NO NO NO	2.68 NO NO

No.	Heating type	Fuel	Emission factors NH_3 [kg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#2	Gas oil stoves	Gas oil	2.68	2.68	2.68
#3	Vapourizing burners	Gas oil	2.68	2.68	
#4	Yellow burners	Gas oil	2.68	2.68	
#5	Blue burners with conventional technology	Gas oil	2.68	2.68	
#6	Blue burners with low temperature or condensing technology	Gas oil	2.68	2.68	
#7	Natural gas convectors	Natural gas	1.00	1.00	1.00
#8	Atmospheric burners	Natural gas Biogas and landfill gas	1.00 1.00	1.00 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	1.00 1.00	1.00 NO	
#10	LPG stoves	LPG and gas works gas	1.00	1.00	1.00
#11	LPG boilers	LPG and gas works gas	1.00	1.00	
#12	Wood stoves and cooking stoves	Fuel wood Charcoal	5.00	5.00	5.00
#13	Tiled wood stoves and masonry heaters	Fuel wood	5.00	5.00	
#14	Mixed-fuel wood boilers	Fuel wood	NO	5.00	
#15	Natural-draft wood boilers	Fuel wood	NO	5.00	
#16	Forced-draft wood boilers	Fuel wood	NO	5.00	
#17	Wood chips boilers with conventional technology	Wood waste	5.00	5.00	5.00
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	5.00	5.00	
#19	Pellet stoves	Wood waste	5.00	5.00	
#20	Pellet boilers	Wood waste	5.00	5.00	
#21	Coal stoves	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	0.0089 0.023 0.023 0.0088 NO	0.016[1)]
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 0.023	0.0089 0.023 0.023 0.0088 NO	

NO…not occurring (in 2019)

(1) Implied emission factor

3.1.9.3 Emission factors for heavy metals

Fuel Oil

For fuel oil the same emission factors as for 1.A.1 were used.

Coal and Biomass

1.A.4.a.1 Commercial/Institutional: stationary and *1.A.4.b.1 Residential: stationary*

Emission factors for category *1.A.4.b* are based on findings from (HARTMANN, BÖHM & MAIER 2000), (LAUNHARDT et al. 2000), (PFEIFFER, STRUSCHKA & BAUMBACH 2000), (STANZEL et al. 1995).

1.A.4.b.1 Residential: stationary

Results of measurements (SPITZER et al. 1998): show that the TSP emission factor for stoves are about 50% higher than the emission factor for central heating boilers – thus the Cd and Pb emission factor was also assumed to be about 50% higher.

1.A.4.c.1 Agriculture/Forestry/Fishing: stationary

For deciding on an emission factor for fuel wood results from (OBERNBERGER 1995), (LAUNHARDT et al. 2000) and (FTU 2000) were considered. The emission factors for coal were derived from (CORINAIR 1995), Table 12, B112.

Natural gas

Emission factors for heating types burning natural gas, biogas and landfill gas are taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016 based on (UMWELTBUNDESAMT 2017b).

Table 154: NFR 1.A.4. Cd emission factors for the year 2019.

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Heating type</th><th rowspan="2">Fuel</th><th colspan="3">Emission factors
Cd [g/TJ]</th></tr>
<tr><th>1.A.4.a</th><th>1.A.4.b</th><th>1.A.4.c</th></tr>
<tr><td>#1</td><td>Fuel oil boilers</td><td>Residual fuel oil
Diesel
Petroleum, other petroleum products</td><td>0.05
0.02
NO</td><td>NO
NO
NO</td><td>0.05
NO
NO</td></tr>
<tr><td>#2</td><td>Gas oil stoves</td><td>Gas oil</td><td>0.02</td><td>0.02</td><td rowspan="5">0.02</td></tr>
<tr><td>#3</td><td>Vapourizing burners</td><td>Gas oil</td><td>0.02</td><td>0.02</td></tr>
<tr><td>#4</td><td>Yellow burners</td><td>Gas oil</td><td>0.02</td><td>0.02</td></tr>
<tr><td>#5</td><td>Blue burners with conventional technology</td><td>Gas oil</td><td>0.02</td><td>0.02</td></tr>
<tr><td>#6</td><td>Blue burners with low temperature or condensing technology</td><td>Gas oil</td><td>0.02</td><td>0.02</td></tr>
<tr><td>#7</td><td>Natural gas convectors</td><td>Natural gas</td><td>0.00025</td><td>0.00025</td><td rowspan="3">0.00025</td></tr>
<tr><td>#8</td><td>Atmospheric burners</td><td>Natural gas
Biogas and landfill gas</td><td>0.00025
0.00025</td><td>0.00025
NO</td></tr>
<tr><td>#9</td><td>Forced-draft natural gas burners</td><td>Natural gas
Biogas and landfill gas</td><td>0.00025
0.00025</td><td>0.00025
NO</td></tr>
<tr><td>#10</td><td>LPG stoves</td><td>LPG and gas works gas</td><td>0.02</td><td>0.02</td><td rowspan="2">0.02</td></tr>
<tr><td>#11</td><td>LPG boilers</td><td>LPG and gas works gas</td><td>0.02</td><td>0.02</td></tr>
</table>

No.	Heating type	Fuel	Emission factors Cd [g/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#12	Wood stoves and cooking stoves	Fuel wood Charcoal	4.50	4.50	7.00
#13	Tiled wood stoves and masonry heaters	Fuel wood	4.50	4.50	
#14	Mixed-fuel wood boilers	Fuel wood	NO	3.00	
#15	Natural-draft wood boilers	Fuel wood	NO	3.00	
#16	Forced-draft wood boilers	Fuel wood	NO	3.00	
#17	Wood chips boilers with conventional technology	Wood waste	7.00	3.00	7.00
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	7.00	3.00	
#19	Pellet stoves	Wood waste	4.50	4.50	
#20	Pellet boilers	Wood waste	7.00	3.00	
#21	Coal stoves	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	6.00 3.00 3.00 6.00 NO	4.55[(1)]
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 7.00	4.00 2.00 2.00 4.00 NO	

NO…not occurring (in 2019)

NE…not estimated

[(1)] Implied emission factor

Table 155: NFR 1.A.4. Hg emission factors for the year 2019.

No.	Heating type	Fuel	Emission factors Hg [g/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#1	Fuel oil boilers	Residual fuel oil Diesel Petroleum, other petroleum products	0.015 0.007 NO	NO NO NO	0.015 NO NO
#2	Gas oil stoves	Gas oil	0.007	0.007	0.007
#3	Vapourizing burners	Gas oil	0.007	0.007	
#4	Yellow burners	Gas oil	0.007	0.007	
#5	Blue burners with conventional technology	Gas oil	0.007	0.007	
#6	Blue burners with low temperature or condensing technology	Gas oil	0.007	0.007	

No.	Heating type	Fuel	Emission factors Hg [g/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#7	Natural gas convectors	Natural gas	0.10	0.10	0.10
#8	Atmospheric burners	Natural gas Biogas and landfill gas	0.10 0.10	0.10 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	0.10 0.10	0.10 NO	
#10	LPG stoves	LPG and gas works gas	0.007	0.007	0.007
#11	LPG boilers	LPG and gas works gas	0.007	0.007	
#12	Wood stoves and cooking stoves	Fuel wood Charcoal	1.90	1.90	1.90
#13	Tiled wood stoves and masonry heaters	Fuel wood	1.90	1.90	
#14	Mixed-fuel wood boilers	Fuel wood	NO	1.90	
#15	Natural-draft wood boilers	Fuel wood	NO	1.90	
#16	Forced-draft wood boilers	Fuel wood	NO	1.90	
#17	Wood chips boilers with conventional technology	Wood waste	2.00	1.90	1.90
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	2.00	1.90	
#19	Pellet stoves	Wood waste	1.90	1.90	
#20	Pellet boilers	Wood waste	2.00	1.90	
#21	Coal stoves	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	10.70 9.20 9.20 10.70 NO	9.95[(1)]
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 2.00	10.70 9.20 9.20 10.70 NO	

NO…not occurring (in 2019)

(1) Implied emission factor

Table 156: NFR 1.A.4. Pb emission factors for the year 2019.

No.	Heating type	Fuel	Emission factors Pb [g/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#1	Fuel oil boilers	Residual fuel oil Diesel Petroleum, other petroleum products	0.05 0.02 NO	NO NO NO	0.05 NO NO

No.	Heating type	Fuel	Emission factors Pb [g/TJ]		
			1.A.4.a	**1.A.4.b**	**1.A.4.c**
#2	Gas oil stoves	Gas oil	0.02	0.02	0.02
#3	Vapourizing burners	Gas oil	0.02	0.02	
#4	Yellow burners	Gas oil	0.02	0.02	
#5	Blue burners with conventional technology	Gas oil	0.02	0.02	
#6	Blue burners with low temperature or condensing technology	Gas oil	0.02	0.02	
#7	Natural gas convectors	Natural gas	0.0015	0.0015	0.0015
#8	Atmospheric burners	Natural gas Biogas and landfill gas	0.0015 0.0015	0.0015 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	0.0015 0.0015	0.0015 NO	
#10	LPG stoves	LPG and gas works gas	0.02	0.02	0.02
#11	LPG boilers	LPG and gas works gas	0.02	0.02	
#12	Wood stoves and cooking stoves	Fuel wood Charcoal	35.00	35.00	23.00
#13	Tiled wood stoves and masonry heaters	Fuel wood	35.00	35.00	
#14	Mixed-fuel wood boilers	Fuel wood	NO	23.00	
#15	Natural-draft wood boilers	Fuel wood	NO	23.00	
#16	Forced-draft wood boilers	Fuel wood	NO	23.00	
#17	Wood chips boilers with conventional technology	Wood waste	50.00	23.00	23.00
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	50.00	23.00	
#19	Pellet stoves	Wood waste	35.00	35.00	
#20	Pellet boilers	Wood waste	50.00	23.00	
#21	Coal stoves	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	135.00 33.00 33.00 135.00 NO	55.94 (1)
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 50.00	90.00 22.00 22.00 90.00 NO	

NO…not occurring (in 2019)

(1) *Implied emission factor*

3.1.9.4 Emission factors for POPs

1.A.4.a.1 Commercial/Institutional: stationary and *1.A.4.b.1 Residential: stationary*

For categories *1.A.4.a.1* and *1.A.4.b.1* the dioxin emission factors for coal and wood were taken from (HÜBNER & BOOS 2000). For vapourizing burners, tiled wood stoves and masonry heaters, natural-draft wood boilers and pellet stoves the EMEP/EEA Air Pollutant Emission Inventory

Guidebook 2016 was considered. For heating oil a mean value from (PFEIFFER et al. 2000), (BOOS & HÜBNER 1999) measurements by FTU (FTU 2000) and the EMEP/EEA Guidebook 2016 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 2019 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. 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 2019 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) or from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 starting from the year 2000 (interpolation between 1990 and 2000). This method is applied to wood stoves and cooking stoves, mixed-fuel wood boilers, natural-draft wood boilers, wood chips boilers with conventional technology and 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 tiled wood stoves and masonry heaters is set constant. The HCB emission factors for forced-draft wood boilers, pellet stoves and pellet boilers are set constant over time solely taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019.

The PAH emission factors are trimmed mean values from values given in (UBA 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 EFs, 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 PAK emission factors for vaporizing burners, wood stoves and cooking stoves, natural-draft wood boilers and pellet stoves are taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016. 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.1*, *1.A.4.b.1* and *1.A.4.c.1* were subdivided into the contributing PAH4 substances Benzo(b)fluoranthene, Benzo(a)pyrene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene considering the ratio of emission factors from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019.

PCB emission factors for or wood stoves and cooking stoves, pellet stoves, natural-draft wood boilers, coal and gasoil are selected from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016. The PCB emission factor of 3 600 µg/t for residual 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 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.

1.A.4.c.1 Agriculture/Forestry/Fishing: stationary

For oil, gas and LPG the same 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.1* 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.

Table 157: NFR 1.A.4. PCDD/F emission factors for the year 2019.

No.	Heating type	Fuel	Emission factors PCDD/F [mg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#1	Fuel oil boilers	Residual fuel oil Diesel Petroleum, other petroleum products	0.002 0.0004 NO	NO NO NO	0.0015 NO NO
#2	Gas oil stoves	Gas oil	0.0030	0.0030	0.0015
#3	Vapourizing burners	Gas oil	0.0018	0.0018	
#4	Yellow burners	Gas oil	0.0015	0.0015	
#5	Blue burners with conventional technology	Gas oil	0.0012	0.0012	
#6	Blue burners with low temperature or condensing technology	Gas oil	0.0012	0.0012	
#7	Natural gas convectors	Natural gas	0.0060	0.0060	0.0025
#8	Atmospheric burners	Natural gas Biogas and landfill gas	0.0025 0.00064(1)	0.0025 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	0.0016 0.00064(1)	0.0016 NO	
#10	LPG stoves	LPG and gas works gas	0.0030	0.0030	0.0025
#11	LPG boilers	LPG and gas works gas	0.0017	0.0025	

No.	Heating type	Fuel	Emission factors PCDD/F [mg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#12	Wood stoves and cooking stoves	Fuel wood Charcoal	0.75	0.75	0.27[(1)]
#13	Tiled wood stoves and masonry heaters	Fuel wood	0.25	0.25	
#14	Mixed-fuel wood boilers	Fuel wood	NO	0.38	
#15	Natural-draft wood boilers	Fuel wood	NO	0.10	
#16	Forced-draft wood boilers	Fuel wood	NO	0.010	
#17	Wood chips boilers with conventional technology	Wood waste	0.43	0.43	0.13[(1)]
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	0.24	0.24	
#19	Pellet stoves	Wood waste	0.10	0.10	
#20	Pellet boilers	Wood waste	0.010	0.010	
#21	Coal stoves	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	0.75 0.75 0.75 0.75 NO	0.46[(1)]
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 0.30	0.38 0.38 0.38 0.38 NO	

NO…not occurring (in 2019)

(1) Implied emission factor

Table 158: NFR 1.A.4. HCB emission factors for the year 2019.

No.	Heating type	Fuel	Emission factors HCB [mg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#1	Fuel oil boilers	Residual fuel oil Diesel Petroleum, other petroleum products	0.19 0.080 NO	NO NO NO	0.15 NO NO
#2	Gas oil stoves	Gas oil	0.30	0.30	0.15
#3	Vapourizing burners	Gas oil	0.12	0.15	
#4	Yellow burners	Gas oil	0.12	0.15	
#5	Blue burners with conventional technology	Gas oil	0.12	0.15	
#6	Blue burners with low temperature or condensing technology	Gas oil	0.12	0.15	

No.	Heating type	Fuel	Emission factors HCB [mg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#7	Natural gas convectors	Natural gas	0.60	0.60	0.25
#8	Atmospheric burners	Natural gas Biogas and landfill gas	0.14 0.074[(1)]	0.25 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	0.14 0.074[(1)]	0.25 NO	
#10	LPG stoves	LPG and gas works gas	0.30	0.30	0.25
#11	LPG boilers	LPG and gas works gas	0.14	0.25	
#12	Wood stoves and cooking stoves	Fuel wood Charcoal	145.07	140.65	101.74[(1)]
#13	Tiled wood stoves and masonry heaters	Fuel wood	100	100	
#14	Mixed-fuel wood boilers	Fuel wood	NO	158.67	
#15	Natural-draft wood boilers	Fuel wood	NO	100	
#16	Forced-draft wood boilers	Fuel wood	NO	30	
#17	Wood chips boilers with conventional technology	Wood waste	160	160	53.82[(1)]
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	100	100	
#19	Pellet stoves	Wood waste	30	30	
#20	Pellet boilers	Wood waste	5	5	
#21	Coal stoves	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	600 600 600 600 NO	600
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 250	600 600 600 600 NO	

NO…not occurring (in 2019)

(1) Implied emission factor

Table 159: NFR 1.A.4. PAH4 emission factors for the year 2019.

No.	Heating type	Fuel	Emission factors PAH4 [g/TJ]		
			1.A.4.a	**1.A.4.b**	**1.A.4.c**
#1	Fuel oil boilers	Residual fuel oil Diesel Petroleum, other petroleum products	0.24 0.16 NO	NO NO NO	0.24 NO NO
#2	Gas oil stoves	Gas oil	1.70	1.70	0.24
#3	Vapourizing burners	Gas oil	0.35	0.35	
#4	Yellow burners	Gas oil	0.24	0.24	
#5	Blue burners with conventional technology	Gas oil	0.18	0.18	
#6	Blue burners with low temperature or condensing technology	Gas oil	0.040	0.040	
#7	Natural gas convectors	Natural gas	0.20	0.20	0.056[(1)]
#8	Atmospheric burners	Natural gas Biogas and landfill gas	0.040 0.0032	0.040 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	0.010 0.0032	0.010 NO	
#10	LPG stoves	LPG and gas works gas	0.20	0.20	0.125[(1)]
#11	LPG boilers	LPG and gas works gas	0.011	0.040	
#12	Wood stoves and cooking stoves	Fuel wood	345	345	176.76[(1)]
#13	Tiled wood stoves and masonry heaters	Fuel wood Charcoal	170	170	
#14	Mixed-fuel wood boilers	Fuel wood	NO	85	
#15	Natural-draft wood boilers	Fuel wood	NO	35	
#16	Forced-draft wood boilers	Fuel wood	NO	2.0	
#17	Wood chips boilers with conventional technology	Wood waste	24	24	4.28[(1)]
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	2.0	2.0	
#19	Pellet stoves	Wood waste	35	35	
#20	Pellet boilers	Wood waste	2.0	2.0	
#21	Coal stoves	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	170 170 170 24 NO	72.54[(1)]
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 26	85 85 85 12 NO	

NO…not occurring (in 2019)

(1) Implied emission factor

Table 160: NFR 1.A.4.a.1 share of total PAH4 emissions 2019.

No.	Heating type	PAH4 emission share [%]			
		Benzo_a	Benzo_b	Benzo_k	Indeno_k
#1	Fuel oil boilers	30.8%	34.6%	23.1%	11.5%
#2	Gas oil stoves	22.9%	11.4%	20.0%	45.7%
#3	Vapourizing burners	22.9%	11.4%	20.0%	45.7%
#4	Yellow burners	22.9%	11.4%	20.0%	45.7%
#5	Blue burners with conventional technology	22.9%	11.4%	20.0%	45.7%
#6	Blue burners with low temperature or condensing technology	22.9%	11.4%	20.0%	45.7%
#7	Natural gas convectors	18.2%	27.3%	27.3%	27.3%
#8	Atmospheric burners	18.2%	27.3%	27.3%	27.3%
#9	Forced-draft natural gas burners	18.2%	27.3%	27.3%	27.3%
#10	LPG stoves	22.9%	11.4%	20.0%	45.7%
#11	LPG boilers	22.9%	11.4%	20.0%	45.7%
#12	Wood stoves and cooking stoves	35.1%	32.2%	12.2%	20.6%
#13	Tiled wood stoves and masonry heaters	28.6%	45.7%	14.3%	11.4%
#14	Mixed-fuel wood boilers	NO	NO	NO	NO
#15	Natural-draft wood boilers	NO	NO	NO	NO
#16	Forced-draft wood boilers	NO	NO	NO	NO
#17	Wood chips boilers with conventional technology	28.6%	45.7%	14.3%	11.4%
#18	Wood chips boilers with oxygen sensor emission control	28.6%	45.7%	14.3%	11.4%
#19	Pellet stoves	28.6%	45.7%	14.3%	11.4%
#20	Pellet boilers	28.6%	45.7%	14.3%	11.4%
#21	Coal stoves	NO	NO	NO	NO
#22	Coal boilers	38.0%	35.2%	14.1%	12.7%

NO…not occurring (in 2019)

Table 161: NFR 1.A.4.b.1 share of total PAH4 emissions 2019.

No.	Heating type	PAH4 emission share [%]			
		Benzo_a	Benzo_b	Benzo_k	Indeno_k
#1	Fuel oil boilers	NO	NO	NO	NO
#2	Gas oil stoves	22.9%	11.4%	20.0%	45.7%
#3	Vapourizing burners	22.9%	11.4%	20.0%	45.7%
#4	Yellow burners	22.9%	11.4%	20.0%	45.7%
#5	Blue burners with conventional technology	22.9%	11.4%	20.0%	45.7%
#6	Blue burners with low temperature or condensing technology	22.9%	11.4%	20.0%	45.7%

No.	Heating type	PAH4 emission share [%]			
		Benzo_a	Benzo_b	Benzo_k	Indeno_k
#7	Natural gas convectors	18.2%	27.3%	27.3%	27.3%
#8	Atmospheric burners	18.2%	27.3%	27.3%	27.3%
#9	Forced-draft natural gas burners	18.2%	27.3%	27.3%	27.3%
#10	LPG stoves	22.9%	11.4%	20.0%	45.7%
#11	LPG boilers	22.9%	11.4%	20.0%	45.7%
#12	Wood stoves and cooking stoves	35.1%	32.2%	12.2%	20.6%
#13	Tiled wood stoves and masonry heaters	28.6%	45.7%	14.3%	11.4%
#14	Mixed-fuel wood boilers	35.1%	32.2%	12.2%	20.6%
#15	Natural-draft wood boilers	35.1%	32.2%	12.2%	20.6%
#16	Forced-draft wood boilers	9.8%	15.7%	4.9%	69.6%
#17	Wood chips boilers with conventional technology	35.1%	32.2%	12.2%	20.6%
#18	Wood chips boilers with oxygen sensor emission control	28.6%	45.7%	14.3%	11.4%
#19	Pellet stoves	28.6%	45.7%	14.3%	11.4%
#20	Pellet boilers	28.6%	45.7%	14.3%	11.4%
#21	Coal stoves	27.2%	43.5%	16.3%	13.0%
#22	Coal boilers	38.0%	35.2%	14.1%	12.7%

NO…not occurring (in 2019)

Table 162: NFR 1.A.4. PCB emission factors for the year 2019.

No.	Heating type	Fuel	Emission factors PCB [mg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#1	Fuel oil boilers	Residual fuel oil Diesel Petroleum, other petroleum products	NA NA NO	NO NO NO	NA NO NO
#2	Gas oil stoves	Gas oil	NA	NA	NA
#3	Vapourizing burners	Gas oil	NA	NA	
#4	Yellow burners	Gas oil	NA	NA	
#5	Blue burners with conventional technology	Gas oil	NA	NA	
#6	Blue burners with low temperature or condensing technology	Gas oil	NA	NA	
#7	Natural gas convectors	Natural gas	NA	NA	NA
#8	Atmospheric burners	Natural gas Biogas and landfill gas	NA NA	NA NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	NA NA	NA NO	
#10	LPG stoves	LPG and gas works gas	NA	NA	NA
#11	LPG boilers	LPG and gas works gas	NA	NA	

No.	Heating type	Fuel	Emission factors PCB [mg/TJ]		
			1.A.4.a	1.A.4.b	1.A.4.c
#12	Wood stoves and cooking stoves	Fuel wood Charcoal	0.0675	0.0675	0.0242[(1)]
#13	Tiled wood stoves and masonry heaters	Fuel wood	0.0225	0.00225	
#14	Mixed-fuel wood boilers	Fuel wood	NO	0.0342	
#15	Natural-draft wood boilers	Fuel wood	NO	0.009	
#16	Forced-draft wood boilers	Fuel wood	NO	0.00090	
#17	Wood chips boilers with conventional technology	Wood waste	0.0387	0.0387	0.0118[(1)]
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	0.0216	0.0216	
#19	Pellet stoves	Wood waste	0.009	0.009	
#20	Pellet boilers	Wood waste	0.0009	0.0009	
#21	Coal stoves	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	170 170 170 170 NO	170
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 0.027	170 170 170 170 NO	

NO…not occurring (in 2019)

NA…not applicable

(1) Implied emission factor

3.1.9.5 Emission factors for PM

1.A.4.a.1 Commercial/Institutional: stationary and *1.A.4.b.1 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).

For categories *1.A.4.a.1* and *1.A.4.b.1* additional PM emission factors were taken from the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, the Fact Sheet of the Swiss Federal Office for the Environment (FOEN 2015), (GERMAN ENVIRONMENT AGENCY 2008) and (UMWELTBUNDESAMT 2006a) based on literature research (UMWELTBUNDESAMT 2017b) to reflect 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).

Mixed-fuel wood boilers stock with (comparatively) advanced technology is considered with (slightly) lower PM emissions than conventional equipment. The biomass share is given in Table 144.

Table 163: PM emission factors of category 1.A.4 advanced mixed-fuel wood boilers (Source: EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016).

Fuel	No.	PM [kg/TJ]
		1.A.4.a/b
Fuel wood	#14	100.0

The PM emission estimates for categories *1.A.4.a.1* and *1.A.4.b.1* 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).

1.A.4.c.1 Agriculture/Forestry/Fishing: stationary

All emission factors are derived from category *1.A.4.a.1* 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.

The PM emission estimates for category *1.A.4.c.1* 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).

Table 164: NFR 1.A.4. PM emission factors for the year 2019.

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Heating type</th><th rowspan="2">Fuel</th><th rowspan="2">Condensable fraction</th><th colspan="3">Emission factors PM [kg/TJ]</th></tr>
<tr><th>1.A.4.a</th><th>1.A.4.b</th><th>1.A.4.c</th></tr>
<tr><td>#1</td><td>Fuel oil boilers</td><td>Residual fuel oil[85]
Diesel[86]
Petroleum, other petroleum products</td><td>unknown
unknown
NO</td><td>6.67
50
NO</td><td>NO
NO
NO</td><td>6.67
NO
NO</td></tr>
<tr><td>#2</td><td>Gas oil stoves</td><td>Gas oil[87]</td><td>unknown</td><td>3.0</td><td>3.0</td><td rowspan="5">2.22 (1)</td></tr>
<tr><td>#3</td><td>Vapourizing burners</td><td>Gas oil[87]</td><td>unknown</td><td>3.0</td><td>3.0</td></tr>
<tr><td>#4</td><td>Yellow burners</td><td>Gas oil[87]</td><td>unknown</td><td>3.0</td><td>3.0</td></tr>
<tr><td>#5</td><td>Blue burners with conventional technology</td><td>Gas oil[88]</td><td>excluded</td><td>2.0</td><td>2.0</td></tr>
<tr><td>#6</td><td>Blue burners with low temperature or condensing technology</td><td>Gas oil[88]</td><td>excluded</td><td>1.5</td><td>1.5</td></tr>
</table>

85 EMEP/EEA Guidebook 2016, Table 3-30 Non-residential sources, medium-sized (> 50 kWth to ≤ 1 MWth) boilers liquid fuels

86 For diesel a value similar to locomotive diesel engines has been selected

87 WINIWARTER et al. (2001)

88 EMEP/EEA Guidebook 2016, Table 3-21 Boilers burning liquid fuels

No.	Heating type	Fuel	Conden-sable fraction	Emission factors PM [kg/TJ]		
				1.A.4.a	1.A.4.b	1.A.4.c
#7	Natural gas convectors	Natural gas[89]	excluded	2.20	2.20	0.68[(1)]
#8	Atmospheric burners	Natural gas[87] Biogas and landfill gas[87]	unknown unknown	0.50 0.50	0.50 NO	
#9	Forced-draft natural gas burners	Natural gas[90] Biogas and landfill gas[90]	unknown unknown	0.20 0.20	0.20 NO	
#10	LPG stoves	LPG and gas works gas[91]	unknown	2.20	2.20	1.52[(1)]
#11	LPG boilers	LPG and gas works gas[87]	unknown	0.50	0.50	
#12	Wood stoves and cooking stoves	Fuel wood[92] Charcoal[92]	included	148	148	101.85[(1)]
#13	Tiled wood stoves and masonry heaters	Fuel wood[93]	unknown	100	100	
#14	Mixed-fuel wood boilers	Fuel wood[94]	included	NO	122.1	
#15	Natural-draft wood boilers	Fuel wood[95]	excluded	NO	75	
#16	Forced-draft wood boilers	Fuel wood[93]	unknown	NO	50	
#17	Wood chips boilers with conventional technology	Wood waste[93]	unknown	100	100	38.61[(1)]
#18	Wood chips boilers with oxygen sensor emission control	Wood waste[92]	included	55	55	
#19	Pellet stoves	Wood waste[92]	included	30	30	
#20	Pellet boilers	Wood waste[96]	unknown	19	19	
#21	Coal stoves	Hard coal and hard coal briquettes[87] Lignite and brown coal[87] Brown coal briquettes[87] Coke[87] Peat[87]	unknown unknown unknown unknown unknown	NO NO NO NO NO	153 153 153 153 NO	107.52[(1)]
#22	Coal boilers	Hard coal and hard coal briquettes[87] Lignite and brown coal[87]	unknown unknown	NO NO	94 94	

89 EMEP/EEA Guidebook 2016, Table 3-13 Fireplaces burning natural gas

90 EMEP/EEA Guidebook 2016, Table 3-19 Boilers burning natural gas

91 EMEP/EEA Guidebook 2016, Table 3-20 Stoves burning liquid fuels

92 WINIWARTER et al. (2007): The condensable fraction was considered, if data options were available.

93 FOEN (2015)

94 EMEP/EEA Guidebook 2016, Table 3-24 Advanced / ecolabelled stoves and boilers burning wood

95 EMEP/EEA Guidebook 2016, Table 3-34 Non-residential sources, manual boilers burning wood

96 GERMAN ENVIRONMENT AGENCY (2008)

No.	Heating type	Fuel	Condensable fraction	Emission factors PM [kg/TJ]		
				1.A.4.a	1.A.4.b	1.A.4.c
		Brown coal briquettes[87]	unknown	NO	94	
		Coke[87]	unknown	NO	94	
		Industrial waste[87]	unknown	55	NO	

NO…not occurring (in 2019)

(1) Implied emission factor

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.

3.1.9.6 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*.

1.A.4.a.1 Commercial/Institutional: stationary and *1.A.4.b.1 Residential: stationary*

The HCB biomass emission factors have been revised due to significant deviation between the results from national measurements (HÜBNER et al. 2002) and the recommended value according to EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019. For further information, see chapter 3.1.9.4.

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, abrasion of brake and tyre wear and dust dispersion of dust by road traffic in the subcategories.

Table 165: 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.vii**		
		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 cm^3
		0705	Motorcycles > 50 cm^3
• 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**	0810	Pipelines compressors and other transportation

Activity	NFR Category	SNAP	
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 166 provides information on the status of emission estimates of all sub categories. A "✓" indicates that emissions from this sub category have been estimated. Table 165 provides an overview about NFR categories and the corresponding SNAP codes.

Table 166: 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 Other transportation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
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 167.

Table 167: Key sources of sector Transport.

NFR Category	Category Name	Key Categories	
		pollutant	KS Assessment
1.A.3.b.1	R.T., Passenger cars	NO_x, NMVOC[1)], CO, Pb[1)], TSP, PM_{10}, $PM_{2.5}$	LA, TA
1.A.3.b.2	R.T., Light duty vehicles	NO_x[2)], TSP[1)], PM_{10}[1)], $PM_{2.5}$[1)]	LA, TA
1.A.3.b.3	R.T., Heavy duty vehicles	SO_2[1)],NO_x, TSP[1)], PM_{10}[1)], $PM_{2.5}$	LA, TA
1.A.3.b.5	R.T., Gasoline evaporation	NMVOC[1)]	TA
1.A.3.b.6	R.T., Automobile tyre and break wear	Pb[2)], TSP, PM_{10}, $PM_{2.5}$[2)]	LA, TA
1.A.3.b.7	R.T., Automobile road abrasion	TSP, PM_{10}[2)], $PM_{2.5}$[2)]	LA, TA
1.A.3.c	Railways	TSP[2)], PM_{10}[2)], $PM_{2.5}$[2)]	LA
1.A.4.c.2	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	NO_x, TSP[1)], PM_{10}, $PM_{2.5}$	LA, TA

LA = Level Assessment (if not further specified – for the years 1990 and 2019)

TA = Trend Assessment 1990-2019

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 air pollutant emission inventory guidebook 2019 (EEA – EUROPEAN ENVIRONMENT AGENCY (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 168: 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

Sector	Pollutant	Uncertainty Activity Data [%]	Uncertainty Emission Factor [%]	Combined uncertainties [%]
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
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	2.0	125.0	125.02
	NO_x	2.0	10.0	10.20
	NMVOC	2.0	200.0	200.01
	NH_3	2.0	750.0	750.00
	$PM_{2.5}$	2.0	125.0	125.02

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 2020 submission Austria used two different methodologies for calculating emissions of IFR flights:

- Tier 3 B: 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, M. & KUDRNA, M. 2002). This methodology was consistent with the very detailed IPCC 2006 GL Tier 3B methodology (advanced version based on the MEET model (MEET – METHODOLOGY FOR CALCULATING TRANSPORT EMISSIONS AND ENERGY CONSUMPTION (KALIVODA, M. & KUDRNA, M. 1997)). For emission calculation air traffic movement data[97] (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 3 A 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. Due to the lack of consistent data Austria was not able to use overlap or surrogate techniques. Therefore the ratio of kerosene used for each type of flight movement (i.e. dom. LTO, dom. cruise, internat. LTO, intern. cruise) was determined for the years 2000-2002 and the average calculated. These shares were multiplied with the total emissions for each year (1990-1999) from the study of Kalivoda and Kudrna (KALIVODA, M. & KUDRNA, M. (2002)) to receive the emissions for each type of flight movement. Based on the total amount of kerosene used in each year during the period 1990-1999 kerosene used for each type of flight movement was determined analogically.

VFR – Visual Flight Rules

The EMEP/EEA 2019 (EEA – EUROPEAN ENVIRONMENT AGENCY (2019)) simple methodology (Tier 1, fuel-based methodology) is applied.

Activity Data

Fuel consumption (kerosene and gasoline) for *1.A.3.a Civil Aviation – LTO* is presented below.

Table 169: Activities for 1.A.3.a.ii Civil Aviation – LTO: 1990–2019.

Year	Activity		
	dom. LTO (VFR)	dom. LTO (IFR)	int. LTO (IFR)
	Gasoline [TJ]	Kerosene [TJ]	Kerosene [TJ]
1990	103	127	1 599
1991	106	143	1 797
1992	109	156	1 953
1993	113	165	2 073

[97] This data is also used for the split between domestic and international aviation.

Year	Activity		
	dom. LTO (VFR)	dom. LTO (IFR)	int. LTO (IFR)
	Gasoline [TJ]	Kerosene [TJ]	Kerosene [TJ]
1994	116	172	2 162
1995	93	193	2 420
1996	89	213	2 675
1997	100	222	2 790
1998	108	231	2 893
1999	115	226	2 835
2000	84	265	2 890
2001	77	217	2 743
2002	99	226	3 207
2003	107	221	3 342
2004	99	237	3 987
2005	115	225	3 714
2006	119	269	3 680
2007	118	274	3 979
2008	121	305	4 044
2009	135	280	3 700
2010	121	267	3 794
2011	182	231	4 314
2012	105	232	4 147
2013	108	232	4 035
2014	99	211	4 080
2015	111	205	4 309
2016	135	203	4 406
2017	98	189	4 267
2018	96	221	4 639
2019	92	226	5 252
1990–2019	-11%	78%	229%

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 national LTO, IFR international LTO, IFR national 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 was adjusted as explained below

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[98], 2009, 2010, 2011, 2012, 2013, 2014, 2015). In addition, domestic flight movements were compared with a second data source for flight movements, Austrocontrol (AUSTROCONTROL 2007[99], 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015) and increased to meet these number flight movements.

Distances between airport pairs have been extracted based on IATA codes from single queries on the internet.[100]

Beginning with the inventory year 2016 flight movements have only been taken from Austrocontrol (AUSTROCONTROL 2016, 2017, 2018, 2019), as they seem to be more representative compared with international data.

The distance between departure and arrival aerodrome has been calculated by an automatic distance generator using following formula:

$$D = r * \arccos(\sin(\pi*\varphi(A)/180) * \sin(\pi*\varphi(B)/180) * \cos(\pi*\varphi(A)/180) * \cos(\pi*\varphi(B)/180) * \cos(\pi*(\lambda(A)-\lambda(B))/180))$$

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 has been 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).

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[98] for the years 2000-2007

[99] for the years 2000-2006

[100] www.world-airport-codes.com

Table 170: Fuel consumption for national/intern. LTO cycles and number of IFR LTO cycles: 1990–2019.

Year	Activity			
	nat. LTO (IFR) Kerosene [kt]	**nat. LTO (IFR) [flight mvts]**	**int. LTO (IFR) Kerosene [kt]**	**int. LTO (IFR) [flight mvts]**
1990	2.94	-	36.90	-
1991	3.31	-	41.49	-
1992	3.59	-	45.09	-
1993	3.81	-	47.84	-
1994	3.98	-	49.91	-
1995	4.45	-	55.87	-
1996	4.92	-	61.76	-
1997	5.13	-	64.40	-
1998	5.32	-	66.79	-
1999	5.21	-	65.44	-
2000	6.11	22 611	66.71	95 033
2001	5.01	20 325	63.33	97 740
2002	5.21	21 422	74.04	95 961
2003	5.10	20 243	77.15	97 873
2004	5.47	20 175	92.03	110 470
2005	5.20	20 179	85.74	117 837
2006	6.20	20 727	84.94	120 757
2007	6.33	20 740	91.85	129 737
2008	7.04	21 457	93.35	132 466
2009	6.46	20 530	85.41	120 723
2010	6.16	20 532	87.57	123 759
2011	5.32	16 185	99.58	140 058
2012	5.37	16 405	95.73	135 691
2013	5.35	15 741	93.14	129 500
2014	4.87	14 776	94.11	130 674
2015	4.73	13 282	99.39	129 921
2016	4.70	15 515	101.76	151 241
2017	4.37	14 781	98.55	145 143
2018	5.11	19 735	107.15	157 722
2019	5.22	19 679	121.06	170 242
1990–2019	77%	-13%	228%	79%

VFR flights

Fuel consumption for VFR flights were directly obtained from the energy balance, as total fuel consumption for this flight mode is represented by the total amount of aviation gasoline sold in Austria.

Table 171: Fuel consumption for VFR flights: 1990–2019.

Year	**Activity**
	VFR flights Gasoline [kt]
1990	2.49
1991	2.56
1992	2.64
1993	2.72
1994	2.81
1995	2.24
1996	2.15
1997	2.42
1998	2.60
1999	2.77
2000	2.04
2001	1.87
2002	2.39
2003	2.60
2004	2.41
2005	2.79
2006	2.87
2007	2.86
2008	2.94
2009	3.27
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
1990–2019	-12%

Emission Factors

IFR flights

The EFs from the old CORINAIR Guidebook 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.

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:

$FC/LTO = Sum\ FC\_LTO_{unknown} / Sum\ flights\ movements_{unknown}$

For $Cruise_{unknown}$ the equation is:

$FC/km = (Sum\ FC\_cruise_{unknown} / sum\ nm\ cruise_{unknown}) * 125$

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 (1kg/t fuel for LTO and cruise).

For the years from 2016 onwards EFs from Annex 5 of the EMEP/EEA 2019 Guidebook (EEA – EUROPEAN ENVIRONMENT AGENCY (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 – EUROPEAN ENVIRONMENT AGENCY (2019)) per aircraft type and distance class are applied.

NMVOC

For details of 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, M. & KUDRNA, M. (2002)) and deducted by CH_4 emissions.

For the years from 2016 onwards total HC emissions have been calculated applying the EFs from Annex 5 of the EMEP/EEA 2019 Guidebook (EEA – EUROPEAN ENVIRONMENT

AGENCY (2019)) (per aircraft type and distance class) and deducted by CH_4 emissions to estimate NMVOC emissions.

NH_3

For details of 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, M. & KUDRNA, M. (2002)).

No NH_3 EFs are included in Annex 5 of the EMEP/EEA 2019 Guidebook (EEA – EUROPEAN ENVIRONMENT AGENCY (2019)) per aircraft type and distance class.

$PM_{2.5}$

$PM_{2.5}$ emissions for IFR flights have been calculated with an IEF from the year 2000 obtained from the study mentioned above (KALIVODA, M. & KUDRNA, M. (2002)) based on the fuel consumption derived as described in '**Methodological Issues**' above

<u>VFR flights</u>

For the years 1990–1999 emission estimates were taken from the national aviation study (KALIVODA, M. & KUDRNA, M. (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 – EUROPEAN ENVIRONMENT AGENCY (2019)) (Tier 1). NH_3, $PM_{2.5}$ and VOC_HC emissions are still being calculated with the IEFs of the year 2000 taken from (KALIVODA, M. & KUDRNA, M. (2002)).

Table 172: 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

Implied Emission Factors

<u>VFR and IFR flights</u>

Table 173: IEF for the year 2000 according to (KALIVODA, M. & KUDRNA, M. (2002))

IEF (KALIVODA, M. & KUDRNA, M. (2002))		
2000	**[t]**	**[kg/t fuel]**
Fuel	2 039	
NH_3	0.06	0.03
$PM_{2.5}$	0.03	0.14
VOC_HC	38	18.87

In the following tables the IEFs for *1.A.3.a. Civil Aviation* (domestic LTO + international LTO) are presented. 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 174: Activities and Implied emission factors for NEC gases for 1.A.3.a.ii Civil Aviation (domestic LTO + international LTO): 1990–2019.

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
1991	2 047	22.4	202.2	107.1	0.19	NR
1992	2 218	22.4	203.6	105.4	0.18	NR
1993	2 350	22.5	204.9	104.9	0.18	NR
1994	2 450	22.5	206.1	105.2	0.18	NR
1995	2 706	22.6	208.4	98.9	0.18	24.3
1996	2 977	22.7	208.5	103.8	0.17	NR
1997	3 112	22.7	208.2	111.8	0.18	NR
1998	3 231	22.7	208.0	118.7	0.18	NR
1999	3 175	22.6	208.7	119.7	0.18	NR
2000	3 239	23.1	266.9	116.4	0.17	24.4
2001	3 038	23.1	265.9	115.5	0.17	24.5
2002	3 532	23.1	285.0	115.8	0.17	24.4
2003	3 670	23.1	286.8	116.0	0.17	24.4
2004	4 323	23.1	291.6	113.4	0.17	24.5
2005	4 055	23.1	270.2	115.4	0.17	24.4
2006	4 067	23.1	263.8	116.4	0.17	24.4
2007	4 372	23.1	267.8	115.4	0.17	24.4
2008	4 470	23.1	267.0	115.8	0.17	24.4
2009	4 115	23.1	270.2	117.8	0.18	24.3
2010	4 181	23.1	272.9	116.1	0.17	24.4
2011	4 726	23.1	272.3	118.5	0.18	24.2
2012	4 484	23.1	275.8	113.4	0.17	24.5
2013	4 375	23.1	283.8	113.9	0.17	24.5
2014	4 390	23.1	290.6	112.7	0.17	24.5
2015	4 624	23.1	295.9	112.9	0.17	24.5
2016	4 744	19.5	317.3	45.4	0.17	24.4
2017	4 555	19.5	324.2	40.9	0.17	24.5
2018	4 957	19.5	326.6	41.7	0.17	24.6
2019	5 570	19.4	332.7	38.4	0.17	24.6

Emission factors for heavy metals are presented in chapter 3.2.8.

Category-specific Quality Assurance and Quality Control (QA/QC)

The following QA/QC activities on time series consistency, completeness and comparison with international dataset were done first for CO_2 and in response to the UNFCCC review. However, the methodological changes are also relevant for the calculation of the air pollutants which are therefore described as well in the following.

Time series consistency (Example for CO_2)

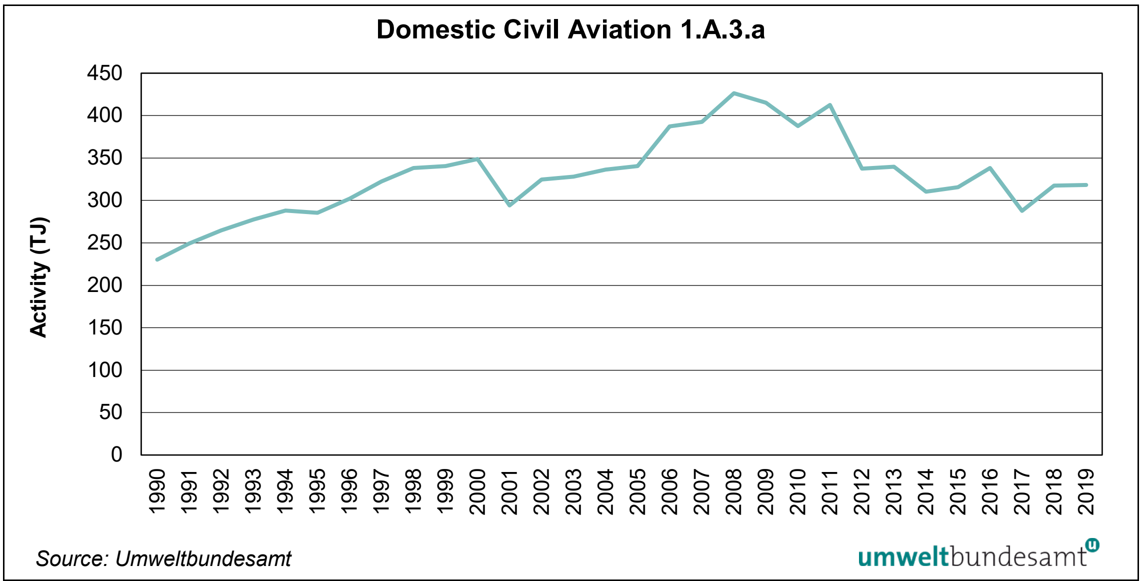


Figure 46: Activity data from 1.A.3.a domestic Civil Aviation: 1990–2019.

Tier 3A updated (for inventory years 2016 onwards)

For the inventory years 2000–2015 the Tier 3A methodology is used for IFR flights. Tier 3A is also used for calculating the year 2016, however with an improved set of flight movements and updated emission factors.

For the validation of the accuracy of the new data the inventory year 2015 has been calculated within 2 steps:

Step 1 / Validation 1:

The results for the inventory year 2015 (of the submission 2017) with the old aircraft types and emission factors was compared with the results when the same activity data is being calculated with the new set of available aircraft types and emission factors.

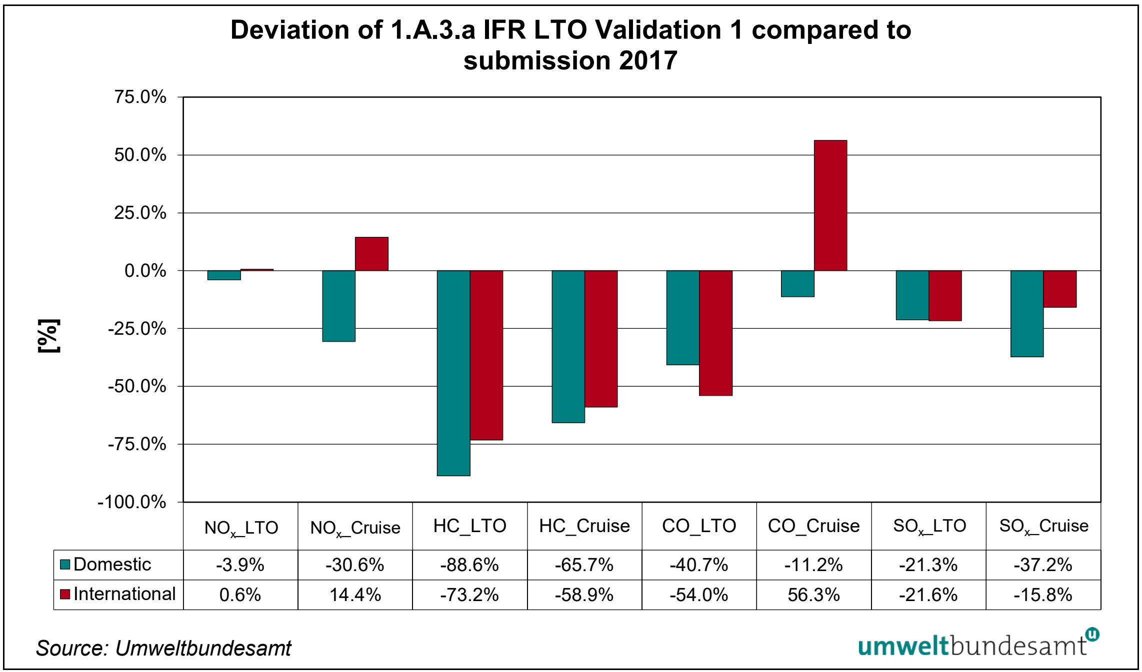


Figure 47: Deviation of emissions of 1.A.3.a Civil Aviation – Validation 1.

The new results for all aircraft types (known and unknown) are lower compared to the submission 2017. It must be noted that many aircrafts which were unknown so far and for which average EFs were calculated can now be allocated to aircraft types listed in the new emission factors spreadsheet. Vice versa some aircraft types which were listed in the old spreadsheets are not listed any more in the new emission factor spreadsheet.

For this reason, a comparison of FC and emissions between known aircraft types of the submission 2018 and the submission 2017 is shown below to demonstrate the separated effect of the changed EFs. Especially HC and CO emissions have drastically changed, however resulting in very small shares (0.1 – 0.3%) compared to the previous submission.

	Submission 2018		Submission 2017		comparison	
aircraft types	national_known	international_known	national_known	international_known	national_known	international_known
Sum Fuel_LTO [kg]	4 205 240	91 300 794	4 634 807	96 961 520	91%	94%
Sum Fuel_Cruise [kg]	6 082 564	571 611 993	7 006 418	560 362 063	87%	102%
Sum HC_LTO [g]	4 167	128 451	5 700 251	246 508 917	0.1%	0.1%
Sum HC_Cruise [g]	3 466	200 005	1 360 011	268 778 760	0.3%	0.1%
Sum NOx_LTO [kg]	43 842	1 302 697	47 195	1 277 592	93%	102%
Sumn NOx_Cruise [kg]	83 786	9 159 335	104 386	7 846 958	80%	117%
Sum CO_LTO [g]	36 334	839 012	64 068 669	1 810 628 962	0.1%	0.05%
Sum CO_Cruise [g]	23 250	1 162 227	22 181 483	731 757 697	0.1%	0.2%
Sum Anzahl Flüge	12 584	126 434	12 584	126 434	100%	100%
Sum Flug-nm	1 685 375	81 632 688	1 685 375	81 632 688	100%	100%

Figure 48: Comparison of FC and emissions of known aircraft types.

An analysis of domestic flight movements in the inventory year 2015 has shown that the following three aircraft types hold the strongest shares in flown distances holding together a share of 85%:

- Dash 8 Q400 4580 hp (DH8D) with 60%
- Fokker 100 (F100) incl. F70[101] with 25%

[101] It should be noted that the Fokker 70 (F70) was labelled as a F100 due to the fact that the old CORINAIR spreadsheet did not include the F70 aircraft.

This information is useful for the explanation of the changes in domestic emissions:

Table 175: Deviations in EFs of aircraft types DH8D and F100.

DOMESTIC Deviation		**Deviaton in EFs**	
		DH8D	F100
NO_x_LTO	-4%	-0.1%	-6%
NO_x Cruise	-31%	-37% on weighted average for distance classes 250nm and 500nm	+5% on weighted average for distance classes 250nm and 500nm
HC_LTO	-98%	As IEFs have been used up to the submission 2018, an EF comparison on aircraft level is not possible.	
HC_Cruise	-66%		
CO_LTO	-41%	+10%	-49%
CO_Cruise	-11%	-50% on weighted average for distance classes 250nm and 500nm	+118% on weighted average for distance classes 250nm and 500nm
SO_2_LTO	-21%	As IEFs have been used up to the submission 2018, an EF comparison on aircraft level is not possible.	
SO_2_Cruise	-37%		

An analysis of international flight movements in the year 2015 has shown that the following air-crafts hold the strongest shares in flown distances having together a share of 92% (the first three types holding 52%):

- A320 with 26%
- A319 with 14%
- B777 with 12%
- F100 with 9%
- A321 with 8%
- B767 with 8%
- B737 with 7%
- DH8D with 5%
- B737_100 with 1%

It should be noted that in the old spreadsheet the A320 was the equivalent aircraft type also for the A319. Thus, no comparison is possible. The B777 was the equivalent aircraft type for B778, B77W, B77L, B773, B772. In the new emission factor spreadsheet for some of these aircrafts specific emission factors are now provided: B772, B773, B77W. The B777 does not exist any-more in the new spreadsheet, thus only the A320 and the A319 (which used to be an A320) will be compared in detail for explaining the following differences in international emissions.

Table 176: Deviations in EFs of aircraft type A320.

INTERNATIONAL Deviation		**Deviaton in emission factors**
		A320
NO_x_LTO	+1%	+1%
NO_x Cruise	+14%	+5% on weighted average for distance classes 250 nm and 500 nm
HC_LTO	-73%	As IEFs have been used up to the submission 2018, an EF comparison on aircraft level is not possible.
HC_Cruise	-59%	

INTERNATIONAL Deviation		Deviaton in emission factors
CO_LTO	-54%	-52%
CO_Cruise	+56%	+179% on weighted average for distance classes 250nm and 500nm
SO_2_LTO	-22%	As IEFs have been used up to the submission 2018, an EF comparison on aircraft level is not possible.
SO_2_Cruise	-16%	

Up to submission 2017 for HC the IEFs from the national flight study (KALIVODA, M. & KUDRNA, M. (2002)) were taken as shown below. The new HC EFs result in lower absolute HC and CH_4 emissions. The HC IEF for domestic LTO is 88% lower; for international LTO 71% lower which is in line with the deviations shown in Figure 47. The HC IEF for domestic cruise is 64% lower; for international cruise 59% lower which is in line with the deviations shown in Figure 47.

Table 177: Implied emission factors of HC for IFR kerosene for inventory year 2015.

kg/kg fuel	DOMESTIC		INTERNATIONAL	
	IEFs KALIVODA, M. & KUDRNA, M. (2002)	Tier 3A updated IEFs	IEFs KALIVODA, M. & KUDRNA, M. (2002)	Tier 3A updated IEFs
HC_LTO	0.008	0.001	0.005	0.0014
HC_Cruise	0.001	0.001	0.0008	0.0003

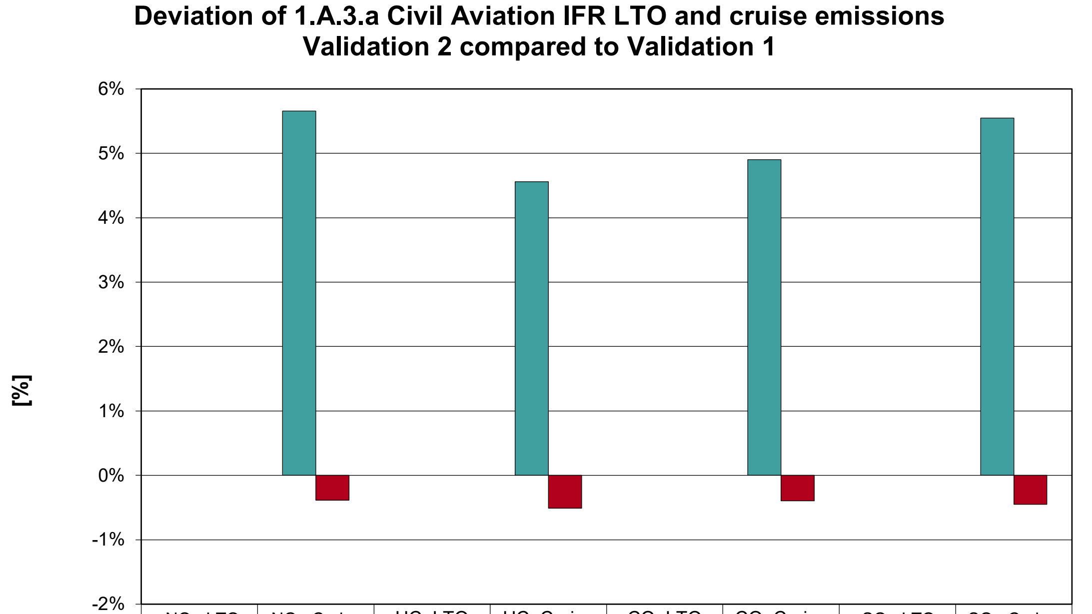
Up to submission 2017 for SO_2 the IEFs from the national flight study (KALIVODA, M. & KUDRNA, M. (2002)) were taken as shown below. The new SO_2 EFs result in lower absolute SO_2 emissions. All SO_2 IEF are lower by 16% which is in line with the deviations shown in Figure 47.

Table 178: Implied emission factors of HC for IFR kerosene for inventory year 2015.

kg/kg fuel	DOMESTIC		INTERNATIONAL	
	IEFs KALIVODA, M. & KUDRNA, M. (2002)	Tier 3A updated IEFs	IEFs KALIVODA, M. & KUDRNA, M. (2002)	Tier 3A updated IEFs
SO_2_LTO	0.001	0.00084	0.001	0.00084
SO_2_Cruise	0.001	0.00084	0.001	0.00084

Step 2 / Validation 2:

In the second step, the results for the inventory year 2015 of the submission 2017 with the old aircraft types and emission factors were compared with the results when the same activity data is being calculated with the new set of available aircraft types and emission factors and the new distance calculation formula.



	NO_x_LTO	NO_x_Cruise	HC_LTO	HC_Cruise	CO_LTO	CO_Cruise	SO_x_LTO	SO_x_Cruise
Domestic	0.0%	5.7%	0.0%	4.6%	0.0%	4.9%	0.0%	5.5%
International	0.0%	-0.4%	0.0%	-0.5%	0.0%	-0.4%	0.0%	-0.5%

Source: Umweltbundesamt

Figure 49: Deviation of emissions of 1.A.3.a Civil Aviation – Validation 2.

The new distance calculation is based on great circle distances between airport pairs and only leads to changes in FC cruise and emissions for cruise. For domestic flights the accuracy of distances flown is increased by 5.5% on average leading to an increase of FC and emissions for cruise. For international flights the accuracy is improved by 0.5% on average resulting in slightly lower FC and emissions for cruise.

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) it was explained that emissions of ground activities at domestic airports are also included, even if they are not separately reported under *1.A.3.a Aviation*. This can be assured as Austria reports emissions from **total fuel sold** from the energy balance.

The approach in the Austrian inventory is as follows: After calculating fuel consumption for inland road transport and off-road transport using a bottom-up approach (NEMO, GEORG), the sum of this fuel used is compared with the total fuel sold from the national energy balance (for details see 1.A.3.b Road Transport). The difference is then allocated to fuel export, which includes fuel consumption for ground activities at airports and harbors as well, including fuel consumption by unregistered vehicles. As the fuel consumption reported under fuel export is included in the national totals[102], an underestimation of emissions can be excluded.

Category-specific Recalculations

Based on a recommendation of the 2020 UNFCCC inventory review Austria improved time series consistency by using a trend extrapolation for inventory years 1990-1999. For details please refer to 'Methodological Issues' above.

Category-specific Planned Improvements

No category-specific improvements are planned.

3.2.5 NFR Memo Item 1.A.3.a Civil Aviation – Cruise

In 2019, the share of Civil Aviation – Cruise in the total fuel consumption in the aviation sector in Austria amounted to 86% (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 and international cruise increased over the period from 1990–2019 by about 8% and 231% respectively which is shown in the following table.

[102] GHG emissions from fuel export are included in 1.A.3.b, and are presented separately in Table 66 (Chapter 3.2.12.2)

Table 179: Activities for Civil Aviation – Cruise: 1990–2019.

Year	Kerosene	
	Domestic cruise [TJ]	**International cruise [TJ]**
1990	293	10 498
1991	329	11 804
1992	358	12 828
1993	379	13 611
1994	396	14 198
1995	443	15 894
1996	490	17 569
1997	511	18 322
1998	530	19 001
1999	519	18 617
2000	571	20 406
2001	527	19 944
2002	525	17 963
2003	527	16 621
2004	543	19 712
2005	571	23 212
2006	593	24 471
2007	615	25 915
2008	540	25 935
2009	506	22 314
2010	480	24 366
2011	429	25 479
2012	409	24 330
2013	405	23 106
2014	371	23 098
2015	365	24 934
2016	310	27 551
2017	293	26 606
2018	314	30 138
2019	315	34 780
1990–2019	8%	231%

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.

Table 180: Activities and Implied emission factors for NEC gases and CO for Civil Aviation – Cruise: 1990–2019.

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	0.16	25.0
1991	12 132	23.1	231.1	16.4	0.16	NR
1992	13 186	23.1	232.4	16.3	0.16	NR
1993	13 990	23.1	233.7	16.3	0.16	NR
1994	14 594	23.1	235.1	16.4	0.16	NR
1995	16 337	23.1	235.6	16.1	0.16	25.0
1996	18 058	23.1	235.0	17.4	0.16	NR
1997	18 833	23.1	235.0	18.7	0.16	NR
1998	19 530	23.1	235.0	20.0	0.16	NR
1999	19 136	23.1	236.3	20.0	0.16	NR
2000	20 977	23.1	307.2	19.8	0.16	25.0
2001	20 471	23.1	308.9	19.8	0.16	25.0
2002	18 488	23.1	306.8	19.8	0.16	25.0
2003	17 147	23.1	303.8	19.9	0.16	25.0
2004	20 255	23.1	300.8	19.8	0.16	25.0
2005	23 784	23.1	293.8	19.8	0.16	25.0
2006	25 064	23.1	300.8	19.8	0.16	25.0
2007	26 529	23.1	301.3	19.8	0.16	25.0
2008	26 475	23.1	298.3	19.8	0.16	25.0
2009	22 820	23.1	300.8	19.8	0.16	25.0
2010	24 846	23.1	305.7	19.8	0.16	25.0
2011	25 907	23.1	307.9	19.7	0.16	25.0
2012	24 739	23.1	310.4	19.7	0.16	25.0
2013	23 512	23.1	317.4	19.7	0.16	25.0
2014	23 469	23.1	319.1	19.7	0.16	25.0
2015	25 300	23.1	323.3	19.7	0.16	25.0
2016	27 860	19.4	369.1	8.2	0.16	25.0
2017	26 898	19.4	374.0	7.5	0.16	25.0
2018	30 451	19.4	378.9	7.3	0.16	25.0
2019	35 095	19.4	383.7	6.8	0.16	25.0

Emission factors for heavy metals are presented in chapter 3.2.8.

Category-specific Recalculations

Based on a recommendation of the 2020 UNFCCC inventory review Austria improved time series consistency by using a trend extrapolation for inventory years 1990-1999. For details please refer to 'Methodological Issues' above.

Category-specific Planned Improvements

No category-specific improvements are planned.

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, however, led to a reduction of emissions per vehicle or per mileage respectively of mostly all other air pollutants.

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.

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 (2020)). For passenger cars, light duty vehicles, buses and motorcycles the mileage data from the periodical inspection database is used.

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 yearly Austrian energy balance) is allocated to fuel export (fuel sold in Austria but consumed abroad).

The emissions reported for Austria also include the emissions from the fuel exports.

Fuel export[103]

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, R.; HAUSBERGER, S.; BENKE, G. ET AL. (2004); MOLITOR, R; SCHÖNFELDER, S.; HAUSBERGER, S.; BENKE, G. 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, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015b), p.22).

[103] 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).

NEMO – Network Emission Model

From the submission in 2015 onwards calculations are based on the model NEMO – Network Emission Model (DIPPOLD, M.; REXEIS, M. & HAUSBERGER, S. (2012); HAUSBERGER, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015a), HAUSBERGER, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015B)). NEMO combines a detailed calculation of the fleet composition with the simulation of energy consumption and emission output on vehicle level. It is fully 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. The balances use the vehicle stock and functions of the km driven per vehicle and year to assess the total traffic volume of each vehicle category.

Model input is:

1) Vehicle stock of each 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 growth rates of kilometres driven by PCs and HDVs separated for the federal street network (motorways) and the federal county network (urban, rural) (BMVIT 2019)
4) Number of passengers per vehicle and tons payload per vehicle;
5) Optional either/or
   - total gasoline and diesel consumption of the area under consideration,
   - average km per vehicle and year.

Following data is calculated:

a) Km driven per vehicle and year or total fuel consumption,
b) Total vehicle mileages,
c) Total passenger-km and ton-km,
d) Specific emission values for the vehicle fleets [g/km], [g/t-km], [g/pass-km],
e) Total emissions (CO, HC, NO_x, particulate matter, CO_2, SO_2 and several unregulated pollutants among them CH_4 and N_2O) and energy consumption (FC) of road traffic.

Figure 50 shows a schematic picture of the methodology of NEMO.

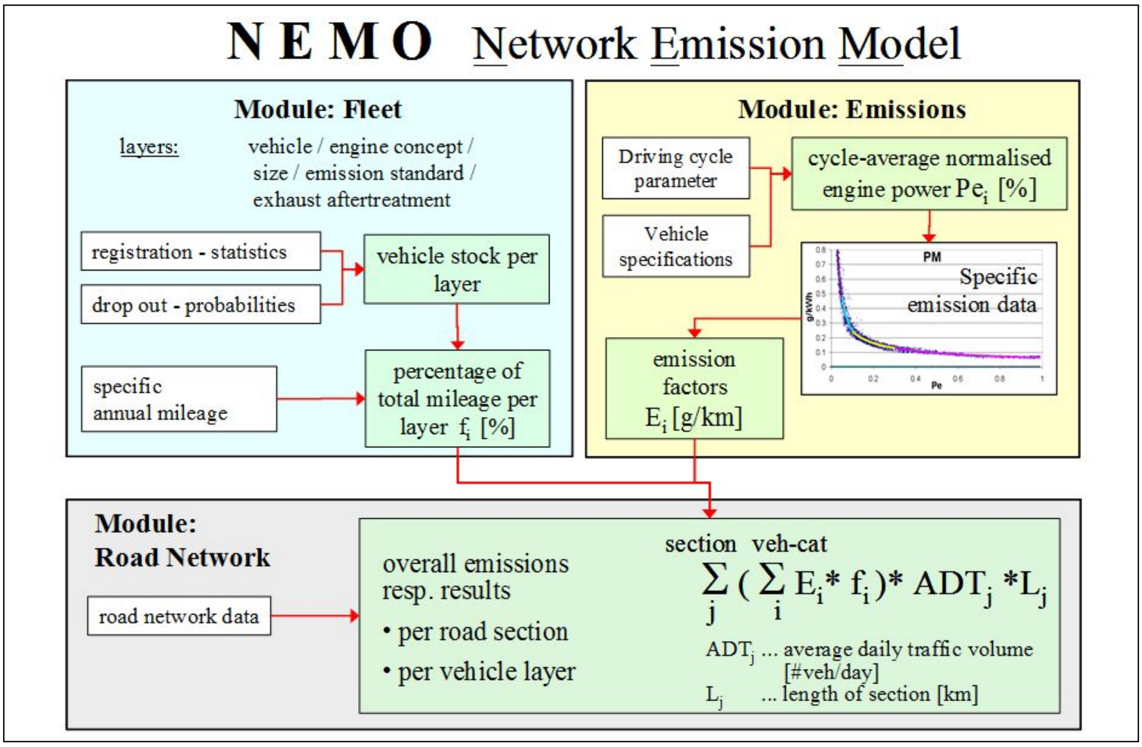


Figure 50: Schematic picture of the NEMO model.

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.

$$stock_{Jg_i,\text{year i}} = stock_{Jg_i,\text{year i}-1} \times \text{survival probability}_{Jg_i}$$

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)

$$\text{total mileage}_{E_i} = \sum_{Jg=\text{start.}}^{\text{end}} (\text{stock}_{Jg,\text{year i}} \times \text{km/vehicle}_{Jg_i,\text{year i}})$$

4) Calculation of the total fuel consumption and emissions of each emission category

$$\text{Emission}_{E_i} = \text{total mileage}_{E_i} \times \text{emission factor}_{K_j,E_i}$$

5) Calculation of the total fuel consumption and emissions of each vehicle category

$$\text{Emission}_{\text{veh.category}} = \sum_{E_i=1}^{end} \text{Emission}_{E_i}$$

6) Calculation of the total passenger-km and ton-km

$$\text{transport volumes}_{\text{veh.category}} = \sum_{E_i=1}^{end} (\text{vehicle mileage}_{E_i} \times \text{loading}_{E_i})$$

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)

Activity Data

From 2018 to 2019 fuel consumption in TJ (gasoline, diesel and alternative fuels including liquid biomass) of road transport increased by 0.1%. Specific consumption per average vehicle kilometer per vehicle category did not improve for diesel passenger cars and light duty vehicles between 2018 and 2019; it declined by 0.5% for gasoline passenger cars, and by 0.5% for heavy duty vehicles. .

The following table gives an overview of the amount of fuel sold in Austria (including fuel export) differentiated by fuel type.

Table 181: Activities from 1.A.3.b Road Transport differentiated by fuel type: 1990–2019.

	Fuel consumption (based on fuel sold) [TJ]					
Year	**total**	**gasoline**	**diesel oil**	**LPG**	**gaseous**	**biomass**
1990	176 289	103 535	72 340	413	-	-
1991	195 830	113 597	81 805	428	-	-
1992	195 642	108 598	86 600	444	-	-
1993	197 657	104 164	93 042	451	-	-
1994	198 412	100 429	97 522	462	-	-
1995	202 185	97 003	104 688	494	-	-
1996	223 483	89 715	133 098	670	-	-
1997	210 345	85 029	124 786	530	-	-
1998	236 898	88 985	147 323	590	-	-
1999	228 769	82 693	145 455	622	-	-
2000	241 103	79 895	160 536	672	-	-
2001	259 202	80 484	177 995	722	-	-
2002	287 508	86 689	199 835	984	-	-
2003	311 124	88 671	221 321	1 132	-	-
2004	318 047	86 266	230 820	947	14	-
2005	324 929	83 843	237 942	932	16	2 196
2006	312 674	80 474	222 937	948	15	8 299
2007	316 444	78 597	227 533	923	76	9 315
2008	299 457	70 619	216 256	1 002	137	11 442
2009	294 527	70 415	208 008	945	330	14 830
2010	306 035	69 298	219 657	889	453	15 738
2011	295 843	66 766	212 300	854	485	15 437
2012	295 600	65 014	213 094	900	532	16 060
2013	309 188	63 763	228 167	841	646	15 770
2014	301 922	62 564	221 246	739	698	16 676
2015	308 969	63 200	226 059	558	721	18 432
2016	318 589	62 548	237 527	506	715	17 293
2017	326 371	61 870	247 114	479	708	16 200
2018	329 763	64 310	248 006	344	689	16 413
2019	330 217	64 074	249 276	220	758	15 889
1990–2019	**87%**	**-38%**	**245%**	**-47%**	**5175%[104]**	**623%[105]**

[104] Trend 2004-onwards

[105] Trend 2005-onwards

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 182: NO_x emissions from 1.A.3.b Road Transport differentiated by means of transportation 1990–2019.

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	3.54	7.30	35.42	13.42	0.13
1991	53.95	9.03	7.34	38.65	15.80	0.13
1992	52.45	5.11	7.59	38.98	16.26	0.13
1993	49.60	3.32	7.67	38.23	18.04	0.14
1994	48.31	1.40	7.93	38.26	15.94	0.14
1995	46.29	0.80	8.02	38.32	16.67	0.15
1996	45.37	-1.84	8.25	38.48	36.72	0.16
1997	44.16	-2.61	8.36	38.99	23.41	0.17
1998	43.76	0.02	8.47	39.53	34.24	0.19
1999	43.63	-2.18	8.48	39.99	28.09	0.20
2000	43.68	-2.10	8.38	41.01	34.02	0.21
2001	44.24	0.05	8.42	40.62	39.56	0.22
2002	45.73	5.40	8.76	40.24	42.36	0.23
2003	47.37	9.30	9.28	40.59	45.16	0.24
2004	48.32	10.89	9.79	40.17	43.33	0.25
2005	48.30	12.30	10.08	39.94	44.73	0.26
2006	48.47	11.89	10.45	39.93	34.34	0.26
2007	48.99	13.23	10.80	37.71	29.81	0.26
2008	47.15	11.88	10.65	33.53	24.75	0.26
2009	46.02	12.77	10.65	28.50	22.63	0.25
2010	46.77	12.75	10.95	26.66	22.73	0.25
2011	47.43	11.73	11.12	25.35	16.55	0.25
2012	47.25	11.38	11.05	23.13	15.52	0.25
2013	47.92	10.66	11.07	21.39	18.84	0.25
2014	49.20	10.36	11.16	19.64	15.00	0.24
2015	49.93	11.64	11.23	17.05	12.35	0.24
2016	49.13	11.99	11.03	14.75	8.78	0.24
2017	46.39	11.84	10.35	12.61	6.91	0.23
2018	44.26	10.02	9.99	11.05	5.35	0.23
2019	41.98	9.08	9.14	9.72	4.45	0.22
1990–2019	-26%	157%	25%	-73%	-67%	78%

In 2019, the total share of fuel export in *1.A.3.b* amounted to 18% or 13.5 kt NO_x of which 67% are attributed to passenger road transport and 33% to road freight transport.

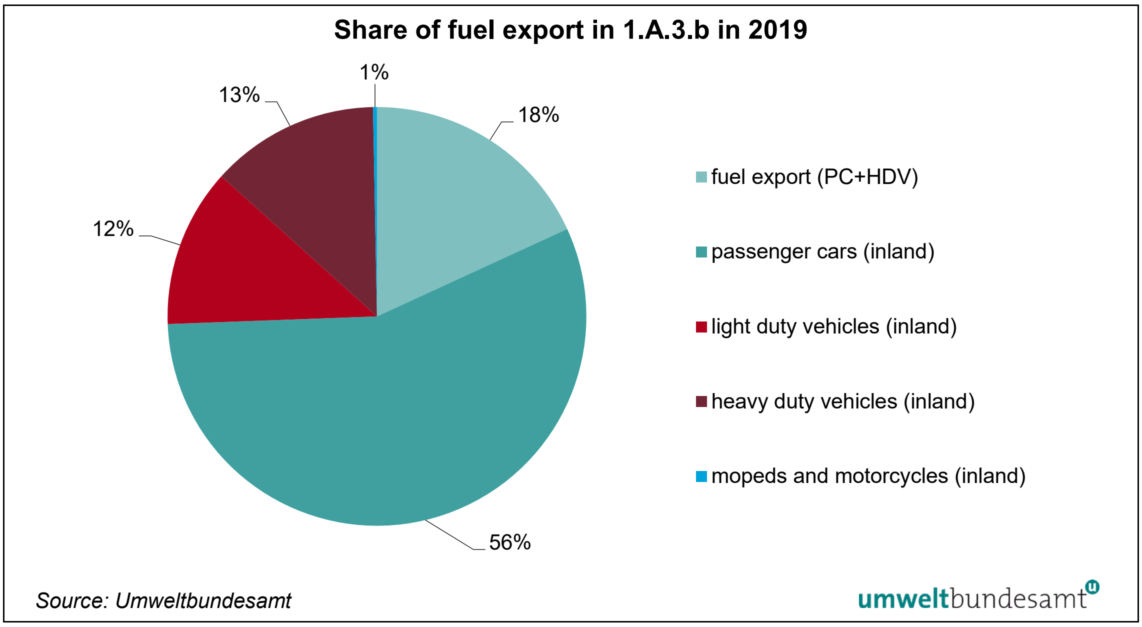


Figure 51: Share of fuel export (NO_x) in 1.A.3.b Road Transport in 2019.

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%[106]
- 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 2019 the energetic substitution by biofuels amounted to 6.19% in the road transport sector (BMK – BUNDESMINISTERIUM FÜR KLIMASCHUTZ, UMWELT, ENERGIE, MOBILITÄT, INNOVATION UND TECHNOLOGIE (2020))[107]. In 2005, the first year of blending biofuels, the substitution amounted to only 0.8% (UMWELTBUNDESAMT (2006C)).

For the year 2019 a consumption of 448 328 tons of HVO[108] & biodiesel (for blending with diesel) and 86 311 tons of bioethanol (for blending with gasoline) are used as input data in the cal-

[106] An allocation to agriculture is not possible at the moment, because of the technical model framework.

[107] The required substitution target amounts to 5.75%, measured by energy content.

[108] HVO…Hydrotreated Vegetable Oils

culation models based on NEMO and GEORG (see 1.A.2.g.vii). The following amounts are used in pure form: 58 637 tons of biodiesel and plant oil; 349 t (equivalent to 478 000 m³) of biogas (BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2020)).

Table 183: Use of biofuels in absolute figures 2005–2019.

Year	pure		blended		biofuels total [t]
	biofuel pure [t]	biogas [t]	biodiesel [t]	bioethanol [t]	
2005	17 000	-	75 000	-	92 000
2006	52 500	-	288 000	-	340 500
2007	89 209	-	298 828	20 391	408 428
2008	121 276	0	304 291	84 910	510 477
2009	133 690	1	405 909	99 424	639 024
2010	92 377	2	427 000	105 883	625 262
2011	101 824	6	422 072	102 755	626 656
2012	74 983	9	440 938	105 378	621 308
2013	80 536	15	443 389	88 842	612 783
2014	159 153	463	474 692	87 688	721 996
2015	174 255	350	528 944	89 557	793 106
2016	80 875	344	495 764	86 912	663 895
2017	46 613	214	459 032	85 226	591 085
2018	63 177	306	462 396	88 206	614 085
2019	58 637	349	448 328	86 311	593 625
2005–2019	245%	30504%[109]	498%	323%[110]	545%

Emission Factors

Emission factors used for NEMO (Version 5.0.1) 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, S. & KELLER, M. 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 V4.1 published end of August 2019 has been applied (MATZER, C.; WELLER, K.; DIPPOLD, M.; LIPP, S.; RÖCK, M.; REXEIS, M. & HAUSBERGER S. (2019)).

Summarized innovations in HBEFA Version 4.1:

- All emission factors for the "warm operating condition" have been updated based on:
  - New emission measurements are available. PEMS and "Dieselgate" have made large amounts of new measurement data available since the last HBEFA version
- For the first time, the influence of the ambient temperature on the NO_x exhaust-aftertreatment systems was implemented. The lower the ambient temperature, the worse these systems work. This resulted in an increase in the emission-factors for diesel cars and light duty vehicles (Euro 3- Euro 6)

109 Trend 2009-onwards

110 Trend 2007-onwards

- New traffic situations and driving cycles with revised dynamic parameters
- HBEFA4.1 shows the effect of the mandatory software update of VW vehicles with the EA189 engine ("Diesel Gate") on the average Euro 5 emission factor
- Influence of age on exhaust gas aftertreatment systems:
  - So far, constant emissions have been assumed for mileage greater than 50,000 km. In HBEFA 4.1. This was changed based on remote sensing data. This leads to an increase in pollutant emissions up to mileage of 250,000km. This also has retroactive effects for the past few years and an effect on NOx emissions

Moreover, specific CO_2 emission factors of new passenger cars and light duty vehicles according to the national CO_2 monitoring data for the Austrian fleet, have been implemented (BMNT 2019b, c).

Cold-start emissions

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 3.2 and integrated in HBEFA V.3.3)
- 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).

Exhaust emissions of mopeds and motorcycles – PM

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 – EUROPEAN ENVIRONMENT AGENCY (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 5.0.1 version uses emission factors from the newest HBEFA Version (Version 4.1). The emission factors are based on vehicle measurements,

Non-exhaust emissions – PM

From the submission 2018 onwards non-exhaust emissions from brake/tyre wear and road abrasion (road surface wear) are reported separately under *1.A.3.b.6 and 1.A.3.b.7.* This results in a revised time-series for *1.A.3.b.7* and a completely new time-series for *1.A.3.b.6*. 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 2016 Guidebook (EEA – EUROPEAN ENVIRONMENT AGENCY (2016)) 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 2016 Guidebook (EEA – EUROPEAN ENVIRONMENT AGENCY (2016)), 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 2016 Guidebook (EEA – EUROPEAN ENVIRONMENT AGENCY (2016)). Total evaporative emissions are now including

- diurnal losses,
- hot soak and
- running losses.

The emissions of these three subcategories for *1.A.3.b Road Transport* are displayed below and can be reported separately. This improvement was made following a recommendation of the NEC Review 2017.

Table 184: NMVOC emissions from evaporation in 1.A.3.b. Road Transport

Year	diurnial losses	Hot soak	running losses
		[kt]	
1990	0.7	5.0	14.0
1991	0.6	4.5	12.7
1992	0.6	4.1	11.6
1993	0.6	3.6	10.1
1994	0.5	3.2	8.9
1995	0.5	2.7	7.6
1996	0.4	2.3	6.4
1997	0.4	1.9	5.3
1998	0.3	1.6	4.4
1999	0.3	1.3	3.6
2000	0.3	1.1	2.9
2001	0.3	0.9	2.3

Year	diurnial losses	Hot soak	running losses
		[kt]	
2002	0.2	0.7	1.9
2003	0.2	0.6	1.6
2004	0.2	0.5	1.3
2005	0.2	0.4	1.1
2006	0.1	0.3	0.6
2007	0.1	0.2	0.6
2008	0.1	0.2	0.5
2009	0.1	0.2	0.4
2010	0.1	0.1	0.4
2011	0.1	0.1	0.3
2012	0.1	0.1	0.3
2013	0.1	0.1	0.3
2014	0.1	0.1	0.3
2015	0.1	0.1	0.3
2016	0.1	0.1	0.2
2017	0.1	0.1	0.2
2018	0.1	0.1	0.2
2019	0.1	0.1	0.2

Relative factors used on top of commercial fuels incl. blending of biofuels (=reference fuels)

As a consequence of the provisional main findings in the CRR 2016 it shall be explained that all emission factors of alternative and pure biofuels used in NEMO are considered in the model by relative factors compared to commercial fuels. 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 185: Relative factors used for bioethanol E85 and biogas.

Gasoline	blended gasoline	bioethanol E85	biogas
FC	1.00	1.00	0.84
NOx	1.00	1.51	0.67
HC	1.00	1.37	0.44
CO	1.00	0.88	0.70
PM exhaust	1.00	1.00	0.71
Nox_raw	1.00	1.51	0.67
N_2O	1.00	0.64	0.34
NO_2	1.00	1.51	1.11
NH_3	1.00	1.00	0.68
CH_4	1.00	1.94	2.94

Gasoline	blended gasoline	bioethanol E85	biogas
Benzol	1.00	1.00	1.00
C22H12	1.00	1.00	1.00
C20H12 (k)	1.00	1.00	1.00
C20H12 (b)	1.00	1.00	1.00
C20H12 (a)	1.00	1.00	1.00

Table 186: 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.

Table 187: Activities and Implied emission factors for NEC gases for 1.A.3.b Road Transport: 1990–2019.

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	176 289	27.1	659.4	546.7	4.5	3.79
1991	195 830	27.4	637.8	486.2	6.0	3.55
1992	195 642	28.9	616.1	433.5	7.2	3.71
1993	197 657	30.5	591.9	377.1	8.3	3.75
1994	198 412	31.4	564.4	333.5	9.1	3.90
1995	202 185	28.0	545.3	288.1	9.8	3.92
1996	223 483	12.4	568.9	225.8	9.2	3.67
1997	210 345	11.5	534.7	203.6	10.2	3.99
1998	236 898	10.9	532.8	167.5	10.4	3.66
1999	228 769	10.2	516.7	145.8	10.8	3.91
2000	241 103	9.6	519.3	122.0	10.4	3.81
2001	259 202	9.2	513.5	104.2	10.0	3.62
2002	287 508	7.9	496.4	90.4	9.7	3.36

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
2003	311 124	7.2	488.4	78.8	9.1	3.19
2004	318 047	0.6	480.3	70.5	8.5	3.17
2005	324 929	0.5	478.9	62.9	7.9	3.12
2006	312 674	0.4	464.8	52.4	7.9	3.31
2007	316 444	0.4	444.9	46.6	7.3	3.34
2008	299 457	0.4	428.1	42.2	6.9	3.44
2009	294 527	0.4	410.2	38.3	6.5	3.42
2010	306 035	0.4	392.5	33.3	6.1	3.35
2011	295 843	0.4	380.0	30.4	5.5	3.54
2012	295 600	0.4	367.3	27.4	5.0	3.54
2013	309 188	0.4	356.2	24.1	4.3	3.42
2014	301 922	0.4	349.8	22.4	4.0	3.59
2015	308 969	0.4	331.6	20.5	3.8	3.60
2016	318 589	0.4	301.1	18.5	3.6	3.61
2017	326 371	0.4	270.6	16.6	3.4	3.60
2018	329 763	0.4	245.3	15.5	3.4	3.72
2019	330 217	0.4	225.9	14.2	3.3	3.77

Emission factors for heavy metals and POPs are presented in 3.2.8.

Category-specific Quality Assurance and Quality Control (QA/QC)

Quality management for input data of *1.A.3.b Road Transport* is implemented by carrying out the following checklist after receipt of input data:

- ✓ 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?

Category-specific Recalculations

The calibration of the mileage model of the vehicle categories to the energy balance (LPG, biogas) resulted in minor changes in activity data and emissions per vehicle category over the entire time series.

Category-specific Planned Improvements

No category-specific improvements are planned.

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.vii 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*.

3.2.7.1 NFR 1.A.2.g.vii Off-road vehicles and other machinery

Methodological Issues

Energy consumption and emissions of off-road traffic in Austria are calculated with the model GEORG (Grazer Emissionsmodell für Off-Road Geräte). This model has been developed within a study about off-road emissions in Austria (HAUSBERGER, S. (2000)). The study was prepared to improve the poor data quality in this sector. The following categories were taken into account:

- *1.A.2.f* Industry,
- *1.A.3.c* Railways,
- *1.A.3.d* Navigation,
- *1.A.4.b* Household and Gardening,
- *1.A.4.c* Agriculture and Forestry,
- *1.A.5* Military activities.

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*). 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 EMEP/EEA 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 (fuel statistics),
- Questionnaire to vehicle and machinery users (HAUSBERGER, S. (2000)),

- Interviews with experts and expert judgment
  validating the questionnaire results (HAUSBERGER, S. (2000)) and
- Information from vehicle and machinery manufacturers (HAUSBERGER, S. (2000)).

An allocation of pure biofuels on the off -road sector has not been performed due to lack of data.

Activities used for estimating the emissions of mobile sources in *1.A.2.g.vii* are presented in Table 194. Activities include liquid fuels (diesel, gasoline and biofuels).

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.vii Industry* and *1.A.4.c.2 Agriculture and Forestry* were updated on the basis of a new study (SCHWINGSHACKL, M.; REXEIS, M. & WELLER, K. (2020A)).

The following tables show the exhaust emission factors for four categories of engine types (average motor capacity) depending on the year of construction used in the GEORG model for *1.A.2.g.vii Industry* and *1.A.4.c.2 Agriculture and Forestry*.

Table 188: Emission factors for diesel engines < 56 kW.

Year	CO	NO_x	NH_3	HC	CH_4	PM
	[g/kwh]					
AG1	10.58	11.99	0.0060	1.94	0.047	2.184
AG2	8.85	10.92	0.0045	1.48	0.036	1.682
Stage 1	2.55	6.56	0.0039	0.80	0.005	0.308
Stage 2	2.25	6.04	0.0029	0.67	0.004	0.166
Stage 3a	1.12	8.94	0.0020	0.22	0.002	0.079
Stage 3b	0.67	5.67	0.0020	0.05	0.001	0.034
Stage 4	0.67	5.67	0.0020	0.005	0.001	0.027
Stage 5	0.44	3.32	0.0020	0.05	0.001	0.010

Table 189: Emission factors for diesel engines 56 - 80 kW.

Year	CO	NO_x	NH_3	HC	CH_4	PM
	[g/kwh]					
AG1	10.58	11.99	0.0060	1.94	0.047	2.184
AG2	8.85	10.92	0.0045	1.48	0.036	1.682
Stage 1	2.55	6.56	0.0039	0.80	0.005	0.308
Stage 2	2.25	5.64	0.0029	0.67	0.004	0.166
Stage 3a	1.12	6.89	0.0020	0.22	0.002	0.079
Stage 3b	0.67	4.21	0.0020	0.05	0.001	0.034
Stage 4	0.35	1.52	0.0020	0.005	0.001	0.027
Stage 5	0.31	0.55	0.0020	0.02	0.001	0.010

Table 190: Emission factors for diesel engines 80 - 130 kW.

Year	CO	NO_x	NH_3	HC	CH_4	PM
	[g/kwh]					
AG1	9.24	10.19	0.0030	1.62	0.039	1.623
AG2	7.70	12.39	0.0024	1.21	0.029	0.885
Stage 1	2.55	6.56	0.0020	0.80	0.005	0.174
Stage 2	2.25	4.83	0.0014	0.67	0.003	0.153
Stage 3a	1.12	5.86	0.0010	0.22	0.002	0.079
Stage 3b	0.67	4.21	0.0010	0.05	0.001	0.034
Stage 4	0.35	1.52	0.0010	0.005	0.001	0.027
Stage 5	0.31	0.55	0.0010	0.02	0.001	0.010

Table 191: Emission factors for diesel engines >130 kW.

Year	CO	NO_x	NH_3	HC	CH_4	PM
	[g/kwh]					
AG1	9.24	10.19	0.0030	1.62	0.039	1.623
AG2	7.70	12.39	0.0024	1.21	0.029	0.885
Stage 1	2.55	6.56	0.0020	0.80	0.005	0.174
Stage 2	2.25	4.83	0.0014	0.67	0.003	0.153
Stage 3a	1.12	5.86	0.0010	0.22	0.002	0.079
Stage 3b	0.67	2.55	0.0010	0.05	0.001	0.034
Stage 4	0.35	1.52	0.0010	0.005	0.001	0.027
Stage 5	0.31	0.55	0.0010	0.02	0.001	0.010

Table 192: Emission factors for 4-stroke-petrol engines.

Year	NO_x	NH_3	NMVOC	PM
	[g/kwh]			
AG1	3.070	0.0019	16.166	0.025
AG2	4.110	0.0017	12.940	0.025
Stage 1	4.490	0.0016	12.360	0.025
Stage 2	4.490	0.0018	11.933	0.025
Stage 3a	4.490	0.0018	11.015	0.025
Stage 3b	4.490	0.0018	11.015	0.025
Stage 4	4.490	0.0018	11.015	0.025
Stage 4 SCR	4.490	0.0018	11.015	0.025
Stage 5	4.490	0.0018	11.017	0.025

Table 193: Emission factors for 2-stroke-petrol engines.

Year	NO_x	NH_3	NMVOC	PM
		[g/kwh]		
AG1	1.035	0.0017	247.797	0.439
AG2	1.135	0.0015	174.290	0.291
Stage 1	1.675	0.0013	164.637	0.291
Stage 2	1.395	0.0012	50.490	0.291
Stage 3a	1.395	0.0004	50.490	0.291
Stage 3b	1.395	0.0004	50.490	0.291
Stage 4	1.395	0.0004	50.490	0.291
Stage 4 SCR	1.395	0.0004	50.490	0.291
Stage 5	1.395	0.0004	50.490	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, the EMEP/EEA 2019 Guidebook (EEA – EUROPEAN ENVIRONMENT AGENCY (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 provided in the EMEP/EEA 2019 Guidebook (EEA – EUROPEAN ENVIRONMENT AGENCY (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.vii* are presented below. Activities of mobile machinery in *1.A.2.g.vii* 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.

Table 194: Activities and Implied emission factors for NEC gases for 1.A.2.g.7 Off-road – Industry: 1990–2019.

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	3 448	59.5	878.5	149.9	0.32	152.2
1991	3 897	59.5	880.4	149.4	0.32	NR
1992	4 127	59.5	882.1	149.0	0.32	NR
1993	4 340	59.5	883.3	148.7	0.32	NR
1994	4 554	50.4	897.2	146.4	0.31	NR
1995	4 821	18.6	921.3	142.3	0.31	138.3
1996	6 008	18.6	956.6	136.2	0.30	NR

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1997	5 663	18.6	984.0	132.0	0.29	NR
1998	6 660	18.6	1 004.3	128.6	0.28	NR
1999	6 352	16.3	1 018.4	126.3	0.28	NR
2000	7 426	16.3	1 027.9	124.4	0.28	106.6
2001	6 980	16.3	1 032.5	123.4	0.27	104.6
2002	6 793	16.3	1 023.1	122.2	0.27	102.1
2003	7 241	16.3	962.3	116.7	0.26	91.3
2004	7 965	2.4	861.6	107.2	0.25	76.0
2005	11 017	2.4	736.9	93.5	0.23	58.9
2006	13 680	2.4	637.2	83.8	0.21	44.3
2007	14 825	0.5	590.2	75.4	0.19	35.4
2008	16 352	0.5	572.7	66.8	0.18	29.7
2009	15 988	0.5	562.1	62.1	0.17	26.2
2010	15 331	0.5	556.6	59.7	0.17	24.3
2011	15 409	0.5	558.9	56.0	0.16	22.4
2012	15 965	0.5	544.1	49.0	0.15	19.7
2013	16 057	0.5	511.9	42.4	0.15	16.9
2014	15 735	0.5	486.7	38.2	0.14	15.1
2015	15 331	0.5	462.7	34.5	0.14	13.4
2016	15 429	0.5	428.0	30.4	0.14	11.5
2017	16 196	0.5	378.0	25.3	0.13	9.3
2018	17 348	0.5	330.3	20.2	0.13	7.4
2019	18 269	0.5	293.9	16.1	0.12	5.9

Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Category-specific Recalculations

The update of 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.vii Industry* and *1.A.4.c.2 Agriculture and Forestry* on the basis of a new country-specific study (SCHWINGSHACKL, M.; REXEIS, M. & WELLER, K. (2020A)) resulted in significantly increased NMVOC emissions from 2002 onwards (e.g. 2008: +0.54 kt).

Category-specific 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 *1.A.2.g.vii* (see Chapter 3.2.7.1*)*.

Activity Data

In this category emissions from diesel railcars and steam engines are considered. Activities used for estimating the emissions of *1.A.3.c Railways* are presented below. Activities include liquid fuels (diesel and biodiesel) as well as solid fuels (coal) yearly taken from the national energy balance.

Table 195: Activities for 1.A.3.c Railways: 1990–2019.

Year	Liquid fuels [TJ]	Solid fuels [TJ]
1990	2 311	69.7
1991	2 120	63.4
1992	2 099	66.2
1993	2 051	59.8
1994	2 071	58.8
1995	1 926	61.0
1996	1 736	60.8
1997	1 753	34.6
1998	1 730	30.8
1999	1 788	29.8
2000	1 788	26.0
2001	1 728	18.2
2002	1 869	20.2
2003	1 880	15.8
2004	1 880	6.1
2005	2 189	5.2
2006	2 137	5.8
2007	2 125	5.5
2008	2 123	4.8
2009	2 078	6.3
2010	2 034	4.6
2011	1 710	4.6
2012	1 759	4.9
2013	1 620	4.9
2014	1 695	4.9
2015	1 520	4.84
2016	1 575	4.87
2017	1 637	4.93
2018	1 303	4.68
2019	1 311	4.56
1990–2019	**-43%**	**-93%**

Emission Factors

Emission factors were taken from (HAUSBERGER, S. (2006)). Implied emission factors of *1.A.3.c Railways* are listed in the following table.

Table 196: Activities and Implied emission factors for NEC gases for 1.A.3.c Railways: 1990–2019.

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
1991	2 182.9	110.3	766.6	153.0	0.3	NR
1992	2 165.2	113.0	768.8	152.7	0.3	NR
1993	2 110.6	109.1	771.9	152.0	0.3	NR
1994	2 129.4	107.9	778.7	151.1	0.3	NR
1995	1 986.9	104.3	784.9	150.6	0.3	256.8
1996	1 796.4	83.2	790.9	150.2	0.3	NR
1997	1 787.8	57.6	800.8	147.4	0.3	NR
1998	1 761.1	54.3	808.3	146.3	0.3	NR
1999	1 818.3	52.4	816.3	145.1	0.3	NR
2000	1 814.5	48.8	825.1	143.8	0.3	249.0
2001	1 746.2	41.9	835.2	142.1	0.3	248.5
2002	1 889.4	42.4	842.6	138.2	0.3	235.9
2003	1 895.6	38.2	838.4	135.6	0.3	232.6
2004	1 885.8	29.2	835.0	132.5	0.2	229.0
2005	2 194.0	27.7	826.1	127.8	0.2	211.1
2006	2 142.7	28.5	820.7	123.7	0.2	207.2
2007	2 130.9	28.3	799.7	115.9	0.2	196.7
2008	2 127.6	27.7	779.1	107.9	0.2	185.5
2009	2 084.7	29.1	760.8	100.1	0.2	176.0
2010	2 038.8	27.8	740.0	91.9	0.2	165.9
2011	1 714.5	28.6	718.4	83.8	0.2	169.0
2012	1 764.0	28.7	696.6	79.5	0.2	159.7
2013	1 625.4	29.2	663.6	72.1	0.2	156.4
2014	1 699.8	29.0	632.6	64.6	0.2	141.1
2015	1 524.5	29.6	611.6	61.3	0.2	147.1
2016	1 580.2	29.4	600.2	60.4	0.2	143.0
2017	1 641.5	29.2	576.8	56.8	0.2	135.3
2018	1 307.9	30.2	564.2	55.5	0.2	158.3
2019	1 315.9	30.0	552.7	54.0	0.2	156.2

Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Category-specific Recalculations

There are only insignificant recalculations due to slightly updated activity data.

Category-specific Planned Improvements

The activity data are taken from the national energy balance that is provided by the national statistical office ('Statistik Austria'). The changes (between 2004-2005, 2010–2011 and 2017-2018) will be analyzed together with Statistik Austria according to our sectoral improvement plan. If the changes are caused by the survey design or the method used by the statistical office, a national bottom up study will be carried out (The results could be used to improve the national energy balance).

3.2.7.3 NFR 1.A.3.d Navigation

Methodological Issues

Austria uses the bottom-up model GEORG (HAUSBERGER, S. (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 (STATSTIK AUSTRIA (2000-2020)). Additionally, fuel consumption for working boats is taken into account in the national fuel consumption of navigation.

Methodological issues of the model GEORG are described in the subchapter on mobile sources of *1.A.2.g.vii (*see Chapter *3.2.7.1).*

Activity Data

This sector includes emissions from fuels used by vessels of all flags that depart and arrive in Austria (excludes fishing) and emissions from international inland waterways, including emissions from journeys that depart in Austria and arrive in a different country. Activities used for estimating the emissions of *1.A.3.d Navigation* are presented in Table 197. Activities include liquid fuels (diesel, gasoline and biofuels).

Emission Factors

Emission factors were taken from (HAUSBERGER, S. (2006)) and the new country-specific study (SCHWINGSHACKL, M.; REXEIS, M. & WELLER, K. (2020A)). Implied emission factors of *1.A.3.d Navigation* are listed below.

Table 197: Activities and Implied emission factors for NEC gases for 1.A.3.d Navigation: 1990–2019.

Year	Activities	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	993	53.2	1 155.5	946.9	0.3	57.2
1991	934	52.8	1 145.9	972.4	0.3	NR
1992	937	52.8	1 147.1	970.1	0.3	NR
1993	962	53.0	1 152.0	957.9	0.3	NR
1994	1 123	51.8	1 176.8	886.1	0.3	NR
1995	1 229	38.5	1 190.1	841.3	0.3	57.6
1996	1 267	20.5	1 195.1	818.6	0.3	NR

Year	Activities	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1997	1 278	20.5	1 197.4	803.4	0.3	NR
1998	1 370	20.6	1 206.5	771.3	0.3	NR
1999	1 368	19.9	1 207.4	759.9	0.3	NR
2000	1 469	20.1	1 215.9	729.5	0.3	56.5
2001	1 530	20.1	1 220.9	708.5	0.3	56.3
2002	1 659	20.3	1 220.0	673.5	0.3	56.2
2003	1 454	19.8	1 197.6	685.1	0.3	55.2
2004	1 728	15.7	1 197.2	623.9	0.3	54.9
2005	1 747	15.3	1 171.9	590.8	0.3	53.3
2006	1 655	14.3	1 144.8	572.2	0.3	51.6
2007	1 702	14.0	1 119.2	533.6	0.3	50.0
2008	1 614	13.4	1 088.4	515.4	0.2	48.4
2009	1 507	12.2	1 055.5	500.4	0.2	46.7
2010	1 664	13.1	1 040.2	459.5	0.2	45.5
2011	1 617	12.1	1 019.5	446.1	0.2	44.2
2012	1 562	12.8	1 000.5	429.2	0.2	43.1
2013	1 663	12.8	990.0	405.0	0.2	42.4
2014	1 695	11.6	979.3	392.3	0.2	41.7
2015	1 582	10.3	963.0	389.6	0.2	40.8
2016	1 678	10.4	952.7	369.1	0.2	40.1
2017	1 754	10.2	938.0	353.6	0.2	39.3
2018	1 591	8.3	926.8	361.4	0.2	38.9
2019	1 793	8.4	919.9	341.7	0.2	38.5

Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Category-specific 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.d Navigation*. This can be assured as Austria reports emissions from **total fuel sold** from the energy balance.

The approach in the Austrian inventory is as follows: After calculating fuel consumption for inland road transport and off-road transport using a bottom-up approach (NEMO, GEORG), the sum of this fuel used is compared with the total fuel sold from the national energy balance (for details see *1.A.3.b Road Transport*). The difference is then allocated to fuel export, which includes fuel consumption for ground activities at airports and harbors as well, including fuel consumption by unregistered vehicles. As the fuel consumption reported under fuel export is included in the national totals[111], an underestimation of emissions can be excluded.

Category-specific Recalculations

Domestic fuel consumption data have been updated on the basis of a new study on Austria's off-road emissions (SCHWINGSHACKL, M.; REXEIS, M. & WELLER, K. (2020)). A special focus was placed on the shipping, in detail on passenger ships on the Danube. These ships have not been sufficiently analysed until now because of the poor data availability. The activity data was revised upwards, causing increased emissions over the entire time series

Category-specific Planned Improvements

No 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.vii 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.vii* (see Chapter 3.2.7.1*).*

Activity Data

In addition to vehicles used in household and gardening this category contains ski slope machineries and snow vehicles. Activities used for estimating emissions of *1.A.4.b.2 Household and gardening – mobile sources* are presented in Table 206. Activities include liquid fuels (diesel, gasoline and biofuels).

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[111] GHG emissions from fuel export are included in 1.A.3.b and are presented separately in Table 66 (Chapter 3.2.12.2)

Emission Factors

Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of *1.A.2.g.vii* (see Chapter 3.2.7.1). Implied emission factors of *1.A.4.b.2 Household and gardening – mobile sources* are listed below.

Table 198: Activities and Implied emission factors for NEC gases for 1.A.4.b.ii Off-road – Household and gardening: 1990–2019.

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	2 663.3	0.1	60.1
1991	2 287	25.5	366.7	2 663.4	0.1	NR
1992	2 303	25.7	370.5	2 652.5	0.1	NR
1993	2 307	25.8	374.1	2 642.4	0.1	NR
1994	2 289	22.3	379.9	2 605.1	0.1	NR
1995	2 286	10.2	396.4	2 506.2	0.1	55.1
1996	2 255	10.2	406.5	2 434.0	0.1	NR
1997	2 225	10.2	415.9	2 356.1	0.1	NR
1998	2 196	10.2	426.0	2 273.4	0.1	NR
1999	2 181	9.3	435.6	2 192.4	0.1	NR
2000	2 173	9.3	446.0	2 116.9	0.1	45.4
2001	2 165	9.3	455.8	2 056.7	0.1	43.6
2002	2 152	9.3	458.6	2 014.0	0.1	41.0
2003	2 135	9.4	454.6	1 996.0	0.1	37.8
2004	2 110	2.4	448.4	1 913.9	0.1	34.8
2005	2 072	2.4	441.5	1 770.5	0.1	32.1
2006	2 032	2.4	434.1	1 627.8	0.1	29.5
2007	1 991	0.5	427.5	1 475.2	0.1	27.0
2008	1 943	0.5	423.0	1 322.1	0.1	24.5
2009	1 903	0.5	415.5	1 167.6	0.1	22.0
2010	1 870	0.5	404.7	1 028.3	0.1	19.5
2011	1 842	0.5	392.4	912.8	0.1	17.3
2012	1 807	0.5	375.8	824.0	0.1	15.3
2013	1 773	0.5	354.9	776.7	0.1	13.4
2014	1 740	0.5	335.5	747.0	0.1	11.8
2015	1 690	0.5	318.9	720.7	0.1	10.3
2016	1 631	0.5	303.7	697.9	0.1	9.1
2017	1 583	0.5	286.6	671.1	0.1	7.9
2018	1 547	0.5	268.3	642.0	0.1	6.9
2019	1 510	0.5	252.4	620.6	0.1	6.3

Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Category-specific recalculations

Based on a new study (SCHWINGSHACKL, M.; REXEIS, M. & WELLER, K. (2020A)) the specific emission factors for NO_x, PM, CO and HC of diesel engines stage 3b, 4 and 5 (mobile machinery and equipment), operating times and stock were updated resulting in significant changes of CO emissions for the whole time series (e.g. 2018: -4,2 kt).

Category-specific Planned Improvements

No 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.vii (*see Chapter 3.2.7.1*).*

Activity Data

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.

Activities used for estimating emissions of *1.A.4.c.2 Agriculture and Forestry – mobile sources* are presented in Table 207. Activities include liquid fuels (diesel, gasoline and biofuels).

Emission Factors

Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of *1.A.2.g.vii* (see Chapter 3.2.7.1). Implied emission factors of *1.A.4.c.2 Agriculture and Forestry – mobile sources* are presented below.

Table 199: Activities and Implied emission factors for NEC gases for 1.A.4.c.ii Off-road Vehicles and Other Machinery – Agriculture/Forestry/Fishing: 1990–2019.

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	371.6	0.4	198.3
1991	10 331	58.3	915.7	325.8	0.5	NR
1992	10 421	58.2	918.2	331.2	0.5	NR
1993	10 472	58.2	921.6	329.1	0.5	NR
1994	10 559	49.3	921.9	345.9	0.5	NR
1995	10 106	18.3	923.0	342.1	0.4	185.3
1996	10 509	18.3	924.5	341.2	0.4	NR
1997	11 036	18.3	928.0	323.5	0.4	NR
1998	10 836	18.3	929.7	314.6	0.4	NR

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1999	10 939	16.0	931.3	308.4	0.4	NR
2000	10 610	16.0	932.0	301.4	0.4	165.6
2001	10 936	16.1	933.3	294.4	0.4	162.9
2002	10 887	16.0	917.8	301.5	0.4	156.9
2003	10 457	16.0	889.8	320.7	0.4	148.5
2004	10 760	2.4	866.5	296.8	0.4	139.9
2005	11 435	2.4	843.7	269.6	0.4	131.5
2006	11 350	2.4	820.4	272.2	0.4	124.4
2007	11 290	0.5	797.3	266.4	0.4	116.6
2008	12 232	0.5	783.5	237.0	0.3	108.2
2009	11 203	0.5	772.7	204.5	0.3	99.8
2010	10 906	0.5	757.9	195.3	0.3	92.4
2011	11 823	0.5	746.2	175.3	0.3	84.8
2012	10 913	0.5	733.1	166.0	0.3	78.0
2013	10 564	0.5	712.1	153.9	0.3	71.1
2014	11 677	0.5	689.8	134.8	0.3	64.3
2015	10 802	0.5	664.3	132.8	0.3	59.2
2016	11 615	0.5	638.0	118.3	0.2	53.4
2017	10 777	0.5	609.5	118.9	0.2	49.3
2018	10 875	0.5	580.2	116.3	0.2	45.3
2019	11 459	0.5	553.6	106.8	0.2	41.1

Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Category-specific recalculations

Based on a new study (SCHWINGSHACKL, M.; REXEIS, M. & WELLER, K. (2020A)) the specific emission factors for NO_x, PM, CO and HC of diesel engines stage 3b, 4 and 5 (mobile machinery and equipment), operating times and stock were updated resulting in minor changes of activity data and emissions.

Category-specific Planned Improvements

No improvements are planned.

3.2.7.7 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 applied methodology is described in the subchapter on mobile sources of *1.A.2.g.vii* (see Chapter 3.2.7.1*)*.

Activity Data

Emission estimates for military activities were taken from (HAUSBERGER, S. (2000)). Information on the fleet composition was taken from official data presented in the internet as no other data were available. Also no information on the road performance of military vehicles was available, that's why emission estimates only present rough estimations, which were obtained making the following assumptions: for passenger cars and motorcycles the yearly road performance as calculated for civil cars was used. The yearly road performance for such vehicles was estimated to be 30 h/year (as a lot of vehicles are old and many are assumed not to be in actual use anymore).

Activities used for estimating the emissions of *1.A.5.b Military Off-road* are presented below.

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 for mobile off-road sources are described in the subchapter on mobile sources of 3.2.7 *Other mobile sources – Off Road*.

Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Military Aviation

Methodological Issues

For the years 1990–1999 fuel consumption for military flights was reported by the Ministry of Defence. For the years from 2000 onwards the trend has been extrapolated. The calculation of emissions from military aviation does not distinguish between LTO and cruise.

Activity Data

Activities used for estimating the emissions of Military Aviation (kerosene) and Military Off-Road Transport with diesel are presented in the following table.

Table 200: Activities from 1.A.5.b Other – mobile: 1990–2019.

Year	Kerosene [TJ]	Diesel [TJ]
1990	452	29
1991	481	29
1992	434	29
1993	513	28
1994	543	28
1995	419	28
1996	506	28
1997	482	28
1998	555	28
1999	544	27
2000	533	27
2001	541	27
2002	549	27

Year	**Kerosene [TJ]**	**Diesel [TJ]**
2003	556	27
2004	564	27
2005	572	27
2006	580	27
2007	587	27
2008	595	27
2009	603	27
2010	611	27
2011	618	27
2012	626	27
2013	634	27
2014	642	27
2015	650	27
2016	657	27
2017	664	27
2018	672	27
2019	681	27
1990–2019	**51%**	**-6%**

Emission Factors

For the years from 2000 onwards, emissions for military flights have been calculated with IEFs from the year 2000 taken from (KALIVODA, M. & KUDRNA, M. (2002)).

Table 201: 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

Category-specific Recalculations

No recalculations have been made in this year's submission.

3.2.8 Emission factors for heavy metals, POPs and PM 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 82, 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.

For Pb emission factors for gasoline before 1995 were calculated from the legal content limit for the different types of gasoline and the amounts sold of the different types 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 202: 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 203: 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

Lead 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 – European Environment Agency (2019)).

The result contains shares of lead emissions for road traffic according to the guidebook for the following components:

- Engine
- Liquids
- tire wear
- brake abrasion

Table 204: Pb emission factors for 1A3bvi Tyre and Break wear (SNAP 070700X7A, 070700X7B, 070700X7C)

Pb EF [mg/1000 Vehicle km]	1985
2Wheelers	486.7
Passenger cars	47.4
LDV & HDV	108.5

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.[112]

PAH emission factors

The Austrian transport model NEMO includes emission factors for the following four PAHs relevant for category *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 – EUROPEAN ENVIRONMENT AGENCY (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 – EUROPEAN ENVIRONMENT AGENCY (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, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015C)) via relationship factors from the tyre and brake TSP emission values.

- 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 (UBA) (1998)), (SCHEIDL, K. (1996)) and (ORTHOFER, R. & VESELY, A. (1990)) as well as measurements of emissions of a tractor engine by FTU (FTU – FORSCHUNGSGESELLSCHAFT TECHNISCHER UMWELTSCHUTZ (2000)) were applied.
- For diesel fuelled mobile off-road sources the HDV emission factor was taken;

[112] Emissions from off-road machinery are reported under *1.A.2.g.vii* (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 gasoline driven mobile sources in *1.A.3.d* and *1.A.4.c* (agriculture) the PC gasoline value;
- For gasoline fuelled mobile sources in *1.A.2*, *1.A.4.b* and *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 *1.A.4.b – stoves* were used.

Table 205: 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 205 and based on findings from (HÜBNER 2001).

HCB emissions

HCB emissions were calculated on the basis of dioxin emissions and assuming a factor of 200 (HÜBNER 2001).

PCB emission factors

For the calculation of PCB emissions in the model NEMO specific emission factors were taken from (EEA – EUROPEAN ENVIRONMENT AGENCY (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 *1.A.3.b Road Transport* are a minor source (HAUSBERGER, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015C)).

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, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015C)).

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 206: Activities and Implied emission factors for heavy metals for 1.A.3.a.ii Civil Aviation (domestic LTO + international LTO): 1990–2019.

Year	Activity	IEF Cd	IEF Hg	IEF Pb
	[TJ]		[kg/PJ]	
1990	1 829	0.02	0.01	895.0
1991	2 047	0.02	0.01	824.1
1992	2 218	0.02	0.01	783.5
1993	2 350	0.02	0.01	762.1
1994	2 450	0.02	0.01	753.3
1995	2 706	0.02	0.01	0.02
1996	2 977	0.02	0.01	0.02
1997	3 112	0.02	0.01	0.02
1998	3 231	0.02	0.01	0.02
1999	3 175	0.02	0.01	0.02
2000	3 239	0.02	0.01	0.02
2001	3 038	0.02	0.01	0.02
2002	3 532	0.02	0.01	0.02
2003	3 670	0.02	0.01	0.02
2004	4 323	0.02	0.01	0.02
2005	4 055	0.02	0.01	0.02
2006	4 067	0.02	0.01	0.02
2007	4 372	0.02	0.01	0.02
2008	4 470	0.02	0.01	0.02
2009	4 115	0.02	0.01	0.02
2010	4 181	0.02	0.01	0.02
2011	4 726	0.02	0.01	0.02
2012	4 484	0.02	0.01	0.02
2013	4 375	0.02	0.01	0.02
2014	4 390	0.02	0.01	0.02
2015	4 624	0.02	0.01	0.02
2016	4 744	0.02	0.01	0.05
2017	4 555	0.02	0.01	0.06
2018	4 957	0.02	0.01	0.06
2019	5 570	0.02	0.01	0.07

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 207: Activities and Implied emission factors for heavy metals for International Bunkers (domestic + international cruise traffic): 1990–2019.

Year	Activity	IEF Cd	IEF Hg	IEF Pb
	[TJ]		[kg/PJ]	
1990	10 791	0.02	0.01	0.02
1991	12 132	0.02	0.01	0.02
1992	13 186	0.02	0.01	0.02
1993	13 990	0.02	0.01	0.02
1994	14 594	0.02	0.01	0.02
1995	16 337	0.02	0.01	0.02
1996	18 058	0.02	0.01	0.02
1997	18 833	0.02	0.01	0.02
1998	19 530	0.02	0.01	0.02
1999	19 136	0.02	0.01	0.02
2000	20 977	0.02	0.01	0.02
2001	20 471	0.02	0.01	0.02
2002	18 488	0.02	0.01	0.02
2003	17 147	0.02	0.01	0.02
2004	20 255	0.02	0.01	0.02
2005	23 784	0.02	0.01	0.02
2006	25 064	0.02	0.01	0.02
2007	26 529	0.02	0.01	0.02
2008	26 475	0.02	0.01	0.02
2009	22 820	0.02	0.01	0.02
2010	24 846	0.02	0.01	0.02
2011	25 907	0.02	0.01	0.02
2012	24 739	0.02	0.01	0.02
2013	23 512	0.02	0.01	0.02
2014	23 469	0.02	0.01	0.02
2015	25 300	0.02	0.01	0.02
2016	27 860	0.02	0.01	0.02
2017	26 898	0.02	0.01	0.02
2018	30 451	0.02	0.01	0.02
2019	35 095	0.02	0.01	0.02

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 208: Activities and Implied emission factors for heavy metals and POPs for 1.A.3.b Road Transport: 1990–2019.

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	176 289	0.09	0.01	1 004.27	1.49	0.02	4.65	0.002
1991	195 830	0.09	0.01	749.01	1.50	0.02	4.19	0.002
1992	195 642	0.09	0.01	520.61	1.53	0.02	3.67	0.002
1993	197 657	0.09	0.01	336.43	1.56	0.02	3.16	0.002
1994	198 412	0.09	0.01	201.72	1.62	0.01	2.75	0.002
1995	202 185	0.09	0.01	15.64	1.67	0.01	2.36	0.002
1996	223 483	0.09	0.01	14.61	1.64	0.01	1.92	0.002
1997	210 345	0.09	0.01	15.88	1.67	0.01	1.69	0.003
1998	236 898	0.09	0.01	14.55	1.58	0.01	1.45	0.002
1999	228 769	0.09	0.01	15.51	1.53	0.01	1.27	0.003
2000	241 103	0.09	0.01	15.09	1.44	0.01	1.11	0.003
2001	259 202	0.09	0.01	14.31	1.36	0.01	1.00	0.003
2002	287 508	0.08	0.01	13.27	1.29	0.00	0.91	0.003
2003	311 124	0.08	0.01	12.60	1.23	0.00	0.84	0.003
2004	318 047	0.08	0.01	12.53	1.19	0.00	0.78	0.003
2005	324 929	0.08	0.01	12.33	1.15	0.00	0.80	0.003
2006	312 674	0.08	0.01	13.06	1.16	0.00	0.86	0.003
2007	316 444	0.08	0.01	13.06	1.13	0.00	0.86	0.003
2008	299 457	0.08	0.01	13.45	1.11	0.00	0.92	0.003
2009	294 527	0.08	0.01	13.50	1.08	0.01	1.00	0.003
2010	306 035	0.08	0.01	13.20	1.06	0.01	1.02	0.003
2011	295 843	0.08	0.01	13.92	1.04	0.01	1.00	0.002
2012	295 600	0.08	0.01	13.90	1.02	0.01	1.03	0.002
2013	309 188	0.08	0.01	13.43	1.02	0.01	1.02	0.002
2014	301 922	0.08	0.01	14.13	1.03	0.01	1.03	0.002
2015	308 969	0.08	0.01	14.16	1.03	0.01	1.05	0.002
2016	318 589	0.08	0.01	14.17	1.00	0.00	1.00	0.002
2017	326 371	0.08	0.01	14.14	0.99	0.00	0.96	0.001
2018	329 763	0.09	0.01	14.58	0.99	0.00	0.95	0.001
2019	330 217	0.09	0.01	14.78	0.99	0.00	0.93	0.001

Category-specific Recalculations

The calibration of the mileage model of the vehicle categories to the energy balance (LPG, biogas) resulted in minor changes in activity data and emissions per vehicle category over the entire time series.

NFR 1.A.3.c Railways

Table 209: Activities and Implied emission factors for heavy metals and POPs for 1.A.3.c Railsways 1990–2019.

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	2 380.2	0.18	0.32	2.6	8.7	0.02	3.3	0.0012
1991	2 182.9	0.18	0.32	2.6	8.7	0.02	3.3	0.0012
1992	2 165.2	0.18	0.33	2.7	8.8	0.02	3.4	0.0012
1993	2 110.6	0.17	0.31	2.5	8.6	0.02	3.2	0.0011
1994	2 129.4	0.17	0.30	2.5	8.6	0.02	3.2	0.0011
1995	1 986.9	0.19	0.34	2.8	8.8	0.02	3.4	0.0012
1996	1 796.4	0.20	0.37	3.0	9.1	0.02	3.6	0.0012
1997	1 787.8	0.12	0.21	1.7	7.9	0.01	2.5	0.0011
1998	1 761.1	0.11	0.19	1.6	7.8	0.01	2.4	0.0011
1999	1 818.3	0.11	0.18	1.5	7.7	0.01	2.3	0.0011
2000	1 814.5	0.10	0.16	1.3	7.5	0.01	2.2	0.0010
2001	1 746.2	0.08	0.12	0.9	7.2	0.01	1.9	0.0010
2002	1 889.4	0.08	0.12	1.0	7.2	0.01	1.9	0.0010
2003	1 895.6	0.06	0.10	0.8	7.1	0.01	1.7	0.0010
2004	1 885.8	0.04	0.04	0.3	6.7	0.01	1.3	0.0010
2005	2 194.0	0.03	0.03	0.2	6.6	0.01	1.3	0.0010
2006	2 142.7	0.03	0.04	0.3	6.6	0.01	1.6	0.0010
2007	2 130.9	0.03	0.03	0.3	6.5	0.01	1.6	0.0010
2008	2 127.6	0.03	0.03	0.2	6.5	0.01	1.6	0.0010
2009	2 084.7	0.04	0.04	0.3	6.6	0.01	1.7	0.0010
2010	2 038.8	0.03	0.03	0.2	6.5	0.01	1.7	0.0010
2011	1 714.5	0.03	0.04	0.3	6.5	0.01	1.7	0.0011
2012	1 764.0	0.03	0.04	0.3	6.5	0.01	1.8	0.0011
2013	1 625.4	0.04	0.04	0.3	6.6	0.01	1.7	0.0011
2014	1 699.8	0.03	0.04	0.3	6.5	0.01	1.8	0.0011
2015	1 524.5	0.04	0.04	0.3	6.6	0.01	1.8	0.0010
2016	1 580.2	0.04	0.04	0.3	6.6	0.01	1.8	0.0010
2017	1 641.5	0.04	0.04	0.3	6.6	0.01	1.7	0.0010
2018	1 307.9	0.04	0.04	0.3	6.6	0.01	1.8	0.0009
2019	1 315.9	0.04	0.04	0.3	6.6	0.01	1.8	0.0009

NFR 1.A.3.d Navigation

Table 210: Activities and Implied emission factors for heavy metals and POPs for 1.A.3.d Navigation 1990–2019.

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	0.02	0.01	261.92	6.26	0.01	2.13	0.005
1991	934	0.02	0.01	228.25	6.25	0.01	2.19	0.005
1992	937	0.02	0.01	177.97	6.25	0.01	2.19	0.005
1993	962	0.02	0.01	125.37	6.26	0.01	2.16	0.005
1994	1 123	0.02	0.01	66.26	6.28	0.01	2.00	0.004
1995	1 229	0.02	0.01	0.03	6.29	0.01	1.92	0.004
1996	1 267	0.02	0.01	0.03	6.29	0.01	1.89	0.004
1997	1 278	0.02	0.01	0.03	6.29	0.01	1.88	0.004
1998	1 370	0.02	0.01	0.03	6.30	0.01	1.82	0.004
1999	1 368	0.02	0.01	0.03	6.30	0.01	1.82	0.003
2000	1 469	0.02	0.01	0.03	6.31	0.01	1.76	0.003
2001	1 530	0.02	0.01	0.03	6.31	0.01	1.73	0.003
2002	1 659	0.02	0.01	0.03	6.32	0.01	1.68	0.003
2003	1 454	0.02	0.01	0.03	6.31	0.01	1.76	0.003
2004	1 728	0.02	0.01	0.03	6.33	0.01	1.64	0.003
2005	1 747	0.02	0.01	0.03	6.32	0.01	1.65	0.003
2006	1 655	0.02	0.01	0.03	6.30	0.01	1.76	0.003
2007	1 702	0.02	0.01	0.02	6.31	0.01	1.73	0.003
2008	1 614	0.02	0.01	0.02	6.30	0.01	1.78	0.003
2009	1 507	0.02	0.01	0.02	6.28	0.01	1.87	0.003
2010	1 664	0.02	0.01	0.02	6.30	0.01	1.79	0.002
2011	1 617	0.02	0.01	0.02	6.29	0.01	1.82	0.002
2012	1 562	0.02	0.01	0.02	6.29	0.01	1.83	0.002
2013	1 663	0.02	0.01	0.02	6.30	0.01	1.78	0.002
2014	1 695	0.02	0.01	0.02	6.29	0.01	1.81	0.002
2015	1 582	0.02	0.01	0.02	6.28	0.01	1.88	0.002
2016	1 678	0.02	0.01	0.02	6.29	0.01	1.81	0.002
2017	1 754	0.02	0.01	0.02	6.30	0.01	1.77	0.002
2018	1 591	0.02	0.01	0.02	6.29	0.01	1.85	0.002
2019	1 793	0.02	0.01	0.02	6.30	0.01	1.78	0.002

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 211 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 211: 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	050102Underground 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
1.B.1.a.ii	Coal Mining and Handling: Surface mines	050101Open 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
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
1.B 2.a	i Exploration, Production, Transport	0503 Extraction, 1st treatment and loading of gaseous fossil fuels	NA	NA	NA	IE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	iv Refining /Storage(2)		IE	IE	IE	✓	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	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(3)	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	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2.c	Venting and flaring(2)		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1.B.2.d	Other fugitive emissions		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) *including emissions from 1.B.2.a.i (Exploration, Production and Transport of Oil) and oil pipelines*

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 2013) and the tier 2 emission factor 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 (BMWFJ 2008) emissions decreased sharply (80%) between 2003 and 2004.

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 emissions from Underground Mining the Tier 1 emission factors were applied as there is no activity data available to apply the Tier 2 emission factors.

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 and are presented in Table 212 together with the national emission factors. The emission factors from the national study WINIWARTER et al. 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 212: 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	40	51	39	42
$PM_{2.5}$	14	12	16	6	5
NMVOC	-	-	-	200	3000

Table 213: 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	2 503	2 402	2 448	NO
1995	1 484	1 743	2 354	1 297	1
2000	1 847	1 381	2 435	1 249	NO
2001	2 039	1 630	2 320	1 206	NO
2002	1 943	1 561	2 589	1 412	NO
2003	2 412	1 653	2 481	1 152	NO

Year	Activity [kt]			Activity [kt]	
	Storage of solid fuels			Mining activities	
	Bituminous coal	Lignite	Coke Oven Coke	Lignite	Bituminous coal
2004	2 424	1 215	2 443	235	NO
2005	2 146	1 272	2 684	NO	NO
2006	2 341	753	2 700	NO	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
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	1 368	68	2 349	NO	NO

3.3.3 NFR 1.B.2.a Oil – Methodological issues

As all oil fields are combined oil and gas production fields, total NMVOC emissions of combined oil and gas production are reported in this category. Further in this category, NMVOC emissions of transport and distribution of crude oil, oil products as well as from oil refining are considered.

Activity data for NMVOC emissions from natural gas extraction are reported from „Fachverband Mineralöl" (Austrian association of oil industry). NMVOC emissions are reported from 1992 onwards, for the years before the emission value of 1992 was used.

Activity data for the transport of crude oil is reported by the Fachverband Mineralöl (Austrian association of oil industry). 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.

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". 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 214 .

Table 214: Activity data and implied emission factors for fugitive NMVOC emissions from NFR category 1.B.2.a.

Year	Transport of crude oil[113]	Refinery dispatch station		Oil refining	
	Activity [1 000m³]	NMVOC IEF [g/t]	Gasoline [kt]	NMVOC IEF [g/t]	Crude oil refined [kt]
1990	7 993	1 109	2 554	472.31	7 952
1995	8 721	916	2 402	174.03	8 619
2000	8 720	811	1 980	168.09	8 240
2001	8 855	296	1 998	61.71	8 799
2002	9 020	281	2 142	61.81	8 947
2003	9 309	269	2 223	61.69	8 819
2004	8 930	262	2 133	59.23	8 442
2005	9 000	205	2 073	58.91	8 743
2006	8 810	221	1 992	59.61	8 472
2007	9 090	228	1 966	60.15	8 496
2008	9 380	183	1 835	57.87	8 710
2009	8 930	186	1 842	56.60	8 286
2010	8 300	171	1 972	54.80	7 719
2011	8 900	181	1 886	50.31	8 170
2012	9 200	173	1 853	46.83	8 349
2013	9 300	169	1 798	40.07	8 584
2014	9 300	183	1 730	47.78	8 435
2015	9 500	161	1 725	43.83	8 853
2016	8 900	139	1 723	50.46	8 184
2017	9 000	157	1 744	57.79	8 064
2018	9 800	128	1 794	41.47	8 970
2019	10 000	128	1 746	38.14	9 124

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
2001	238	1 998	269	1 998
2002	264	2 142	270	2 142
2003	233	2 223	270	2 223
2004	215	2 133	270	2 133
2005	206	2 073	270	2 073
2006	233	1 992	270	1 992
2007	233	1 966	270	1 966
2008	246	1 835	270	1 835

[113] Refinery crude oil throughput

Year	Transport and depots		Service stations	
	NMVOC IEF [g/t]	Gasoline [kt]	NMVOC IEF [g/t]	Petrol [kt]
2009	151	1 842	270	1 842
2010	119	1 972	270	1 972
2011	112	1 886	270	1 886
2012	134	1 853	270	1 853
2013	134	1 798	270	1 798
2014	151	1 730	270	1 730
2015	143	1 725	270	1 725
2016	146	1 723	270	1 723
2017	125	1 744	270	1 744
2018	127	1 794	270	1 794
2019	149	1 746	270	1 746

Between 1990 and 2019 NMVOC emissions from the transport of crude oil increased by 25% due to the increased refinery activity.

NMVOC emissions from refinery dispatch stations, transport and depots and from service stations and refuelling of cars decreased remarkably (93%, 90% and 76% respectively) between 1990 and 2019 due to installation of gas recovery units.

NMVOC emissions from oil refining and gas extraction also showed a notable decrease of 91% and 63% respectively between 1990 and 2019. 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 extraction and 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). 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 2013–2019 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). NMVOC emissions from gas distribution networks were calculated by applying the country-specific share of 1.2% NMVOC in natural gas. This share is based on the natural gas composition in Austria. 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 "Fachverband der Gas- und Wärmeversorgungsunternehmungen", "Association of Gas- and District Heating Supply Companies") and material specific emission factors (WARTHA 2005).

Table 215: 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 m³]	Raw gas Throughput [1 000 m³]	NMVOC IEF [g/1000m³]	Gas production [1000m³]	NMVOC IEF [g/km]	Distribution mains [km]
1990	8 062	248 090	849	1 288 000	2 043	11 672
1995	3 772	405 638	676	1 482 000	1 248	17 778
2000	120	358 357	525	1 805 000	864	24 099
2001	120	393 492	485	1 954 000	829	25 042
2002	120	347 513	468	2 014 000	833	24 216
2003	120	408 198	465	2 030 000	797	25 699
2004	120	373 099	472	1 963 000	744	26 158
2005	120	338 349	557	1 637 000	724	26 958
2006	120	402 990	501	1 819 000	713	27 413
2007	120	444 029	284	1 848 000	696	27 945
2008	120	372 406	289	1 531 000	682	28 348
2009	120	466 628	300	1 670 000	673	28 533
2010	120	397 132	288	1 816 000	662	28 733
2011	120	375 168	295	1 684 000	659	29 023
2012	120	375 420	270	1 807 000	650	29 260
2013	116	335 874	319	1 467 000	634	29 496
2014	117	307 475	397	1 247 000	625	29 826
2015	140	279 102	383	1 166 000	617	30 067
2016	128	179 474	352	1 253 000	608	30 215
2017	142	252 837	235	1 742 000	597	30 507
2018	97	237 622	379	969 000	597	30 089
2019	101	227 559	457	891 000	587	30 279

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 216) 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 (2100 g NH_3/MWh electricity produced and 0.44g Hg/MWh electricity produced).

Table 216: Activity data for fugitive NH_3- and Hg- emissions from NFR category 1.B.2.d

Year	Geothermal energy extraction [GWh]
1990	NO
1995	NO

Year	Geothermal energy extraction [GWh]
2000	NO
2001	NO
2002	NO
2003	NO
2004	NO
2005	2.30
2006	3.06
2007	2.41
2008	1.62
2009	1.51
2010	1.40
2011	1.05
2012	0.68
2013	0.31
2014	0.38
2015	0.06
2016	0.02
2017	0.09
2018	0.24
2019	0.20

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 217 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 25).

Table 217: 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

Recalculations of TSP, PM_{10} and $PM_{2.5}$ emissions in the category 1.B.1.a (Coal Mining and Handling) for the years 2014 and 2016-2018 are due to a revision of the energy balance by Statistik Austria. This revision leads to an increase of 0.002 kt TSP emissions, 0.001 kt PM_{10} emissions and 0.0004 kt $PM_{2.5}$ emissions in 2018.

3.3.9 Planned Improvements

No improvements are currently planned.

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 2019.

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).

4.1 General description

4.1.1 Completeness

Table 218 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 218: 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	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	NA	NA	NA
2.D.3.c	Asphalt roofing	NA	NA	NA	NE	✓	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

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.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	NA	NA	NA	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
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

4.1.2 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 219.

Table 219: 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, PM_{10}, $PM_{2.5}$	LA, TA
2.C.1	Iron and Steel Production	Cd, Pb, Hg, DIOX, PCB, HCB TSP PM_{10} $PM_{2,5}$	LA, TA
2.C.3	Aluminium production	DIOX, HCB	LA,TA
2.D.3.a	Domestic solvent use including fungicides	NMVOC	LA,TA
2.D.3.d	Coating applications	NMVOC	LA,TA
2.D.3.e	Degreasing	NMVOC	LA, TA

NFR Category	Source Categories	Key Categories	
		Pollutant	KS-Assessment
2.D.3.g	Chemical Products	NMVOC	LA, 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	LA
2.H	Other Processes	NMVOC	LA
2 I	Wood Processing	TSP	LA

TA = Trend Assessment 2019

LA = Level Assessment (if not further specified – for the years 1990 and 2019)

4.1.3 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.

4.1.4 Uncertainty Assessment

The table below gives an overview of uncertainties for Industrial Processes and Product Use 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 2021a). 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 220: 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

NRF sector	Pollutant	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty (%)
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
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	30.0	30.4
2.G	SO_2	100	125.0	160.1
2.G	NO_x	100	125.0	160.1
2.G	NMVOC	100	125.0	160.1
2.G	$PM_{2.5}$	100	125.0	160.1
2.G	NH_3	20.0	40.0	44.7
2.H	NO_x	10.0	40.0	41.2
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

4.1.5 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 221, which also address verification. Some plants that report emission data have quality management systems according to the ISO 9000 series or similar systems in place.

Table 221: 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	BGBl 1994/498 Verordnung für Anlagen zur Glaserzeugung
2.C.1	BGBl. II Nr. 264/2014 Gießerei-Verordnung 2014

Source Category	Austrian legislation
2.C.1	BGBl 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	BGBl 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

4.1.6 Planned Improvements

2.D.3.c Asphalt roofing

This subsector has been reinvestigated during the evaluation of the solvents model: nowadays, all of the Austrian production sites have installed off-gas treatment systems and emissions are thus assumed to be negligible. However, as no information on the installation date of the off-gas treatment is yet available, the notation key was changed to "NE". An estimation of historical emissions will be included in future submissions. Due to the change of plans due to the Covid pandemic, and the focus on the update of the solvents model, this investigation has been postponed to 2021, and results will be included in the submission 2022.

2.D.3.b Road paving with asphalt

$PM_{2.5}$ will be estimated when data on processes and possible abatement technologies in place are fully investigated. Results will be included in submission 2022.The investigation was originally planned for this submission, however, due to the change of plans due to the Covid pandemic, all resources were focussed on the update of the Solvents model

4.2 NFR 2.A.1-2.A.3 Mineral Products

4.2.1 Fugitive Particulate Matter emissions

4.2.1.1 Source Category Description

In this category, fugitive PM emissions from bulk material handling are reported. These include emissions from quarrying and mining of minerals other than coal, construction and demolition and agricultural bulk materials. Most fugitive PM emissions are reported in NFR category 2.A.5, except emissions from cement that are reported in NFR category 2.A.1, from lime production that are reported in NFR category 2.A.2, and from agricultural bulk material that are reported in NFR category 3.D. Emissions from cement and lime production include point source emissions from kilns.

4.2.1.2 Methodological Issues

The general method for estimating fugitive 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[114] 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[115].

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.

Emission factors are presented in Table 222. Activity data are mainly taken from national statistics and presented in Table 223.

Table 222: Emission factors (EF) for diffuse PM emissions from bulk material handling, mining and construction/demolition

Bulk material / mineral	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)
Cement & Lime milling	7.75	6.98	6.20
Rye flour	43.59	20.62	6.50
Wheat flour	43.59	20.62	6.50

[114] Association of German Engineers – VDI Verein Deutscher Ingenieure

[115] http://www.air.sk/tno/cepmeip/

Bulk material / mineral	EF TSP [g/t]	EF PM_{10} [g/t]	EF $PM_{2.5}$ [g/t]
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
Activity	**EF TSP [g/m²]**	**EF PM_{10} [g/m²]**	**EF $PM_{2.5}$ [g/m²]**
Total area under construction (for sub-category „Construction and demolition" [(1)]	173.4	86.7	8.67

[(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)*

Table 223: Activity data for diffuse PM emissions from bulk material handling, mining and construction/demolition

Activity data [t]	1990	1995	2000	2005	2010	2015	2019
Magnesite	1 179 162	783 497	725 832	693 754	757 063	702 504	691 909
Sand	2 517 296	3 033 907	3 692 910	3 660 228	2 001 407	2 169 684	1 692 835
Gravel	14 264 676	17 192 140	20 978 974	25 361 797	28 304 033	27 550 482	28 080 986
Silicates	1 484 527	810 520	1 991 018	2 580 295	2 593 863	2 017 977	2 284 837
Dolomite	1 879 837	8 789 688	7 152 245	6 291 413	3 914 859	3 963 986	4 237 381
Limestone	15 371 451	19 079 581	23 823 529	22 643 754	21 189 887	21 059 817	21 058 068
Basaltic rocks	3 673 535	4 202 244	4 933 202	3 166 281	3 234 408	3 543 675	3 826 705
Iron ore	2 310 710	2 116 099	1 859 449	2 047 950	2 068 853	2 783 327	3 242 102
Tungsten ore	191 306	411 417	416 456	472 964	429 748	535 762	551 046
Gypsum, Anhydride	751 645	958 430	946 044	911 162	872 273	715 195	900 217
Lime, quick, slacked	512 610	522 934	654 437	788 328	764 845	772 225	783 272
Cement	3 693 539	2 929 973	3 052 974	3 221 167	3 097 043	3 256 561	3 422 866
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	51 925
Wheat flour	259 123	287 461	291 482	324 160	451 086	516 638	399 685
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	129 138
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	1 270 299

Activity data [m²]	1990	1995	2000	2005	2010	2015	2019
Total area under construction (for subcategory „Construction and demolition“	10 142 004	11 060 799	11 788 151	11 973 069	13 733 483	14 037 015	16 761 216

4.2.2 NFR 2.A.5 Mining, Construction/Demolition

4.2.2.1 Source Category Description

This category contains the sub categories "quarrying and mining of minerals other than coal" and "construction and demolition". It covers, *inter alia,* particulate matter emissions from gypsum and anhydrite mining and from construction/demolition activities.

4.2.2.2 Methodological Issues

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. Particulate matter emission factors for gypsum and anhydrite mining were taken from WINIWARTER et al. (2007).

Construction and demolition emissions are based on data from Statistik Austria on the total area under construction (in m²). This area is multiplied by emission factors for TSP, PM_{10} and $PM_{2.5}$ derived by WINIWARTER et al. (2007).

Emission factors and activity data for mining, construction/demolition and handling of products are presented in Table 222 and Table 223, above.

4.2.3 Category-specific Recalculations

NFR 2.A.5.a Quarrying and mining of minerals other than coal

Revised activity data since 2016 for dolomite and limestone were provided by the Austrian mining handbook resulting in minor changes in emissions (+0.0001 kt $PM_{2.5}$ for 2018).

NFR 2.A.5.b Construction and demolition

Due to revisions of the statistical data on building costs, the activity data had to be updated, resulting in minor changes in PM emissions from 2001 onwards (+0.003kt $PM_{2.5}$ for 2018).

4.3 NFR 2.B Chemical Products

4.3.1 NFR 2.B.1 Ammonia and 2.B.2 Nitric Acid Production

4.3.1.1 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 are emitted.

In Austria there is only one producer of ammonia and nitric acid.

The following chart (Figure 52) depicts the process of ammonia synthesis, the main production lines (ammonia, urea, melamine, nitric acid, fertilizer etc.) with their main raw material as well their internal subsequent processing of related products (UMWELTBUNDESAMT 2004c). A detailed process description of the Ammonia production and downstream processes can be found in the Austria`s National Inventory Report (UMWELTBUNDESAMT 2021a).

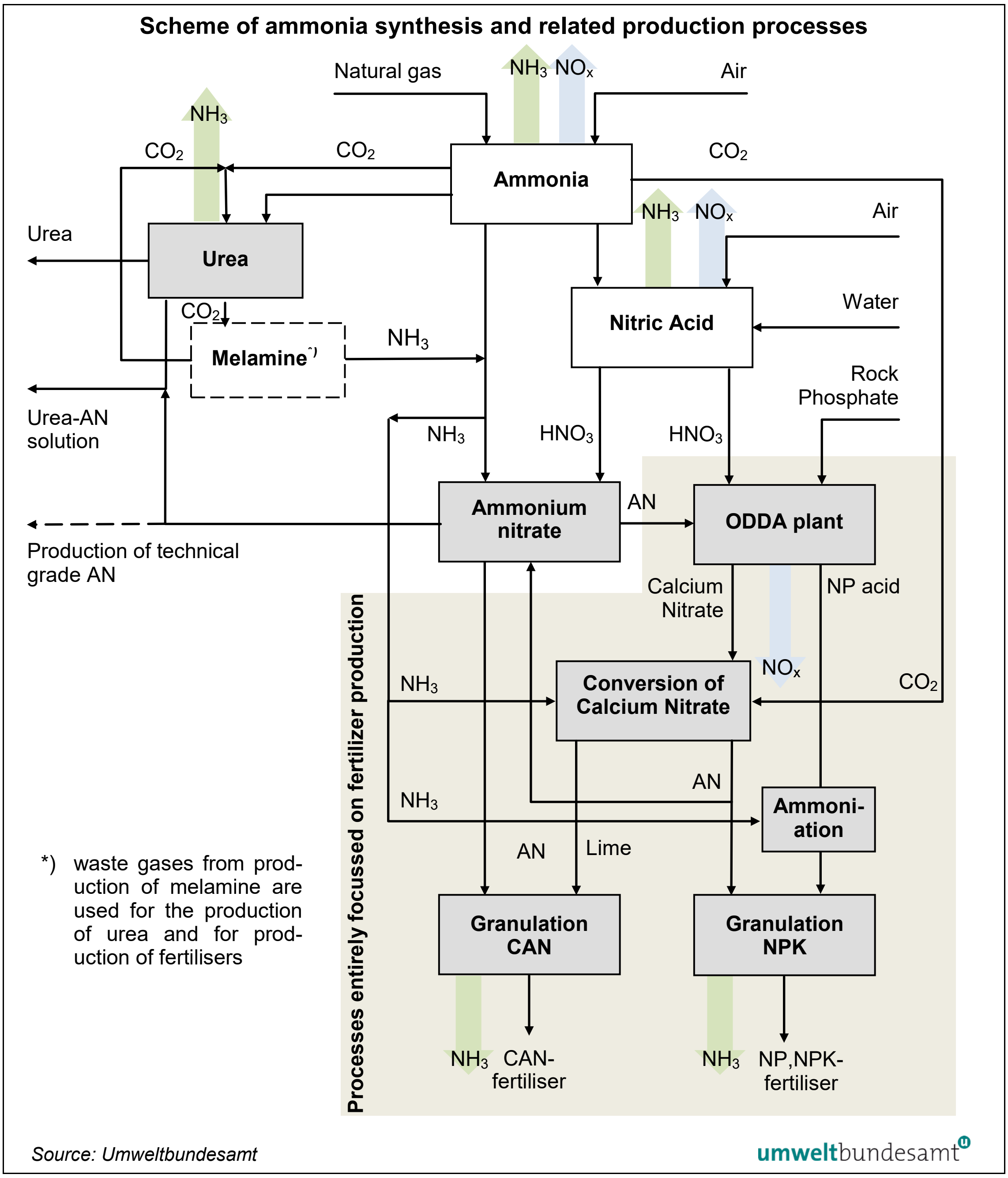


Figure 52: Scheme of ammonia synthesis and related production processes.

4.3.1.2 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 224 and Table 225). 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. NO_x emissions from 1990 to 1992 are included in category *2.B.5 Other processes in organic chemical industries*.

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 224: Emissions and implied emission factors for NO_x, NH_3 and CO 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]
1990	IE	NA	7.4	16.0	123.1	267.1
1995	285.9	604.4	10.7	22.6	95.1	201.1
2000	206.5	428.1	7.0	14.5	43.0	89.2
2005	244.0	509.9	9.9	20.7	52.6	109.9
2010	197.7	399.1	10.7	21.6	56.9	114.9
2015	198.4	381.6	9.5	18.3	61.2	117.7
2019	217.9	394.1	23.5	42.5	32.3	58.4

Table 225: 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	IE	NA	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
2019	67.1	116.6	8.9	15.5

4.3.2 NFR 2.B.10 Other Chemical Industry

4.3.2.1 Source Category Description

This category includes NH_3 emissions from the production of ammonium nitrate, fertilizers and urea as well as NO_x emissions from fertilizer production. For the years 1990 to 1992, all NO_x emissions from inorganic chemical processes are reported as a total under this category.

This category furthermore includes SO_2 and CO emissions from inorganic chemical processes and NMVOC emissions from organic chemical processes, which were not further split into sub categories.

Emissions of minor importance are

- Heavy metals and particulate matter from fertilizers;
- Hg emissions from chlorine production (1999 changeover from mercury cell to membrane cell, thus no more emissions);
- HCB emissions from the production of per- and trichloroethylene (1992 cessation of production) and
- Particulate matter emissions from the production of ammonium nitrate.
- NMVOC emissions on facility level from chemical production; the emissions from smaller plants are included in the solvents model
- Emissions from storage, handling and transport of chemical products are included in *NFR 2.B.10.a*

4.3.2.2 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. 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 226: 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	0.71	72.39	12.80	11.52	10.24
1995	0.90	72.39	14.90	13.41	11.92
2000	0.20	12.89	0.20	0.19	0.18
2005	0.33	17.20	0.26	0.24	0.23
2010	0.30	23.08	0.20	0.19	0.18
2015	0.30	23.10	0.10	0.10	0.09
2019	0.60	46.70	0.10	0.10	0.09

Table 227: Emissions and implied emission factors for NH_3 and CO emissions from urea production.

Year	NH_3 emission [t]	NH_3 IEF [g/t]	CO emission [t]	CO IEF [g/t]
1990	38.6	137.0	7.1	7.1
1995	47.7	121.4	9.7	9.7
2000	17.4	44.6	3.6	3.6
2005	30.1	72.3	3.8	3.8
2010	33.8	80.5	3.7	3.7
2015	42.8	98.5	3.7	3.7
2019	43.1	96.1	3.7	3.7

Fertilizer production

For fertilizer production activity data from 1990 to 1994 were taken from national production statistics[116] (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. NO_x emissions from 1990 to 1992 are included in *Other processes in organic chemical industries*.

Cd, Hg and Pb emissions were calculated by multiplying the above mentioned activity data by national emission factors (HÜBNER 2001a) that derive from analysis of particulate matter fractions as described in MAGISTRAT DER LANDESHAUPTSTADT LINZ (1995). Particulate matter emissions (fugitive and non-fugitive) were estimated for the whole fertilizer production in Austria (WINIWARTER et al. 2007) for the years 1990, 1995 and 1999. Implied emission factors were calculated from emission and activity data that were used to calculate emissions from 2000 to 2005. The shares of PM_{10} and $PM_{2.5}$ are 58.6% and 30.9%, respectively, for the whole time-series.

[116] 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.

Table 228: 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	IE	IE	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
2019	86.7	79.3	33.1	30.3

Table 229: 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	945	554	292
1995	0.62	0.08	0.77	434	254	134
2000	0.64	0.09	0.80	447	262	138
2005	0.65	0.09	0.81	456	267	141
2010	0.65	0.09	0.82	459	269	142
2015	0.65	0.09	0.81	456	267	141
2019	0.68	0.09	0.85	478	280	148

Other processes in organic and inorganic chemical industries

All SO_2, NO_x and NMVOC process emissions from chemical industries (both organic and inorganic) are reported together as a total in category *2.B.10 Other Chemical Industry*. For NO_x emissions from 1993 onwards, emission data have been split and allocated to the respective emitting processes (ammonia production, fertilizer production and nitric acid production).

Activity data up to 1992 were taken from Statistik Austria. In the year 1997 a study commissioned by associations of industries was published (WINDSPERGER & TURI 1997). The activity figures for the year 1993 included in this study were used for all years afterwards, as no more up-to date activity data are available.

Emission data for NO_x and CO were taken from the same study (WINDSPERGER & TURI 1997); they were obtained from direct inquiries at the industries. SO_2 emissions were re-evaluated by direct inquiries at the industries in 2004. Emissions of this source category are calculated on SNAP level 3 and then aggregated to the NFR category.

NMVOC emissions of this category arise from two large chemical plants. Smaller chemical production plants are considered in the solvents model, emissions are reported under 2.D.3. Austria is not able to allocate emissions from the large plants to different processes as set out in the 2019 EMEP/EEA Guidebook. For one plant, plant-specific data has been obtained from 1999 onwards (these emissions are below the defined PRTR threshold value). For the second and much larger plant, PRTR data have been included from 2007 onwards. Before 2007, plant-specific data were available for 1996, 2000, 2003. In 1998, an abatement system was installed.

Activity data and emissions for NO_x, NMVOC, CO and SO_2 from other organic and inorganic chemical industries are presented in Table 230.

Table 230: Activity data and NMVOC, NO_x, SO_2 and CO emissions from other processes in organic and inorganic chemical industries.

Year	Processes in organic chemical industries		Processes in inorganic chemical industries			
	Activity	NMVOC emissions	Activity	NO_x emissions	SO_2 emissions	CO emissions
	[t]		[t]			
1990	461 000	1 618	963 824	4 072	1 565	12 537
1995	473 000	1 618	908 640	IE	712	11 064
2000	482 333	524	908 640	IE	595	11 064
2005	478 427	443	908 640	IE	572	11 064
2010	495 353	569	908 640	IE	497	11 064
2015	519 860	324	908 640	IE	365	11 064
2019	552 973	268	908 640	IE	365	11 064

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.

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.

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.

Table 231: 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	180.00	NO	NO
2000	NA	NA	NO	NO
2005	NA	NA	NO	NO
2010	NA	NA	NO	NO
2015	NA	NA	NO	NO
2019	NA	NA	NO	NO

4.3.3 Category-specific Recalculations

No recalculations have been made for this year's submission.

4.4 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.

4.4.1 NFR 2.C.1 Iron and Steel Production

4.4.1.1 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.

4.4.1.2 Methodological issues

Blast Furnace Charging

In this category, PM, POP and heavy metal emissions are considered. SO_2, NO_x, NMVOC and CO emissions are included in category 1.A.2.a.

From 1990 to 2000 Heavy metals and POPs (dioxine, HCB) were calculated via multiplying activity data with emission factors. The emissions factors on process level (sinter, coke oven, blast furnace cowpers) were taken from unpublished national studies (HÜBNER 2001a[117]), (HÜBNER 2001b[118]). These emissions on process level have been summed up afterwards. From 2001 onwards the emissions were calculated by multiplying iron production by the implied emission factors for 2000, except dioxine emissions, which have been reported directly from plant operators since 2002.

Particulate matter emissions for the years 1990 to 2001 were taken from a national study (WINIWARTER et al. 2001). These emissions were taken from environmental declarations from the companies. For the years 2002 onwards, total particulate matter emissions are reported directly by the operator. Emission factors used for PCB are from the EMEP/EEA Emission Inventory Guidebook 2016 (EEA 2016).

Pig iron production figures were taken from national statistics. Activity data, POP, HM and PM emissions are presented in Table 232.

[117] according to EUROPEAN COMMISSION IPPC BUREAU (2000); MAGISTRAT DER LANDESHAUPTSTADT LINZ (1995)

[118] according to HÜBNER (2000); EUROPEAN COMMISSION IPPC BUREAU (2000); UMWELTBUNDESAMT BERLIN (1998)

Table 232: Activity data (Pig Iron) and emissions from blast furnace charging.

	1990	1995	2000	2005	2010	2015	2019
Activity [t]	3 444 000	3 888 000	4 320 000	5 457 755	5 643 855	5 794 527	5 740 903
				Emissions [kg]			
Cd	342	86	98	124	129	132	131
Hg	218	281	236	298	308	316	313
Pb	26 307	2 118	2 557	3 230	3 340	3 429	3 398
PAH	341	142	139	176	182	186	185
BAP	92	38	38	47	49	50	50
BBF	104	43	42	54	55	57	56
BKF	75	31	30	38	40	41	40
IND	71	29	29	36	38	39	38
				Emissions [g]			
DIOX	33	10	12	2	2	1	1
HCB	7 241	2 261	2 657	3 357	3 472	3 564	3 531
PCB	8 610	9 720	10 800	13 644	14 110	14 486	14 352
				Emissions [t]			
TSP	6 209	4 113	4 174	2 268	849	718	620
PM_{10}	4 346	2 879	2 922	1 587	595	503	434
$PM_{2.5}$	1 863	1 234	1 252	680	255	215	186

Table 233 presents coke input in the sinter plant, coke oven output and blast furnace chowpers.

Table 233: 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

Basic Oxygen Furnace Steel Plant

In this category, POP and heavy metal emissions are considered. SO_2, NO_x, NMVOC and CO emissions are included in category 1.A.2.a. PM emissions are reported together with emissions from blast furnace charging.

Emission factors for heavy metal emissions were taken from national studies: 1990–1994 (WINDSPERGER et al. 1999), 1995–2000 (HÜBNER 2001a[117]), the latter was also used for the years 2001 onwards, and multiplied with steel production to calculate HM emissions. POP emissions were calculated by multiplying steel production by national emission factors (HÜBNER 2001b[118]) and, for PCB, with emission factors from the EMEP/EEA Emission Inventory Guidebook 2019 (EEA 2019. The shares of the PAH fractions are based on plant specific data of Luxembourg, as no default shares are included in the guidebook and no plant specific data from Austria is available.

Steel production data were taken from national production statistics, Activity data, POP and HM emission factors are presented in the table below; particulate matter emissions are reported together with emissions from blast furnace charging.

Table 234: Activity data, HM and POP emission factors and PM emissions from basic oxygen furnace steel plants.

	1990	1995	2000	2005	2010	2015	2019
Activity [t]	3 921 341	4 538 355	5 183 461	6 407 738	6 570 357	7 020 178	6 881 814
Emission factor [mg/t BOF Steel]							
Cd	19	13	→				13
Hg	3	1	→				1
Pb	984	470	→				470
PAH	0.04	0.01	→				0.01
BAP	0.01	0.003	→				0.003
BBF	0.01	0.004	→				0.004
BKF	0.01	0.003	→				0.003
IND	0.01	0.002	→				0.002
Emission factor [µg/t BOF Steel]							
DIOX	0.69	0.23	→				0.23
HCB	138	46	→				46
PCB	2500	2500	→				2500
Emission factor [g/t BOF Steel]							
TSP	IE	IE	→				IE
PM_{10}	IE	IE	→				IE
$PM_{2.5}$	IE	IE	→				IE

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 235 together with electric steel production figures.

Table 235: Activity data and emission factors for emissions from Electric Steel Production 1990–2019.

	1990	1995	2000	2005	2010	2015	2019
Activity [t]	370 107	453 645	540 539	622 485	637 383	667 000	710 400
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[117])

(6) (Hübner 2001b[118])

(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 236: Activity data and emission factors for cast iron 1990–2019.

	1990	1995	2000	2005	2010	2015	2019
Activity [t]	196 844	176 486	191 420	196 017	167 854	165 193	167 420
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).

4.4.2 NFR 2.C.2 – 2.C.6 Non-ferrous Metals

4.4.2.1 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.

4.4.2.2 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).

The Pb emission factor for secondary aluminium production is based on the following regulations/assumptions:

(i) TSP emissions from aluminium production is legally limited to 20 mg/m³ (BGBl. II 1/1998 for Al),
(ii) as the facilities have to be equipped with PM filters to reach this limit, the emissions are usually well below the legal emission limit,
(iii) thus PM emissions were estimated to be 5 mg/m³; (iv) using results from BAT documents (0.25% Pb content in PM; 126–527 mg PM/t Al; UMWELTBUNDESAMT 2000b) and (EUROPEAN COMMISSION, IPPC BUREAU 2000) an emission factor of 200 mg/t Al was calculated.

The 2016 EMEP/EEA Guidebook emission factors were used for PM and PCB. In 1997, a fabric filter was installed on the production site; therefore the emissions of the filterable pollutants were calculated with the default abatement efficiency (99%) from the 2016 EMEP/EEA Guidebook.

Production data on secondary aluminium production are confidential.

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.

For secondary copper production the emission factors were taken from the EMEP/EEA GB 2016 for PM, PCB and SOx. EFs for HM, HCB and Dioxin were taken from national studies (HÜBNER 2001a). For the years from 2004 onwards abatement factors were applied for HM, PM and Dioxin.

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 237: Activity data and emission factors for non-ferrous (light metal) cast 1990–2019.

	1990	1995	2000	2005	2010	2015	2019
Activity [t]	46 316	59 834	92 695	109 927	121 426	140 749	133 406
			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 238: Emission factors and activity data for heavy metal cast 1990–2019.

	1990	1995	2000	2005	2010	2015	2019
Activity [t]	8 525	10 384	13 214	18 456	16 577	12 814	11 367
			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

4.4.3 Category-specific Recalculations

NFR 2.C.3 Aluminium production

Verified CO_2 emissions for the years 2016, 2017 and 2018 for secondary aluminium production became available from the ETS. As activity data was calculated based on the verified emissions and an CS EF this led to recalculations of Pb, Dioxine, HCB and particular matter emissions (+0.0002kt $PM_{2.5}$ for 2018).

For 1990-1993 data on the individual PAHs occurring in primary aluminium production were estimated for the first time in this year's submission.

NFR 2.C.1 Iron and Steel Production

The four individual PAHs are estimated for the first time in this year's submission.

4.5 NFR 2.D.3-2.G Solvents and other Product use

This chapter describes the methodology used for calculating air emissions from *Solvent and Other Product 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.
- PM from NFR 2.G Other (Fireworks and Tobacco Smoking)

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
2.D.3.g	Asphalt blowing
2.G	Other product use

4.5.1 Emission Trends

In the year 2019, 30% of total NMVOC emissions in Austria (32.42 kt) originated from *Solvent and Other Product Use*. Table 239 presents the trend in NMVOC emissions by subcategories.

Table 239: Total NMVOC emissions and trend from 1990–2019 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	114.44	20.31	0.01	NE	41.78	13.26	0.44	12.79	12.65	13.20
1995	81.28	21.88	0.01	NE	25.20	8.18	0.37	7.42	9.26	8.95
2000	58.80	18.91	0.01	NE	16.67	6.51	0.29	4.78	5.42	6.22
2001	57.34	18.62	0.01	NE	15.91	6.48	0.28	4.92	4.94	6.18
2002	56.85	18.00	0.01	NE	14.96	6.35	0.28	5.01	6.18	6.07
2003	55.42	17.78	0.02	NE	14.49	5.95	0.25	5.45	5.83	5.66
2004	46.20	15.04	0.02	NE	12.01	4.77	0.20	4.96	4.69	4.50
2005	53.41	17.69	0.02	NE	13.82	5.33	0.22	6.15	5.22	4.96
2006	59.23	20.01	0.02	NE	15.26	5.73	0.22	7.21	5.56	5.22
2007	58.23	20.12	0.02	NE	14.94	5.48	0.20	7.38	5.23	4.84
2008	55.68	19.74	0.02	NE	14.25	5.12	0.18	7.25	4.76	4.35
2009	45.42	16.57	0.02	NE	11.59	4.10	0.14	6.00	3.67	3.33
2010	44.77	16.87	0.02	NE	11.41	4.00	0.12	5.90	3.40	3.05
2011	44.45	17.37	0.02	NE	11.32	3.95	0.11	5.76	3.13	2.79
2012	42.99	17.50	0.02	NE	10.95	3.84	0.10	5.36	2.77	2.45

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**					
2013	38.34	16.35	0.02	NE	9.78	3.48	0.07	4.47	2.21	1.95
2014	36.44	16.38	0.02	NE	9.33	3.40	0.06	3.82	1.82	1.60
2015	31.40	13.96	0.02	NE	8.75	3.34	0.04	2.75	1.42	1.12
2016	30.89	14.65	0.02	NE	8.26	3.00	0.04	2.68	1.18	1.05
2017	31.99	15.35	0.02	NE	8.75	3.05	0.04	2.69	1.07	1.02
2018	32.04	16.04	0.02	NE	8.62	2.88	0.04	2.61	0.86	0.97
2019	32.42	16.73	0.03	NE	8.74	2.79	0.04	2.52	0.66	0.92
Trend 1990–2019	*-71.67%*	*-17.60%*	*328.64%*		*-79.07%*	*-78.97%*	*-90.87%*	*-80.30%*	*-94.81%*	*-93.07%*
Share in National Total										
1990	**34.11%**	**6.05%**	**0.00%**		**12.45%**	**3.95%**	**0.13%**	**3.81%**	**3.77%**	**3.94%**
2019	**29.86%**	**15.41%**	**0.02%**		**8.05%**	**2.57%**	**0.04%**	**2.32%**	**0.60%**	**0.84%**

NMVOC emissions in this sector decreased by 72% between 1990 and 2019, 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)[119] (repealed by Solvent Ordinance 1995)
- Solvent Ordinance 1995[120] (repealed by Solvent Ordinance 2005)
- Paint finishing systems Ordinance (1995)[121] (repealed by VOC Installations Ordinance)

In the subsequent years the legislation was adapted to be in line with European legislation:

- VOC Installations Ordinance (2002)[122], implementation of "Solvent Emission Directive"[123]
- VOC Ordinance 2005[124] – implementation of "Paints Directive"[125]

[119] Verordnung des Bundesministers für Umwelt, Jugend und Familie über Verbote und Beschränkungen von organischen Lösungsmitteln (**Lösungsmittelverordnung**), BGBl. Nr. 492/1991

[120] Verordnung des Bundesministers für Umwelt über Verbote und Beschränkungen von organischen Lösungsmitteln (**Lösungsmittelverordnung 1995 – LMVO 1995**), BGBl 872/1995

[121] 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

[122] 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

[123] 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

[124] 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

- Amendment of VOC Ordinance (2005) [126] – implementation of "Industrial Emissions Directive" 2010/75/EC[127]

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.

4.5.2 NMVOC Emissions from Solvent and other product use (Category 2.D.3.a-i)

4.5.2.1 Methodological Issues

Due to the intensity of preparation and details needed, updates of the bottom up data are planned for every 5 years, this means that solvent balances should have been collected next in 2021 for the year 2020. However, due to the Covid pandemic and the expected changes in industry (closing of factories, increased production of disinfectants) it was decided to move the update forward and base it on the year 2019. This update resulted in a re-evaluation of the allocation of companies to different SNAPs, in order to find a better alignment between ÖNACE data on employees and the companies allocated to a certain SNAP. This led to a difference of 4% between the bottom-up and top-down sum for 2019, and to a 14% difference for 2015, and resulted in recalculations between 2003 and 2018. The next update is planned for 2025. For the years in between only the top down sum will be updated and the allocation of the activity data as well as the emission factors from the year 2019 will be used.

Emissions are estimated using a combination of

- Top-down data from national statistics which provide information on the overall solvent use in Austria
- with bottom-up information from company solvent balances in solvent consuming sectors

Top down data:

From national import/export and production statistics the national consumption of solvents is obtained:

National consumption of Substance$_i$ = (Substance$_i$ Import – Substance$_i$ Export + Substance$_i$ Production)

The non-solvent use of substances (i.e. where the substance is used as a reagent) is subtracted from national consumption:

Solvent Use per Substance$_i$ = Solvent Balance per Substance$_i$ – 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

[125] 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

[126] 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

[127] 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$_p$

Bottom up data

Domestic solvent use

Ddata 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 and 2019.

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 240).

Table 240: 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

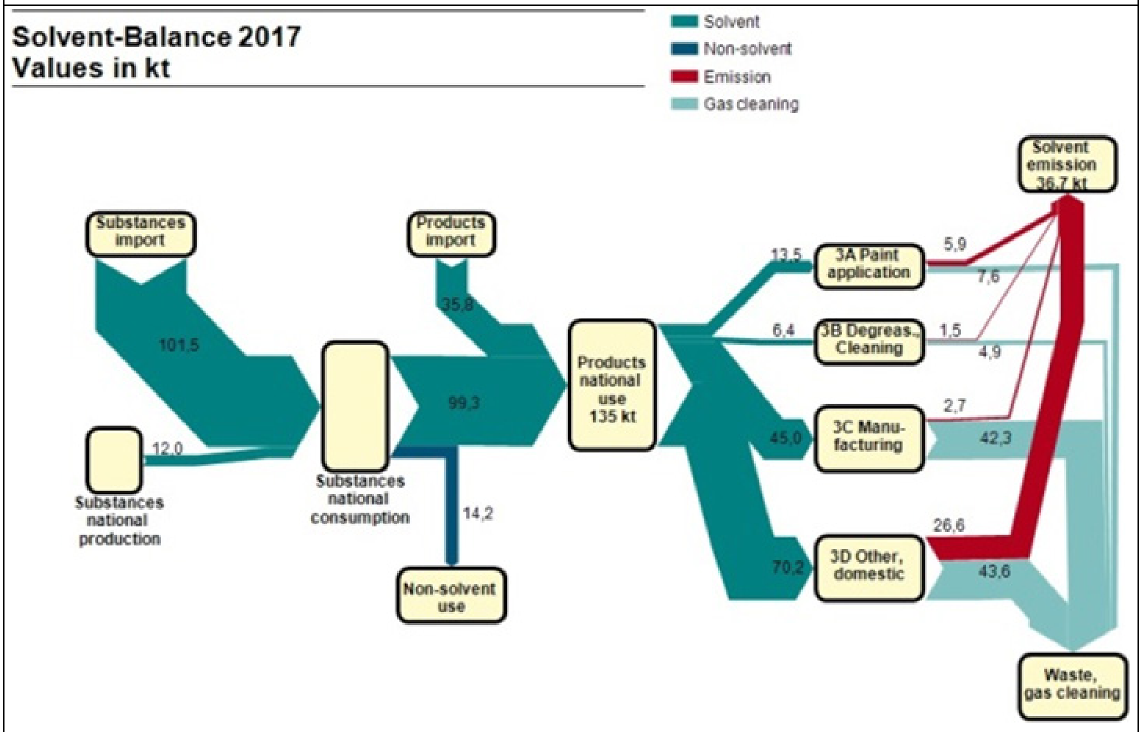
The above mentioned survey was carried out in all industrial branches with solvent applications; results for solvent use per substance category were collected at NACE-level-4. The total amounts of solvents collected were extrapolated using the number of employees to upscale to the total industrial branch (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 and again for the year 2019 an extensive research was 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). Some of these reports did not offer information on activity data, so gap filling was provided by the IIÖ (WINDSPERGER et al. 2019). The companies were then allocated to the different NACE categories, and collected emissions and activity data was scaled up using the number of employees as explained above.

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).

Sankey model of the calculation of solvent emission



Source: WINDSPERGER et al. (2019) umweltbundesamt

Figure 53: Sankey model of the calculation of solvent emission.

Top down / bottom up combination

Data from the top down approach (for the reference year 2000, up to 2002 as well as 2015 and 2019) were compared with data from the bottom up approach. As there were large discrepancies 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.

4.5.2.2 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 241: Activity data for solvent and other product use [t] 1990–2019.

	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	137 930	23 361	50 131	15 467	459	18 585	14 729	15 192
1995	130 096	25 296	50 371	13 564	426	12 465	13 474	14 492

	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			
2000	112 878	21 896	35 517	11 940	340	23 798	8 242	11 140
2001	112 715	21 698	35 281	12 210	340	24 073	7 960	11 148
2002	114 051	21 112	34 638	12 342	337	24 023	10 557	11 031
2003	113 505	20 986	34 911	12 110	316	24 183	10 616	10 364
2004	97 184	17 874	30 145	10 178	253	21 258	9 147	8 309
2005	115 718	21 172	36 199	11 892	281	25 972	10 960	9 223
2006	132 495	24 113	41 795	13 357	298	30 491	12 628	9 792
2007	134 861	24 414	42 896	13 331	279	31 803	12 933	9 185
2008	133 934	24 116	42 951	12 977	253	32 344	12 923	8 346
2009	113 852	20 386	36 801	10 806	195	28 135	11 050	6 455
2010	117 362	20 898	38 237	10 908	180	29 665	11 459	5 995
2011	122 394	21 671	40 188	11 134	166	31 625	12 020	5 566
2012	124 936	21 997	41 342	11 120	147	32 984	12 341	4 981
2013	118 205	20 694	39 416	10 288	118	31 871	11 743	4 051
2014	119 914	20 884	40 311	10 206	98	32 964	11 987	3 441
2015	116 933	17 932	40 544	10 097	66	33 506	12 243	2 524
2016	111 745	18 737	38 137	9 467	66	31 046	11 961	2 311
2017	117 346	19 541	40 131	10 045	66	32 146	13 200	2 195
2018	116 573	20 346	39 538	9 894	66	31 205	13 461	2 039
2019	118 558	21 151	40 067	10 055	66	31 157	14 132	1 903

4.5.2.3 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 2018 and are as follows:

SNAP 060408	1 356 g NMVOC/person per year	
SNAP 060411	451 g	NMVOC/person per year

Table 242: Implied NMVOC Emission factors for Category 3 Solvent and Other Product Use 1990–2019.

	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
2001	0.86	0.45	0.53	0.83	0.20	0.62	0.55
2002	0.85	0.43	0.51	0.82	0.21	0.58	0.55
2003	0.85	0.42	0.49	0.80	0.23	0.55	0.55
2004	0.84	0.40	0.47	0.78	0.23	0.51	0.54
2005	0.84	0.38	0.45	0.77	0.24	0.48	0.54

	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			
2006	0.83	0.37	0.43	0.75	0.24	0.44	0.53
2007	0.82	0.35	0.41	0.73	0.23	0.40	0.53
2008	0.82	0.33	0.39	0.72	0.22	0.37	0.52
2009	0.81	0.31	0.38	0.70	0.21	0.33	0.52
2010	0.81	0.30	0.37	0.68	0.20	0.30	0.51
2011	0.80	0.28	0.36	0.67	0.18	0.26	0.50
2012	0.80	0.26	0.35	0.65	0.16	0.22	0.49
2013	0.79	0.25	0.34	0.63	0.14	0.19	0.48
2014	0.78	0.23	0.33	0.62	0.12	0.15	0.47
2015	0.78	0.22	0.33	0.60	0.08	0.12	0.44
2016	0.78	0.22	0.32	0.60	0.09	0.10	0.46
2017	0.79	0.22	0.30	0.60	0.08	0.08	0.47
2018	0.79	0.22	0.29	0.60	0.08	0.06	0.47
2019	0.79	0.22	0.28	0.60	0.08	0.05	0.48

4.5.3 NFR 2.D.3.b., 2.D.3.c. and 2.D.3. g - NMVOC Emissions related to Asphalt

In this chapter the following sectors related to asphalt producing and processing are included

- 2.D.3.b Road paving with asphalt
- 2.D.3.c: Asphalt roofing
- 2.D.3.g Asphalt blowing

During the development of the updated model on solvent emissions in Austria in 2018, these processes have also been investigated and revised.

2.D.3.b Road paving with asphalt

The emissions caused by road paving with asphalt were formerly calculated within the solvents model. During the refinement of this sector it became visible, that these production processes related to NMVOC couldn't be caused by solvent use as these emissions result from the product itself. So, the default values of the EMEP EEA GB 2019 have been applied for calculating NMVOC emissions. The operation conditions were proven via personal conversation with Gestrada (Austrian Association for Asphalt). Activity data were obtained for the whole time series from the national production statistics. $PM_{2.5}$ emissions will be estimated for the next submission.

Table 243: Activity data and NMVOC emissions from road paving with asphalt.

	Activity	NMVOC emissions
Year	[t]	
1990	402 727	6.0
1995	522 418	7.8
2000	429 292	6.4
2005	1 304 864	19.6
2010	1 414 091	21.2
2015	1 314 188	19.7

Year	Activity	NMVOC emissions
	[t]	
2017	1 353 548	20.3
2018	1 503 348	22.6
2019	1 726 241	25.9

2.D.3.c Asphalt roofing

This subsector has been re-investigated in 2018. There are four production sites of asphalt roofing material in Austria. Currently all of these production sites have gas collection systems and gas purification units (e.g. thermal afterburner). However, further investigation is necessary in order to provide a robust time series. For that reason emissions are reported as "NE" in the current submission.

2.D.3.g Asphalt blowing

In Austria there are only 2 asphalt blowing plants. One is part of the only Austrian refinery and therefore the emissions are included in NFR category 1.A.1.b (petroleum refinery). The off gas of the second asphalt blowing plant is treated in a fluidized bed burner (with an exhaust gas purification unit), these emissions are negligible. Emissions are therefore reported as "IE".

4.5.4 Emissions from Other Product Manufacture and Use (Category 2.G)

The category 2.G covers emissions which originate from the use of fireworks and tobacco.

	2.G other use (Use of fireworks (SNAP 0604))	2.G other use (Use of tobacco (SNAP 0604))
Key category	Pb (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	Inhabitants (Smokers)
Method	EMEP/EEA 2019 default emission factors used.	
Emission factor	EMEP/EEA 2019 default emission factors used	
Recalculation	Recalculation, as new emission factors were used.	

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.

Table 244: Emissions from SNAP 0604_X6A Fireworks from 1990–2019.

NFR	2.G Use of Fireworks								
	SO_2	NO_x	CO	Cd	Hg	Pb	TSP	PM_{10}	$PM_{2.5}$
years	[t]								
1990	4.71	0.41	11.14	0.002	0.0001	1.22	171.18	155.73	80.95
1995	4.19	0.36	9.93	0.002	0.0001	1.09	152.46	138.71	72.10
2000	6.45	0.56	15.26	0.003	0.0001	1.67	234.48	213.32	110.89
2001	4.06	0.35	9.62	0.002	0.0001	1.05	147.77	134.43	69.88
2002	6.38	0.55	15.10	0.003	0.0001	1.66	231.94	211.01	109.69
2003	5.53	0.48	13.08	0.003	0.0001	1.43	200.99	182.85	95.05
2004	5.35	0.46	12.66	0.003	0.0001	1.39	194.47	176.92	91.97
2005	6.03	0.52	14.28	0.003	0.0001	1.57	219.35	199.56	103.74
2006	6.72	0.58	15.91	0.003	0.0001	1.75	244.47	222.41	115.61
2007	6.77	0.58	16.02	0.003	0.0001	1.76	246.11	223.90	116.39
2008	6.75	0.58	15.97	0.003	0.0001	1.75	245.34	223.20	116.02
2009	5.59	0.48	13.24	0.003	0.0001	1.45	203.42	185.07	96.20
2010	5.75	0.49	13.60	0.003	0.0001	1.49	208.93	190.08	98.81
2011	6.34	0.55	15.01	0.003	0.0001	1.65	230.53	209.73	109.02
2012	5.72	0.49	13.55	0.003	0.0001	1.49	208.19	189.41	98.46
2013	6.19	0.53	14.65	0.003	0.0001	1.61	224.97	204.67	106.39
2014	5.32	0.46	12.60	0.003	0.0001	1.38	193.62	176.15	91.57
2015	2.89	0.25	6.85	0.001	0.0001	0.75	105.18	95.69	49.74
2016	4.56	0.39	10.79	0.002	0.0001	1.18	165.81	150.85	78.41
2017	3.54	0.31	8.39	0.002	0.0001	0.92	128.86	117.23	60.94
2018	3.20	0.28	7.59	0.002	0.0001	0.83	116.51	106.00	55.10
2019	4.83	0.42	11.44	0.002	0.0001	1.25	175.69	159.84	83.09

Table 245: Emissions from SNAP 604_X6B Tobacco Use from 1990–2019

NFR	2.G Tobacco Use								
	NO_x	CO	NH_3	NMVOC	Cd	TSP	PM_{10}	$PM_{2.5}$	PAH	Diox
years	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[kg]	[mg]
1990	30.32	928.27	69.91	81.54	90.97	454.87	454.87	454.87	4.14	1.68
1995	29.00	887.76	66.86	77.98	87.00	435.02	435.02	435.02	3.96	1.63
2000	29.08	890.30	67.06	78.20	87.25	436.26	436.26	436.26	3.97	1.62
2001	28.77	880.78	66.34	77.37	86.32	431.60	431.60	431.60	3.93	1.60
2002	29.04	888.89	66.95	78.08	87.11	435.57	435.57	435.57	3.97	1.61
2003	28.17	862.35	64.95	75.75	84.51	422.57	422.57	422.57	3.85	1.57
2004	27.35	837.26	63.06	73.55	82.05	410.27	410.27	410.27	3.74	1.52
2005	25.53	781.41	58.85	68.64	76.58	382.91	382.91	382.91	3.49	1.42
2006	26.64	815.33	61.41	71.62	79.91	399.53	399.53	399.53	3.64	1.48
2007	26.19	801.69	60.38	70.42	78.57	392.84	392.84	392.84	3.58	1.45
2008	25.49	780.14	58.76	68.53	76.46	382.28	382.28	382.28	3.48	1.42
2009	26.10	799.05	60.18	70.19	78.31	391.55	391.55	391.55	3.57	1.45
2010	26.94	824.56	62.10	72.43	80.81	404.05	404.05	404.05	3.68	1.50

NFR	2.G Tobacco Use									
	NO_x	CO	NH_3	NMVOC	Cd	TSP	PM_{10}	$PM_{2.5}$	PAH	Diox
years	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[kg]	[mg]
2011	25.48	780.11	58.76	68.53	76.45	382.27	382.27	382.27	3.48	1.42
2012	25.54	781.90	58.89	68.68	76.63	383.14	383.14	383.14	3.49	1.42
2013	25.62	784.19	59.06	68.88	76.85	384.27	384.27	384.27	3.50	1.42
2014	25.37	776.59	58.49	68.22	76.11	380.54	380.54	380.54	3.47	1.41
2015	25.10	768.48	57.88	67.50	75.31	376.57	376.57	376.57	3.43	1.39
2016	24.74	757.23	57.03	66.52	74.21	371.06	371.06	371.06	3.38	1.37
2017	24.48	749.28	56.43	65.82	73.43	367.16	367.16	367.16	3.35	1.36
2018	23.51	719.72	54.21	63.22	70.54	352.68	352.68	352.68	3.21	1.31
2019	23.32	713.79	53.76	62.70	69.95	349.77	349.77	349.77	3.19	1.30

Table 246: Emissions from SNAP 604_X6B Tobacco Use from 1990–2019

year	Benzo_a	Benzo_b	Benzo_k	Indeno
	kg	kg	kg	kg
1990	1.87	0.76	0.76	0.76
1995	1.79	0.73	0.73	0.73
2000	1.79	0.73	0.73	0.73
2001	1.77	0.72	0.72	0.72
2002	1.79	0.73	0.73	0.73
2003	1.74	0.70	0.70	0.70
2004	1.69	0.68	0.68	0.68
2005	1.57	0.64	0.64	0.64
2006	1.64	0.67	0.67	0.67
2007	1.62	0.65	0.65	0.65
2008	1.57	0.64	0.64	0.64
2009	1.61	0.65	0.65	0.65
2010	1.66	0.67	0.67	0.67
2011	1.57	0.64	0.64	0.64
2012	1.58	0.64	0.64	0.64
2013	1.58	0.64	0.64	0.64
2014	1.56	0.63	0.63	0.63
2015	1.55	0.63	0.63	0.63
2016	1.53	0.62	0.62	0.62
2017	1.51	0.61	0.61	0.61
2018	1.45	0.59	0.59	0.59
2019	1.44	0.58	0.58	0.58

4.5.5 Category-specific Recalculations

NFR 2.D.3.a Solvent Use

Due to the Covid pandemic and its economic impact it was decided to base the update of bottom-up data on information for 2019 rather than 2020. All district authorities were contacted for solvent balances available from companies that are obliged to report under the IED directive. This led to an estimated return rate of approximately 85% of all balances, which was higher than for the last bottom up survey for the year 2015. In the course of updating the model for 2019 the allocation of companies to the different categories was re-evaluated. As scaling up (for sectors where not all companies are obliged to report) is performed using economic sectors, the allocation was improved and now follows the economic rather than the technical activity of the companies (e.g. a company producing printed cardboards is now allocated to cardboard production and not to the printing sector), wherever necessary.

The resulting changes in allocation were made consistently for 2015 and 2019. The improved allocation is also more consistent with the approach for 2000. Data between 2001 and 2015, and 2015 and 2019 were interpolated as before. This led to a change of allocation of AD and emissions per NFR category and therefore also EF/category for all years from 2001 onwards.

Due to the improved allocation and scaling up, total AD from the bottom-up estimate, together with AD for domestic solvent use based on statistical data equalled 96% (in 2019) of the top-down total solvent consumption taken from statistics. For 2015 the gap previously equalled 18%, and is now 13%. In a final step, the "missing" 4% of the AD were then added to those categories where no full survey had taken place. Emissions were calculated using the IEFs from the bottom up survey.

It has to be noted, that for all years there was no change in total AD compared to the last submission. Changes in emissions result from improved allocation of the AD to the different categories, with higher/lower IEFs: e.g. for 2005 emissions were 0.81 kt NMVOC lower, for the end of the time series the improved methodology led to an increase in emissions (e.g. +1.91 kt NMVOC for 2018).

4.6 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.

4.6.1 NFR 2.H.2 Food and Beverages Industry

4.6.1.1 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.

4.6.1.2 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}

All emission factors were taken from BUWAL (1995) because of the very similar structures and standards of industry in Austria and Switzerland. 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:

- TSP1990: 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
- $PM_{2.5}$.......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[128]) 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 247.

Table 247: POP emissions and activity data from smokehouses 1990–2019:

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
⇣	⇣	⇣	⇣	⇣	⇣	⇣	⇣	⇣
2019	19 533	37	13	12	5	8	0.1	26

4.6.2 Category-specific Recalculations

In this year's submission an estimate of the PAH fractions BAP, BBF, BKF, IND in Sector 2.H.2 have been included.

[128] according to MEISTERHOFER (1986)

4.7 NFR 2.I Wood Processing

4.7.1 Source Category Description

This category includes particulate matter emissions from supply (production) and handling of wood-chips and sawmill-by-products for the use in chipboard and paper industry and for the use in combustion plants.

The following subcategories are included:

- Generic wood processing
- Supply and handling of wood chips and sawmill by-products for the use in chipboard and paper industry (split into two sub-categories)
- Use of wood chips and sawmill by-products in chipboard production
- Supply and handling of wood chips and sawmill by-products for use in combustion plants

4.7.2 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. Two major sources are identified: the sawmill industry including wood-processing and the chipboard industry.

Generic wood processing

For generic wood processing, the method developed by WINIWARTER et al. (2007) resulted in the following combined emission factors: TSP: 149.5 g/scm; PM_{10}: 59.8 g/scm; $PM_{2.5}$: 23.92.G/scm; applied to an activity of 4 Mio solid cubic metres (scm). Due to lack of activity data these values were used for the whole time-series.

Supply and handling of wood chips and sawmill by-products for the use in chipboard and paper industry

For this category, WINIWARTER et al. (2007) provided two distinct sets of emission factors for the following two situations:

- Wood chips produced on-site
- Wood chips and sawmill by-products acquired from off-site production

For the former situation, the mass of wood logs acquired and processed on-site was used as activity data. The same activity data was used for all years. Activity data and emission factors are shown in the following table.

Table 248: Activity data (used for all years) and emission factors for supply and handling of wood-chips and sawmill by-products for the use in chipboard and paper industry.

		Produced on-site wood chips-industry-logs	Produced off-site wood chips-industry-byproducts
Emission factor [g/t]	TSP	30.0	20.0
	PM_{10}	12.0	8.0
	$PM_{2.5}$	4.8	3.2

Use of wood chips and sawmill by-products in chipboard production

For chipboard production, emissions were calculated by a factor based on a national study (WINIWARTER et al. 2007, p 41). With these emissions an implied emission factor was calculated using chipboard production data from national statistics (Statistik Austria) that was applied to the whole time-series of chipboard production. Emissions of particulate matter (TSP, PM_{10} and $PM_{2.5}$) caused by the product handling are also included in this source.

Supply and handling of wood chips and sawmill by-products for use in combustion plants

For supply and handling of wood chips and sawmill by-products for use in combustion plants, an implied emission factor was calculated using gross consumption of wood waste in the national energy balance that was applied to the whole time-series.

Table 249: 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]**	**Emissions [t]**		
		TSP	**PM_{10}**	**$PM_{2.5}$**
1990	11 788	25.81	10.32	4.13
1995	12 595	27.58	11.03	4.41
2000	29 982	65.65	26.26	10.50
2005	55 204	120.87	48.35	19.34
2010	102 161	223.68	89.47	35.79
2015	108 175	236.85	94.74	37.90
2019	100 183	219.35	87.74	35.10

4.7.3 Category-specific Recalculations

NFR 2.I Wood processing

Due to revisions of the activity data in the energy balances, reported particular matter emissions have changed for 2005 and subsequent years (e.g. -0.005 kt $PM_{2.5}$ for 2018).

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 (0% to 4%) with the exception of HCB emissions from *3.D.f Use of pesticides* (14% in national total).

To give an overview of Austria's agricultural sector some information is provided below (according to the 2010 Farm Structure Survey – full survey and the Agriculture Structure Surveys 2013 and 2016) (BMLRT 2000–2020): Agriculture in Austria is rather small-structured: 162 018 farms are managed, 56.9% of these farms manage less than 20 ha, whereas only 5.5% of the Austrian farms manage more than 100 ha cultivated area. 128 164 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 agricultural area comprises 2.67 million hectares that is a share of ~ 32% of the total territory (forestry ~ 41%, other area ~ 14%). The shares of the different agricultural activities are as follows:

- 50% arable land,
- 22% grassland (meadows mown several times and seeded grassland),
- 26% extensive grassland (meadows mown once, litter meadows, rough pastures, alpine pastures and mountain meadows),
- 2% other types of agricultural land-use (vineyards, orchards, house gardens, vine and tree nurseries).

5.2 General description

5.2.1 Completeness

Table 250 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 250: 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	IE	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	IE	✓	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**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	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*

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 251.

Table 251: 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.B.4.e	Manure Management (Horses)	NH_3	TA
3.D.a.1	Inorganic N-fertilizers	NH_3	LA, TA
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	LA, TA

LA = Level Assessment (if not further specified – for the years 1990 and 2019)

TA = Trend Assessment 1990–2019

5.2.3 Methodology

The Austrian sectorial inventory model follows the N-flow concept. NH_3 emissions are calculated on the basis of the amount of total ammoniacal nitrogen (TAN). TAN is present in the urine of animals and considered to be equivalent to the N content of urine. This calculation method is more precise than the calculation on the basis of 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 252 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 252: 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)

NFR category		Methodology used
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)
	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)
	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 253: 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 (2008, 2011, 2013, 2017, 2018, 2019, 2020)
3.B (all livestock)	N excretion	PÖTSCH (2005), GRUBER & PÖTSCH (2006), STEINWIDDER & GUGGENBERGER (2003), UNTERARBEITSGRUPPE N-ADHOC (2004) UND ZAR (2004), BMLFUW (2017)
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 254 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 254: 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	+/-200.1%
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%			

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 (BMLRT 2000–2020),
   - ✓ 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).

A general description of Austria's QMS (Quality Management System) and its activities and improvements 2020 is presented in Chapter 1.6.

5.2.6 Planned Improvements

Currently national feeding assumptions and N excretion values are being reviewed within the framework of a scientific study. The project is carried out by the University of Natural Resources and Applied Life Science (BOKU). The implementation of study results is planned for submission 2022.

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).

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). 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 have been estimated using the detailed Tier 2 method following the EMEP/EEA Guidebook 2019. 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 2019 (EEA 2019).

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 2020a) provides national data of annual livestock numbers on a very detailed level. These data are based on livestock counts held in December each year[129].

Table 255, Table 256 and Table 257 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.

[129] 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).

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.

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 255: Domestic livestock population and its trend 1990–2019 (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	255 464	305 339	146 312
1991	876 000	1 658 088	57 333	894 111	253 522	301 910	151 212
1992	841 716	1 559 009	60 481	831 612	239 569	281 509	145 838
1993	828 147	1 505 740	69 316	705 547	257 939	314 982	157 956
1994	809 977	1 518 541	89 999	706 579	263 591	309 586	148 786
1995	706 494	1 619 331	210 479	691 454	266 108	298 244	153 046
1996	697 521	1 574 428	212 700	670 423	259 747	277 635	153 923
1997	720 377	1 477 563	170 540	630 853	259 494	254 986	161 690
1998	728 718	1 442 963	154 276	635 113	254 251	241 908	157 415
1999	697 903	1 454 908	176 680	630 586	255 244	233 039	159 359
2000	621 002	1 534 445	252 792	655 368	246 382	220 102	159 801
2001	597 981	1 520 473	257 734	658 930	241 556	214 156	148 097
2002	588 971	1 477 971	244 954	640 060	236 706	213 226	143 025
2003	557 877	1 494 156	243 103	641 640	229 150	216 971	163 292
2004	537 953	1 513 038	261 528	646 946	230 943	210 454	163 167
2005	534 417	1 476 263	270 465	628 426	229 874	206 429	141 069
2006	527 421	1 475 498	271 314	631 529	222 104	212 887	137 664
2007	524 500	1 475 696	271 327	634 089	211 044	226 014	133 222
2008	530 230	1 466 979	266 452	636 469	200 787	230 457	132 814
2009	532 976	1 493 284	264 547	643 441	196 476	249 486	139 334
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
Trend 90–19	***-42.1%***	***-19.3%***	***315.7%***	***-34.6%***	***-28.2%***	***-20.4%***	***-12.4%***

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 minor 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 air emissions inventory Statistik Austria data is used, they are the best available.

Cattle numbers, dairy as well as non-dairy cattle, decreased in 2019 compared to the previous year. Drought-induced fodder shortages led to reductions of bovine populations. The number of slaughters declined and the production volume of milk went down in 2019 (BMLRT 2020).

Table 256: Domestic livestock population and its trend 1990–2019 (II).

Year	**Livestock category – Population size [heads] ***									
	Swine	**Young & Fattening Pigs >8 kg**	**Breeding Sows > 50 kg**	**Young Swine < 20 kg**	***litter <8kg*** [3)]	***litter 8-20kg*** [4)]	**Sheep**	**Goats**	**Horses** [1)]	**Other (furred game)** [**2)]
1990	3 687 981	2 797 564	382 335	958 645	*508 082*	*450 563*	309 912	37 343	49 200	37 100
1991	3 637 980	2 759 635	377 152	945 648	*501 193*	*444 454*	326 100	40 923	57 803	37 259
1992	3 719 600	2 821 549	385 613	966 864	*512 438*	*454 426*	312 000	39 400	61 400	37 418
1993	3 819 798	2 894 886	396 001	997 945	*528 911*	*469 034*	333 835	47 276	64 924	37 577
1994	3 728 991	2 822 077	394 938	965 992	*511 976*	*454 016*	342 144	49 749	66 748	37 736
1995	3 706 185	2 802 410	401 490	947 707	*502 285*	*445 422*	365 250	54 228	72 491	40 323
1996	3 663 747	2 759 957	398 633	953 126	*505 157*	*447 969*	380 861	54 471	73 234	41 526
1997	3 679 876	2 777 680	397 742	951 800	*504 454*	*447 346*	383 655	58 340	74 170	56 244
1998	3 810 310	2 911 469	386 281	967 094	*512 560*	*454 534*	360 812	54 244	75 347	50 365
1999	3 433 029	2 631 875	343 812	862 910	*457 342*	*405 568*	352 277	57 993	81 566	39 086
2000	3 347 931	2 561 396	334 278	853 315	*452 257*	*401 058*	339 238	56 105	82 943	39 612
2001	3 440 405	2 629 403	350 197	869 443	*460 805*	*408 638*	320 467	59 452	84 319	40 138
2002	3 304 650	2 530 789	341 042	816 640	*432 819*	*383 821*	304 364	57 842	85 696	40 664
2003	3 244 866	2 494 399	334 329	785 166	*416 138*	*369 028*	325 495	54 607	87 072	41 190
2004	3 125 361	2 388 397	317 033	792 323	*419 931*	*372 392*	327 163	55 523	89 816	42 102
2005	3 169 541	2 449 640	315 731	762 585	*404 170*	*358 415*	325 728	55 100	92 560	43 014
2006	3 139 438	2 404 507	321 828	779 440	*413 103*	*366 337*	312 375	53 108	95 304	43 926
2007	3 286 292	2 545 838	318 349	796 424	*422 105*	*374 319*	351 329	60 487	98 048	44 839
2008	3 064 231	2 372 683	297 830	742 865	*393 718*	*349 147*	333 181	62 490	100 792	45 751
2009	3 136 967	2 440 474	293 901	759 607	*402 592*	*357 015*	344 709	68 188	103 536	46 663
2010	3 134 156	2 444 258	284 691	764 542	*405 207*	*359 335*	358 415	71 768	106 280	47 575
2011	3 004 907	2 348 549	275 874	717 895	*380 484*	*337 411*	361 183	72 358	109 024	45 654
2012	2 983 158	2 338 990	263 200	718 808	*380 968*	*337 840*	364 645	73 212	111 768	43 733
2013	2 895 841	2 278 627	254 373	684 606	*362 841*	*321 765*	357 440	72 068	114 512	41 812
2014	2 868 191	2 254 177	246 870	692 725	*367 144*	*325 581*	349 087	70 705	117 256	41 600
2015	2 845 451	2 233 618	249 655	683 354	*362 178*	*321 176*	353 710	76 620	120 000	41 388
2016	2 792 803	2 201 953	240 756	660 555	*350 094*	*310 461*	378 381	82 735	120 000	41 176
2017	2 820 082	2 222 453	243 694	667 802	*353 935*	*313 867*	401 480	91 134	130 000	41 176
2018	2 776 574	2 197 904	232 714	652 748	*345 956*	*306 792*	406 336	91 536	130 000	41 176
2019	2 773 225	2 194 043	234 190	650 928	*344 992*	*305 936*	402 658	92 504	130 000	41 176
Trend 90–19	***-24.8%***	***-21.6%***	***-38.7%***	***-32.1%***	***-32.1%***	***-32.1%***	***29.9%***	***147.7%***	***164.2%***	***11.0%***

** from 1990 to 1992 adjusted age class split for swine as recommended in the centralized review (October 2003)*

*** furred game, mainly deer.*

1) for the years 2000–2002 and 2004–2014: interpolated values

2) for the years 1991–1993, 2000-2002, 2004–2009 and 2011–2012: interpolated values

3) share of litter < 8 kg within young swine category < 20 kg (53%, STATISTIK AUSTRIA 2018a)

4) share of litter 8–20 kg within young swine category < 20 kg (47%, STATISTIK AUSTRIA 2018a)

Swine and sheep numbers decreased in 2019 compared to the previous year. For goats a rise in livestock numbers could be observed in 2019.

In response to a recommendation under the NEC Review 2018 (EC 2018), Austria splitted the piglets numbers < 20 kg into suckling piglets < 8 kg and weaned piglets 8–20 kg. The share of suckling and weaned piglets was calculated on the basis of daily weight gain and official livestock data (STATISTIK AUSTRIA 2018a). This approach was accepted under the NEC Review 2018 and applied for all inventory years.

Horse numbers for 2015, 2016, 2017, 2018 and 2019 are provided by the Ministry of Agriculture and are published in (BMLRT 2000–2020, p. 49). 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 257: Domestic livestock population and its trend 1990–2019 (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
1991	14 397 143	13 478 820	8 340 068	5 138 752	759 307	159 016
1992	13 683 900	12 872 100	7 853 673	5 018 427	671 215	140 585
1993	14 508 473	13 588 850	8 307 661	5 281 189	793 431	126 192
1994	14 178 834	13 265 572	8 288 140	4 977 432	781 643	131 619
1995	13 959 316	13 157 078	7 899 011	5 258 067	679 477	122 761
1996	12 979 954	12 215 194	7 387 086	4 828 108	642 541	122 219
1997	14 760 355	13 949 648	7 894 150	6 055 498	693 010	117 697
1998	14 306 846	13 539 693	7 193 505	6 346 188	645 262	121 891
1999	14 498 170	13 797 829	6 786 341	7 011 488	585 806	114 535
2000	11 786 670	11 077 343	6 555 815	4 521 528	588 522	120 805
2001	12 571 528	11 905 111	6 974 146	4 930 965	547 232	119 185
2002	12 571 528	11 905 111	6 974 146	4 930 965	547 232	119 185
2003	13 027 145	12 354 358	6 525 623	5 828 735	550 071	122 716
2004	13 258 183	12 577 852	6 602 159	5 975 692	559 463	120 869
2005	13 489 222	12 801 345	6 678 696	6 122 650	568 854	119 022
2006	13 720 260	13 024 839	6 755 232	6 269 607	578 246	117 175
2007	13 951 298	13 248 332	6 831 768	6 416 564	587 638	115 328
2008	14 182 336	13 471 826	6 908 304	6 563 521	597 030	113 481
2009	14 413 375	13 695 319	6 984 841	6 710 479	606 421	111 634
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

Year	Livestock category – Population size [heads] *					
	Total Poultry	**Chicken***	**Laying hens***	**Broilers***	**Turkeys****	**Other Poultry****
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	17 460 759	16 745 159	9 075 488	7 669 671	590 219	125 381
2018	17 460 759	16 745 159	9 075 488	7 669 671	590 219	125 381
2019	17 460 759	16 745 159	9 075 488	7 669 671	590 219	125 381
Trend 90–19	***26.3%***	***27.4%***	***8.1%***	***61.6%***	***12.5%***	***-20.2%***

* *interpolated values for the years 2004-2009 and 2011-2012*

** *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 and 2011-2012*

Animal numbers of livestock categories 'Poultry' and 'Other' (furred game) 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 (next in 2020).

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[130] and the Umweltbundesamt. So, for 2017 new 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 and for 2018 and 2019 the values of 2017 have been used. Information on anaerobic digestion is based on data published by the Austrian Energy Regulator (E-CONTROL 2020). 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 258: 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).

[130] From 2020 onwards „The Federal Ministry for Agriculture, Regions and Tourism" (BMLRT)

Table 259: 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
(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 260: 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	--

For 2018 and 2019 the same shares as for 2017 have been used.

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[131] 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 (furred game) is taken from EMEP/EEA-Guidebook 2019, 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.

Table 261: Straw supply for cattle (per head).

<table>
<tr><th rowspan="3"></th><th colspan="8">kg straw per animal and day and year</th></tr>
<tr><th colspan="2">tied system with solid storage</th><th colspan="2">tied system with liquid slurry</th><th colspan="2">loose house systems with solid manure</th><th colspan="2">loose house systems with liquid slurry</th></tr>
<tr><th>kg straw per day</th><th>kg straw per year</th><th>kg straw</th><th>kg straw per year</th><th>kg straw</th><th>kg straw per year</th><th>kg straw</th><th>kg straw per year</th></tr>
<tr><td>Dairy cattle and suckling cows</td><td>1.5</td><td>547.5</td><td rowspan="2">0.2</td><td rowspan="2">73</td><td rowspan="2">4.0* / 2.5*</td><td rowspan="2">1 460 / 912.5</td><td>0.5</td><td>182.5</td></tr>
<tr><td>Young cattle</td><td>1.2</td><td>438</td><td>0.3</td><td>109.5</td></tr>
</table>

** 4 kg straw for deep litter systems and 2.5 kg straw for the bedding in solid manure systems*

[131] Österreichisches Kuratorium für Landtechnik und Landentwicklung

Table 262: 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 2019, Table 3.7).

Manure storage – cattle and swine

Table 263 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). Data for 1990 were estimated by the Austrian expert Alfred Pöllinger in June 2008 on the basis of TIHALO I results (AMON & HÖRTENHUBER 2008). The values from 2006–2016 were derived by linear extrapolation. For 2018 and 2019 the values of 2017 were taken.

Table 263: 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 and 2019 the same shares as for 2017 have been used.

Table 264: 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
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 and 2019 the same shares as for 2017 have been used.

5.3.2.2 Animal excretion – cattle and swine

N excretion

N excretion values as shown in Table 265 and Table 266 are based on the following literature: (GRUBER & PÖTSCH 2006, PÖTSCH et al. 2005, STEINWIDDER & GUGGENBERGER 2003, UNTERARBEITSGRUPPE N-ADHOC 2004 and ZAR 2004) and Richtlinien Sachgerechter Düngung (BMLFUW 2017).

Table 265: Austria specific N excretion values of dairy cows for the period 1990–2019.

Year	Milk yield [kg yr^{-1}]	Nitrogen excretion [kg/animal*yr]	Year	Milk yield [kg yr^{-1}]	Nitrogen excretion [kg/animal*yr]
1990	3 791	76.62	2005	5 783	94.55
1991	3 848	77.13	2006	5 903	95.63
1992	3 908	77.67	2007	5 997	96.48
1993	3 997	78.48	2008	6 059	97.03
1994	4 076	79.18	2009	6 068	97.11
1995	4 619	84.07	2010	6 100	97.40
1996	4 670	84.53	2011	6 227	98.54
1997	4 787	85.58	2012	6 418	100.26
1998	4 924	86.82	2013	6 460	100.64
1999	5 062	88.06	2014	6 542	101.38
2000	5 210	89.39	2015	6 579	101.71
2001	5 394	91.04	2016	6 759	103.33
2002	5 487	91.89	2017	6 865	104.29
2003	5 638	93.24	2018	7 104	106.44
2004	5 802	94.72	2019	7 179	107.11

1) *From 1995 onwards data have been revised by Statistik Austria, which led to significant higher milk yield data of Austrian dairy cows.*

The Austrian N excretion data were calculated following the guidelines of the European Commission according to the requirements of the European nitrate directive:

Cattle: Feed rations represent data of commercial farms consulting representatives of the working groups "Dairy production". These groups are managed by well-trained advisors. Their members, i.e. farmers, regularly exchange their knowledge and experience. Forage quality is based on field studies, carried out in representative grassland and dairy farm areas. The calculations depend on feeding ration, gain of weight, nitrogen and energy uptake, efficiency, duration of livestock keeping etc. On the basis of a national study (HÄUSLER 2009) for suckling cows an average milk yield of 3 500 kg has been assumed for the years from 2004 onwards.

Table 266: Austria specific N excretion values of other cattle and swine.

Livestock category	*Nitrogen excretion* [kg/animal*yr]
Suckling cows[1)] (1990)	69.5
Suckling cows[2)] (2019)	74.0
Cattle 1–2 years	53.6
Cattle < 1 year	25.7
Cattle > 2 years	68.4
Breeding sows (1990)	29.1
Breeding sows (2019)	27.7
Young & fattening pigs (1990)	9.0
Young & fattening pigs (2019)	8.8

1) *Annual milk yield: 3 000 kg*

2) *Annual milk yield: 3 500 kg*

Pigs: breeding pigs, piglets, boars, fattening pigs: number and weight of piglets, daily gain of weight, energy content of feeding, energy and nitrogen uptake, share of animals with N-reduced feeding (PÖLLINGER et al. 2018).

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 BMLFUW (2017).

Table 267: TAN content for Austrian cattle and pig manure after SCHECHTNER (1991) and BMLFUW (2017).

	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 revised 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 new 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 268 provides NH_3 emission factors for the housings of cattle and swine (EIDGENÖSSISCHE FORSCHUNGSANSTALT 1997 and DÖHLER et al. 2002).

Table 268: 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 2019 have been applied (Table 3.9).

Table 269: 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 255, Table 256 and Table 257)*
$Nex_{(T)}$	=	*N excretion of animals of type T in the country [kg N $animal^{-1}$ yr^{-1}] (see Table 265, Table 266 and Table 274)*
$MMS_{(T)}$	=	*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 270: 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 and 2019 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 2019 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 2019).

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 2019. The default value of 0.1 for f_{min} has been applied (EEA 2019).

NH_3 emission factors – cattle and swine

Table 271 provides NH_3 emission factors for the storage of cattle and swine manures (EIDGENÖSSISCHE FORSCHUNGSANSTALT 1997).

Table 271: 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
Pigs, liquid slurry system	0.12
Pigs, solid storage system	0.30

Abatement factors for storage systems of cattle and swine manures

Table 272 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[132] group and published in (REIDY et al. 2008, 2009).

Table 272: 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 2019).

5.3.3.1 Agricultural practice – non-key livestock categories

Solid systems and pasture are the relevant MMS for these animal categories in Austria.

[132] European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

Table 273: Share of N in animal waste management systems (non-key livestock).

Livestock category	Liquid/Slurry	Solid Storage	Pasture/Range/Paddock
	[%]	[%]	[%]
Sheep	0.0	65.0	35.0
Goats	0.0	94.4	5.6
Horses	0.0	80.0	20.0
Laying hens	0.0	96.0	4.0
Broilers	0.0	99.8	0.2
Turkeys	0.0	99.8	0.2
Other poultry	0.0	99.8	0.2
Other animals	0.0	20.0	80.0

Shares are kept constant for all years.

N-input from straw as bedding material – non-key livestock categories

Information on N inputs from straw for sheep, goats, soliped and other animals (furred game) is taken from the EMEP/EEA-Guidebook 2019, 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 262.

5.3.3.2 Animal excretion – non-key livestock categories

Country specific N excretion values are presented in the following table:

Table 274: 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 275 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 2019, Table 3.9).

Table 275: 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	0.41(*)	0.20(*)	0.49(*)
3.B.4.h	Other animals(**)	0.50	0.22	0.32	0.90

*) *EF = weighted mean of ducks & geese for 2019*

**) *In Austria furred game, mainly deer, dominates the livestock category 'other animals'. 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 273, 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 2019).

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 276: Abatement factors (AF) for NH_3 emissions from storage systems (layers and broilers)

Livestock category	Housing system	Share in solid systems 2017	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: no information on the drying is available. Thus, only half of the abatement potential from (UNECE 2015) has been used.

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

In previous submission 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 for the first time. 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 277). 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 277: N amounts digested in biogas facilities 1990-2019

Year	N (manure-inputs)	N (vegetable-inputs)	Total N inputs
		[kg year^{-1}]	
1990	35 459	228 362	263 822
1991	48 191	309 630	357 821
1992	53 579	342 881	396 460
1993	71 846	456 489	528 335
1994	204 387	1 292 892	1 497 279
1995	234 264	1 486 580	1 720 844
1996	257 880	1 629 485	1 887 365
1997	328 751	2 073 984	2 402 735

Year	N (manure-inputs)	N (vegetable-inputs)	Total N inputs
		[kg year^{-1}]	
1998	387 594	2 439 826	2 827 420
1999	529 961	3 336 562	3 866 523
2000	631 000	3 933 677	4 564 676
2001	721 658	4 489 945	5 211 603
2002	805 505	4 991 742	5 797 247
2003	867 011	5 382 074	6 249 085
2004	930 939	5 761 510	6 692 449
2005	985 590	6 066 373	7 051 963
2006	1 036 171	6 342 572	7 378 743
2007	1 152 085	6 988 645	8 140 729
2008	1 204 268	8 227 318	9 431 586
2009	1 251 848	9 745 371	10 997 219
2010	1 299 139	9 163 634	10 462 772
2011	1 356 376	8 718 846	10 075 222
2012	1 429 683	9 145 218	10 574 901
2013	1 498 654	9 537 291	11 035 945
2014	1 534 185	9 715 635	11 249 820
2015	1 613 356	10 190 403	11 803 759
2016	1 557 739	8 559 247	10 116 986
2017	1 281 549	9 326 988	10 608 538
2018	1 218 432	9 931 027	11 149 459
2019	1 199 163	9 772 676	10 971 838

Methodology

The calculations were done according to the Tier 1 methodology of the EMEP/EEA Guidebook 2019 (EEA 2019, 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 2019 (EEA 2019). 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 2019, 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) (see Table 267). Default TAN values according to the EMEP/EEA GB 2019, Table 3.9, have been applied for sheep, goats, horses, poultry and deer.

Emission factors

Emission factors are taken from the EMEP/EEA GB 2019, 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 2019. 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, presented in Table 267). For the other livestock categories the default values according to the EMEP/EEA GB 2019, 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 2019) 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 2020a) (please refer to Table 255, Table 256 and Table 257). Following a recommendation under the NEC Review 2018 (EC 2018), Austria splitted the piglets numbers < 20 kg into suckling piglets < 8 kg and weaned piglets 8–20 kg based on expert judgement (STATISTIK AUSTRIA 2018a). This approach was accepted by the NEC Review 2018 and applied for all inventory years. Emission estimates have been updated accordingly by taking into account swine numbers between 8 and 20 kg in the total number of fattening pigs.

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

Currently, less information on silage feeding is available in Austria. Therefore, the maximum proportion of silage in dry matter of approximately 50 % of the total dry matter intake has been applied for dairy cattle, as provided in the EMEP/EEA GB 2019. For the other cattle categories the proportion of silage in dry matter has been estimated based on animal diets worked out by nutrition experts as included in (AMON et al. 2002).

Sheep, goats and horses are not fed with silage in Austria.

Methodology

The Tier 2 methodology according to the EMEP/EEA GB 2019 (EEA 2019) 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 2021 – Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol" (UMWELTBUNDESAMT 2021a).

Calculations have been done on the basis of feed intake and silage fraction according to the formulas as provided in the EMEP/EEA GB 2019, p. 29. Default Tier 2 emission factors for feeding, building and grazing are taken from Table 3.11 of the EMEP/EEA GB 2019. Table 278 provides the resulting country-specific emission factors for the different cattle categories for 2019.

Table 278: Country-specific NMVOC emission factors of cattle for 2019.

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. storag [kg NMVOC $head^{-1}$ yr^{-1}]	EF application [kg NMVOC $head^{-1}$ yr^{-1}]	EF grazing [kg NMVOC $head^{-1}$ yr^{-1}]
Dairy cows	14.09	5.51	7.29	0.03
Suckling cows	5.46	3.46	3.45	0.11
Cattle < 1 year	8.14	2.50	1.71	0.03
Breeding heifers 1–2 years	8.54	2.78	2.95	0.02
Fattening heifers, bulls & oxen, 1–2 years	7.78	2.44	2.63	0.01
Cattle > 2 years	5.24	2.45	2.68	0.03

All livestock categories other than cattle

NMVOC emissions from swine, sheep, goats, horses, poultry and deer were calculated using the EMEP/EEA 2019 Tier 2 methodology on the basis of VS excretion (EEA 2019, p. 30). For detailed information on the VS excretion, please refer to chapter 5 of "Austria's National Inventory Report 2021 – Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol" (UMWELTBUNDESAMT 2021a).

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 2019). Table 279 provides an overview of NMVOC emission factors and parameters used in the calculations.

Table 279: NMVOC emission factors and fractions used for livestock categories other than cattle for 2019

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	0.43	-
Young & fattening pigs	0.001703	0.17	0.45	-
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	0.29	0.74	-
Broilers	0.009147	1.04	0.81	-
Turkeys	0.005684	0.52	0.38	-
Other poultry	0.005684	0.35	0.51	-
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

Raw material balance

In 2020, new information on input materials for Austria's biogas plants became available (E-CONTROL 2020), resulting in slightly revised amounts of digested manure and energy crops for 2018.

This update is also the reason for the recalculations of ammonia within NFR sector *5.B.2 Biological treatment of waste*.

5.4 NFR 3.B Particle Emissions from Manure Management

Key Category: No

In NRF 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 to be 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 2020a) provides national data of annual livestock numbers on a very detailed level (please refer to Table 255, Table 256 and Table 257).

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 GB 2019 default Tier 1 emission factors.

In Table 280 the applied emission factors are listed.

Table 280: 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
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 to be 45% and the share of $PM_{2.5}$ in TSP is assumed to be 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 revised CLRTAP Reporting Guidelines 2014. 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.

NH_3 emissions from:

- Urine and dung deposited by grazing animals (3.D.a.3) and

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 2019. 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" (BMLRT 2000–2020).

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 281 provides national N fertilizer data from 1990 to 2019.

Table 281: N usage of different types of mineral fertilizers (arithmetic average of two years) in Austria 1990–2019.

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
1991	79 434	-	3 538	3 657	18	49 083	98	3 710
1992	79 956	-	2 539	4 742	18	46 073	168	3 926
1993	76 704	-	920	6 229	16	42 419	228	3 682
1994	73 520	-	342	7 203	15	40 656	227	4 198
1995	74 114	20	400	7 535	16	40 019	208	5 058
1996	74 259	59	639	7 426	18	39 145	205	4 899
1997	76 242	98	878	7 318	19	38 271	203	5 520
1998	77 126	138	1 118	7 209	21	37 397	201	6 440
1999	71 497	177	1 357	7 101	23	36 523	198	6 624
2000	70 547	216	1 597	6 992	25	35 649	196	5 328
2001	71 791	256	1 836	6 883	27	34 775	194	3 589
2002	75 184	295	2 075	6 775	28	33 901	191	3 900
2003	62 950	334	2 315	6 666	30	33 027	189	5 488
2004	48 843	374	2 554	6 558	32	32 153	187	6 900
2005	51 614	413	2 794	6 449	34	31 279	184	7 483
2006	51 760	452	3 033	6 341	35	30 405	182	9 491
2007	52 351	492	3 272	6 232	37	29 531	180	11 405
2008	69 276	531	3 512	6 124	39	28 657	177	10 534
2009	58 031	570	3 751	6 015	41	27 783	175	13 984
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
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

Data sources: Annual fertilizer statistics compiled by AMA (Agrarmarkt Austria, www.ama.at) and annually published in the "Green Reports" (BMLRT, 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 2020): 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 2019 provides specific NH_3 emission factors for different types of synthetic fertilizers and for different climatic conditions and refers to the IPCC 2006 Guidelines regarding the definitions of climatic zones. According to IPCC 2006, Austria belongs to Group III '*temperate and cool temperate countries*' with largely acidic soils. 65% of Austria´s soils are classified as normal (pH<7) and 35% as high (pH>=7) based on Austrian Soil Information System – BORIS – (http://www.borisdaten.at). The EMEP/EEA Guidebook 2019 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 0.158 kg NH_3/kg N was adjusted by 70% resulting in an EF of 0.047 kg NH_3/kg N applied.

In Austria, full time-series data for the different mineral fertilizer types is shown in Table 281. 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 2019, table 3.2) have been calculated. The resulting emission factors, adjusted to Austrian conditions, are indicated in the following table.

Table 282: NH_3 emission factors for the different types of mineral fertilizers in Austria

Mineral fertilizer	Emission factors (EMEP/EEA GB 2019)	Emission factors (EMEP/EEA GB 2019)	Weighted emission factors
	normal (ph <=7)	high (ph >7)	65% normal, 35% high
		[g NH_3 (kg N applied)$^{-1}$]	
Calcium ammonium nitrate (CAN)	8	17	11
N solutions (Urea AN)	98	95	97
Ammonium sulphate (AS)	90	165	116
Calcium nitrate (CN)	10	19	13
NPK mixtures	50	91	64
Urea	155	164	158
N-stabilised fertilizers*			47*
Other**	-	-	50(**)

(*) *default EF of urea reduced by 70% according to (UNECE 2015).*

(**) *For other fertilizers the 2019 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 2019 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 revised 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 2021 – Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol" (UMWELTBUNDESAMT 2021a).

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 2019 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-NH_3-$N_{spread\ SS}$	=	*NH_3-N Emission factor of animal waste from a solid manure system (farmyard manure) spread on agricultural soils (broadcast spreading)*
EF-NH_3-$N_{spread\ LS}$	=	*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 283 gives information on slurry application for the years 1990, 2005 and 2017. 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). For 2017, the data is stemming from the TIHALO II survey (PÖLLINGER et al. 2018). For 2018 and 2019 the same values as for 2017 have been used.

Table 283: Cattle and pig slurry application in Austria 1990, 2005 and 2017.

Animal category:	1990		2005		2017	
	Broadcast application (%)	Low-emission spreading (%)	Broadcast application (%)	Low-emission spreading (%)	Broadcast application (%)	Low-emission spreading (%)
Dairy cows	96.2	3.8	92.4	7.6	94.5	5.5
Suckling cows	97.1	2.9	94.2	5.8	94.5	5.5
Cattle < 1 year	96.6	3.5	93.1	6.9	94.5	5.5
Breeding heifers 1–2 years	96.3	3.7	92.6	7.4	94.5	5.5
Fattening heifers, bulls & oxen, 1–2 years	98.4	1.7	96.7	3.3	94.5	5.5
Cattle > 2 years	94.7	5.3	89.4	10.6	94.5	5.5
Breeding sows plus litter	98.0	2.1	95.9	4.1	68.0	32.0
Fattening pigs	97.0	3.0	94.0	6.0	68.0	32.0

Following the TIHALO II study (PÖLLINGER et al. 2018) the use of low-emission manure spreading techniques for the application of cattle slurry is still low. However, for pig slurries the share of low- emission spreading techniques has been increased significantly in 2017 compared to 2005. Trailing shoe and slurry injection are still not common techniques in Austria in 2017 (1–2% of total low-emission manure spreading).

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 284: 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 285 presents weighted abatement factors (AF) derived from average usages of several reduced-emission techniques for slurry application in 1990, 2005 and 2017. 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. For 2018 and 2019 the same values as for 2017 have been used.

Table 285: Abatement factors (AF) for NH_3 emissions from slurry application.

Application technique	Average weighted AF			AF (Unece 2015)
	1990	2005	2017	
Broadcast spreading	1	1	1	1
Low-emission manure spreading	0.70	0.70	0.65*	
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 2019, Table 3.9) as also indicated in Table 275. 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 2019 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 286) 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 and 2019 the same values as for 2017 have been used.

Table 286: 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%	36%	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 2019, 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 2019).

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 2019) 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 2019 (EEA 2019, 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 287: Amount of sewage sludge (dry matter) produced in Austria, 1990–2019.

Year	Total [t dm]	agriculturally applied [t dm]	agriculturally applied [%]
1990	161 936	31 507	19.5
1991	161 936	31 507	19.5
1992	200 000	30 000	15.0
1993	300 000	45 000	15.0
1994	350 000	38 500	11.0
1995	390 500	42 400	10.9
1996	390 500	42 955	11.0
1997	390 500	42 955	11.0
1998	392 909	43 220	11.0
1999	392 909	43 220	11.0
2000	392 909	43 220	11.0
2001	398 800	41 600	10.4

Year	Total [t dm]	agriculturally applied [t dm]	agriculturally applied [%]
2002	322 096	36 065	11.2
2003	315 130	39 186	12.4
2004	294 942	35 357	12.0
2005	290 110	35 541	12.3
2006	241 364	39 369	16.3
2007	245 202	40 713	16.6
2008	248 169	39 247	15.8
2009	252 181	39 945	15.8
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	237 982	48 314	20.3
2017	236 180	47 549	20.1
2018	234 481	48 170	20.5
2019	233 499	49 676	21.3

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).

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 287)

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 2019 is applied. The default emission factor for other organic wastes of 0.08 kg NH_3 per kg N applied has been used (EEA 2019, Table 3.1).

Emissions of nitric oxide (NO_x)

The Tier 1 approach according to the EMEP/EEA Emission Inventory Guidebook 2019 is applied. The default NO emission factor for other organic wastes of 0.04 kg NO/kg waste N applied (EEA 2019, 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 2008, 2011, 2013, 2017, 2018 & 2019, 2020). N content of digested energy crops was derived from specific literature (RESCH et al. 2006; DLG 1997; LANDESBETRIEB LANDWIRTSCHAFT HESSEN 2013). Amounts of digested manure N are calculated in sector manure management.

Table 288: 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	61 282	228 362	60 236
1991	83 090	309 630	98 742
1992	92 013	342 881	172 251
1993	122 501	456 489	386 072
1994	346 952	1 292 892	558 816
1995	398 929	1 486 580	694 352
1996	437 278	1 629 485	778 047
1997	556 561	2 073 984	732 696
1998	654 736	2 439 826	761 553
1999	895 379	3 336 562	785 463
2000	1 055 616	3 933 677	875 945
2001	1 204 893	4 489 945	966 428
2002	1 339 552	4 991 742	1 050 323
2003	1 444 299	5 382 074	1 097 984
2004	1 546 122	5 761 510	1 133 292
2005	1 627 933	6 066 373	1 137 307
2006	1 702 052	6 342 572	1 100 971
2007	1 875 428	6 988 645	1 114 044
2008	1 932 893	8 227 318	1 158 411
2009	1 980 591	9 745 371	1 231 597
2010	2 028 231	9 163 634	1 303 964
2011	2 092 422	8 718 846	1 408 564
2012	2 194 747	9 145 218	1 560 827
2013	2 288 840	9 537 291	1 471 292

Year	Digestates (livestock manures) [kg N year^{-1}]	Digestates (veg. part) [kg N year^{-1}]	N from compost [kg N year^{-1}]
2014	2 331 640	9 715 635	1 530 673
2015	2 406 550	10 190 403	1 504 839
2016	2 492 978	8 559 247	1 637 533
2017	2 060 878	9 326 988	1 641 556
2018	2 069 204	9 931 027	1 631 028
2019	2 036 211	9 772 676	1 695 228

Compost

Activity data for agricultural compost application was derived by expert judgement by Umweltbundesamt (2015) on the basis of 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 306 (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 289: Amount of compost (dry matter) produced in Austria, 1990–2019.

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
1991	90 673	7 053	7.8	99
1992	119 341	12 304	10.3	172
1993	163 281	27 577	16.9	386
1994	205 698	39 915	19.4	559
1995	230 215	49 597	21.5	694
1996	246 700	55 575	22.5	778
1997	248 815	52 335	21.0	733
1998	260 179	54 397	20.9	762
1999	271 131	56 104	20.7	785
2000	293 394	62 568	21.3	876
2001	342 284	69 031	20.2	966
2002	390 128	75 023	19.2	1 050
2003	432 221	78 427	18.1	1 098
2004	472 354	80 949	17.1	1 133
2005	474 990	81 236	17.1	1 137
2006	470 750	78 641	16.7	1 101
2007	473 800	79 575	16.8	1 114
2008	483 450	82 744	17.1	1 158
2009	496 492	87 971	17.7	1 232
2010	504 530	93 140	18.5	1 304

Year	Total amount of compost [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied compost N [t N]
2011	521 839	100 612	19.3	1 409
2012	546 948	111 488	20.4	1 561
2013	533 965	105 092	19.7	1 471
2014	545 256	109 334	20.1	1 531
2015	543 623	107 489	19.8	1 505
2016	568 005	116 967	20.6	1 638
2017	570 122	117 254	20.6	1 642
2018	569 757	116 502	20.4	1 631
2019	581 259	121 088	20.8	1 695

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 258 to Table 260. 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 266.

Sheep, goats, horses, poultry and other animals

Tier 2 default NH_3-N EFs have been taken (EEA 2019, Table 3.9). For other animals (furred game) 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). For each livestock category, the emissions are reported under 3.D.a.2.a. NO_x emissions from grazing are reported as IE (included elsewhere).

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-sector 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 2019 has been applied. Austria estimates emissions for all of the relevant crop types for which EFs are available in the 2019 EMEP/EEA Guidebook (wheat, rye and rape) (see Table 3.3). 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. The average temperature in Austria varies from 8.4 °C in Klagenfurt to 10.5 °C in Vienna. 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 2019, Table 3.3, 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 1990–2020) and (STATISTIK AUSTRIA 2018b). 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 FSS (Farm Structure Survey) and IACS (Integrated Administration and Control System).

In the years when the full FFS was conducted (1990, 1995, 1999 and 2010) these data were taken (ÖSTAT 1991, 1998, STATISTIK AUSTRIA 2001, 2013). 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.

For the years between the full and random sample surveys the data have been interpolated. The data of the random sample farm structure survey 2016 (STATISTIK AUSTRIA 2018b) are considered in this submission. In the 2015 submission an improvement of areas of alpine pastures was carried out, which led to reduced areas of alpine pastures compared to previous surveys. A detailed description of the recalculation of the alpine grassland area is included in 2015 submission (UMWELTBUNDESAMT 2015).

Further details are given in "Austria's National Inventory Report 2021, chapters *6.3.2 Cropland (Category 4.B)* and *6.4.2 Grassland (Category 4.C)* (UMWELTBUNDESAMT 2021a).

As recommended under the NEC Review 2018 (EC 2018), the cultivated area of wheat, rye and rape is now included in the following table.

Table 290: Agricultural land use data 1990–2019 for calculating NMVOC emissions (3.D.e).

Year	Land Use Areas [ha]						
	Cropland (total)	*Wheat*	*Rye*	*Rape*	*Remaining Cropland*	Grassland (total)	Grassland (extensive)
1990	1 405 141	278 226	93 041	40 844	993 030	1 714 917	455 692
1991	1 404 962	271 068	85 070	45 552	1 003 272	1 707 644	449 508
1992	1 404 784	245 728	69 114	49 919	1 040 023	1 700 371	443 325
1993	1 404 605	240 971	73 701	59 090	1 030 843	1 693 099	437 141
1994	1 404 427	240 961	77 021	71 402	1 015 043	1 685 826	430 957
1995	1 404 248	255 910	76 826	89 246	982 266	1 678 553	424 773
1996	1 400 803	247 602	51 222	64 904	1 037 075	1 671 591	418 899
1997	1 397 357	259 832	57 807	54 897	1 024 821	1 664 628	413 025
1998	1 396 316	264 405	59 282	52 086	1 020 543	1 657 665	407 151
1999	1 395 274	260 579	55 901	65 768	1 013 026	1 650 702	401 277
2000	1 394 457	293 806	52 473	51 762	996 416	1 643 693	398 499
2001	1 393 641	287 777	51 219	56 098	998 547	1 636 684	395 720
2002	1 392 824	288 764	47 145	55 383	1 001 532	1 629 675	392 942
2003	1 392 008	272 001	40 003	44 035	1 035 969	1 622 666	390 163
2004	1 391 191	290 174	45 664	35 284	1 020 069	1 615 657	387 385
2005	1 390 374	288 960	42 847	35 251	1 023 316	1 608 648	384 607
2006	1 389 558	284 577	26 924	42 582	1 035 474	1 588 772	381 828
2007	1 388 741	292 976	46 702	48 509	1 000 554	1 568 897	379 050
2008	1 383 337	296 775	53 171	56 056	977 335	1 549 022	376 271
2009	1 377 934	309 034	48 528	56 933	963 438	1 529 147	373 493
2010	1 372 530	302 852	45 699	53 803	970 176	1 509 271	370 714
2011	1 369 706	304 334	45 943	53 636	965 792	1 493 892	367 997
2012	1 366 881	308 179	48 525	55 821	954 355	1 478 512	365 279
2013	1 364 057	297 286	56 108	58 557	952 106	1 463 133	362 562
2014	1 357 532	304 645	48 241	52 816	951 830	1 434 736	358 957
2015	1 351 006	302 965	39 563	37 529	970 950	1 406 339	355 351
2016	1 344 481	315 088	37 312	39 662	952 418	1 377 942	351 746
2017	1 336 815	295 029	34 476	40 502	966 808	1 359 117	346 941
2018	1 335 080	292 654	40 725	40 504	961 197	1 340 292	342 135
2019	1 333 452	277 291	43 679	35 966	976 516	1 321 467	337 330

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 2019, 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: 1990–2019
- Chlorothalonil: 1990–2019
- DCPA, Dacthal, Chlorthaldimethyl: 1995
- Endosulfan: 1990–2006
- Lindane: 1990–1997
- Picloram: 1990–2019
- 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 291 provides the total amount of active substances.

Table 291: Annual total amounts of active substances containing HCB as impurity in Austria.

Year	Active substances [kg]	Year	Active substances [kg]
1990	463 422.21	2005	18 272.22
1991	463 422.21	2006	20 818.25
1992	346 793.14	2007	20 167.30
1993	326 005.19	2008	20 593.00
1994	37 396.88	2009	18 515.00
1995	34 867.60	2010	21 309.00
1996	32 188.70	2011	16 881.00
1997	28 727.40	2012	15 395.87
1998	20 357.40	2013	19 376.60
1999	19 586.00	2014	20 053.55
2000	22 767.50	2015	6 673.52
2001	24 055.40	2016	26 415.45
2002	20 584.22	2017	46 821.32
2003	20 099.60	2018	39 569.96
2004	19 850.80	2019	60 362.09

Methodology

Austria applies the EMEP/EEA 2019 Tier 1 default approach and the proposed maximum HCB-concentrations (impurity factors) in active substances according to the EMEP/EEA Guidebook 2019, Table 4.

Depending on the usage of specific substances in the time series the implied impurity factors vary from about 8 mg/kg to 175 mg/kg active substance.

5.5.7 Category-specific Recalculations

Update of activity data

Raw material balance (3.B, 3.D)

In 2020, new information on input materials for Austria's biogas plants became available (E-CONTROL 2020), resulting in slightly revised amounts of digested manure and energy crops for 2018.

Methodological changes

NH_3

Inorganic N fertilizers (3.D.a.1)

Revised emissions from inorganic N fertilizers are due to the implementation of a new EF for N-stabilised fertilizers (0.047 kg NH_3/kg N). Information became available that in Austria the fertilizers allocated in previous inventories under category "Other Straight N Compounds" were in fact N-stabilised urea fertilizers. Consequently, the EF of 0.013 kg NH_3/kg N applied in previous inventories was definitely too low (see chapter 5.5.2). This revision resulted in higher NH_3 emissions from synthetic fertilizer applications for the entire time series (+ 0.2 kt NH_3 in 2018).

NMVOC

Cultivated crops (3.D.e)

Due to minor revisions of grassland and cropland areas, NMVOC emissions for most of the years between 1991 and 2018 have been recalculated (– 0.02 kt NMVOC in 2018).

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 2019 Tier 1 methodology (EEA 2019). In accordance with the EMEP/EEA Guidebook 2019, 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 4.2) 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 1990–2020) and (STATISTIK AUSTRIA 2018b). 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 FSS (Farm Structure Survey) and IACS (Integrated Administration and Control System).

In the years when the full FFS was conducted (1990, 1995, 1999 and 2010) these data were taken (ÖSTAT 1991, 1998, STATISTIK AUSTRIA 2001, 2013). 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, 2018b), and these data for cropland area were also taken.

For the years between the full and random sample surveys the data have been interpolated. The data of the random sample farm structure survey 2016 (STATISTIK AUSTRIA 2018b) are considered in this submission. In the 2015 submission an improvement of areas of alpine pastures was carried out, which led to reduced areas of alpine pastures compared to previous surveys. A detailed description of the recalculation of the alpine grassland area is included in 2015 submission (UMWELTBUNDESAMT 2015).

Further details are given in "Austria's National Inventory Report 2021, chapters *6.3.2 Cropland (Category 4.B)* and *6.4.2 Grassland (Category 4.C)* (UMWELTBUNDESAMT 2021a).

Table 292: Agricultural land use data 1990–2019.

Land Use Area Data					
Year	**arable farm land [1 000 ha]**	**grassland (intensive used) [1 000 ha]**	**Year**	**arable farm land [1 000 ha]**	**grassland (intensive used) [1 000 ha]**
1990	1 405	877	2005	1 390	908
1991	1 405	881	2006	1 390	897
1992	1 405	884	2007	1 389	885
1993	1 405	888	2008	1 383	874
1994	1 404	892	2009	1 378	863
1995	1 404	895	2010	1 373	851
1996	1 401	899	2011	1 370	843
1997	1 397	902	2012	1 367	835
1998	1 396	906	2013	1 364	826
1999	1 395	910	2014	1 358	820
2000	1 394	909	2015	1 351	813
2001	1 394	909	2016	1 344	806
2002	1 393	909	2017	1 337	795
2003	1 392	909	2018	1 335	784
2004	1 391	908	2019	1 333	773

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 2019, table 3.1 (EEA 2019).

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 4.2) 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 4.2, Table 223).

Emission factors

The EMEP/EEA GB 2019 does not provide emission factors for this source category. Emission factors are taken from a national study (WINIWARTER et al. 2001) (see Chapter 4.2, Table 222).

5.6.2 Category-specific Recalculations

On-farm storage, handling and transport of agricultural products (3.D.c)

Due to minor revisions of grassland and cropland areas, PM emissions for most of the years between 1991 and 2018 have been recalculated (– 0.001 kt $PM_{2.5}$ in 2018).

5.7 NFR 3.F Field Burning of Agricultural Residues

This category comprises burning straw from cereals and residual wood of vinicultures on open fields in Austria.

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 the Austrian Chamber of Agriculture (AUSTRIAN CHAMBER OF AGRICULTURE 2020), in Austria about 200 ha were burnt in 2019. This value corresponds to about 0.04% of the relevant cereal area in 2019. 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.

Activity data of agricultural land use (viniculture area) are taken from (STATISTIK AUSTRIA 1990–2020) and (STATISTIK AUSTRIA 2018b). 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 2021, chapters *6.3.2 Cropland (Category 4.B)* and *6.4.2 Grassland (Category 4.C)* (UMWELTBUNDESAMT 2021a).

According to an expert judgement from the *Federal Association of Viniculture* (Bundesweinbau-verband Österreich) the amount of residual wood per hectare viniculture is 1.5 to 2.5 t residual wood and the part of it that is burnt is estimated to be 1 to 3%. For the calculations the upper limits (3% of 2.5 t/ha) have been used resulting in a factor of 0.075 t burnt residual wood per hectare viniculture area.

Table 293: Activity data for field burning of agricultural residues 1990–2019.

Year	Viniculture Area [ha]	Burnt Residual Wood [t]	Year	Viniculture Area [ha]	Burnt Residual Wood [t]
1990	58 364	4 377	2005	50 119	3 759
1991	57 981	4 349	2006	49 981	3 749
1992	57 599	4 320	2007	49 842	3 738
1993	57 216	4 291	2008	47 688	3 577
1994	56 422	4 232	2009	45 533	3 415
1995	55 627	4 172	2010	45 480	3 411
1996	54 061	4 055	2011	45 427	3 407
1997	52 494	3 937	2012	45 373	3 403
1998	51 854	3 889	2013	45 320	3 399
1999	51 214	3 841	2014	45 799	3 435
2000	50 304	3 773	2015	46 277	3 471
2001	49 393	3 704	2016	46 756	3 507
2002	48 483	3 636	2017	46 756	3 507
2003	47 572	3 568	2018	46 756	3 507
2004	48 846	3 663	2019	46 756	3 507

The amount of agricultural waste burned is multiplied with a default or a country specific emission factor.

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 2019) 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 on the basis of the IPCC 2006 default methodology (see Austria´s National Inventory Report 2021, chapter on N from crop residues).

For wheat and barley Tier 2 emission factors are available in the guidebook (EEA 2019, 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.

5.7.1.2 Viniculture

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 2019, chapter 5.C.2 Open burning of waste (EEA 2019). The Tier 2 emission factors for orchard crops were used (EEA 2019, Table 3-3).

NH_3

The EMEP/EEA 2019 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 2019 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

5.7.2 Category-specific Recalculations

The correction of a linkage error for 2017 and 2018 resulted in marginal downward revisions of NO_x, SO_2, NMVOC, NH_3, PM and heavy metal emissions for both years.

Furthermore, Benzo(a)pyrene, Benzo(b)flouranthene, Benzo(k)flouranthene and Indeno(1,2,3-c,d)pyrene emissions have been reported for the first time separately in submission 2021. In previous years, PAH emissions have been reported only as total.

6 WASTE (NFR SECTOR 5)

6.1 Sector Overview

This chapter includes information on and descriptions of 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 2019.

Emissions addressed in this chapter include emissions from the sub categories

- *Solid Waste Disposal on Land* (NFR Sector 5.A);
- *Composting* (NRF 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;
- *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 294 presents the contribution of sector Waste to national total emissions of the different pollutants.

Table 294: Contribution to National Total Emissions from NFR sector 5 Waste in 2019.

Pollutant	Source Category: 5 Waste	Pollutant	Source Category: 5 Waste
SO_2	0.13%	PAH	< 0.01%
NO_x	0.01%	Diox	7.15%
NMVOC	0.05%	HCB	0.38%
NH_3	2.57%	TSP	2.06%
CO	0.55%	PM_{10}	1.83%
Cd	0.16%	$PM_{2.5}$	2.07%
Hg	4.07%		
Pb	0.01%		

The overall emission trend reflects changes in waste management policies as well as waste treatment facilities. According to the Landfill Ordinance[133] 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 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 until 2019 due to

[133] 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).

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[134]) and the obligatory pre-treatment of waste[135] since 2004 (with some exemptions until 2009) before deposition (regulated in Austrian Landfill Ordinance[136]).

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[137]) and to demonstrate that all relevant activity data are taken into account in the inventory.

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[134] Verordnung über die getrennte Sammlung biogener Abfälle (BGBl. Nr. 68/1992)

[135] 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)

[136] 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

[137] In fact non-residual waste also comprises waste from other (industrial) sources.

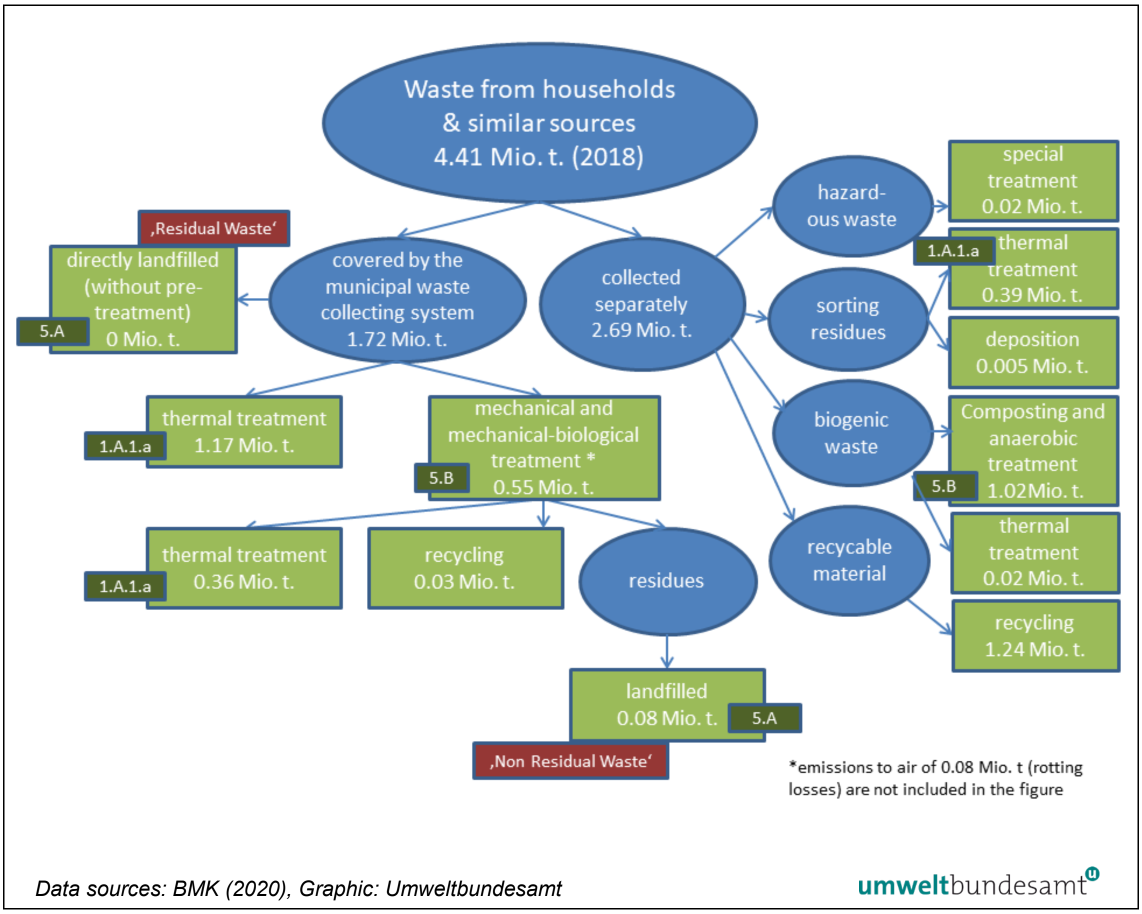

Figure 54: Waste from households and similar sources – treatment and disposal routes 2018. Please note: This illustration only covers data from households and similar sources. Waste from industrial and similar sources (e.g. wastewater treatment plants) are also included in the inventory, but not considered in this figure.

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 295 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 295: 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 296: Key categories of sector Waste

NFR Category	Source Category	Key Category	
		Pollutant	KS-Assessment
5.B	Composting	NH_3	TA
5.C	Waste Incineration	DIOX	TA
5.C	Waste Incineration	Cd	TA
5.E	Other waste	DIOX	LA, TA

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 297: 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. After finalisation of the calculation but prior to submission, the respective section of the IIR is sent to relevant experts for a final check of descriptions and trend analysis. Moreover, 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 have been given by the IBE, but mainly with regard to documentation and archiving.

6.2.6 Planned Improvements

It is planned to include NMVOC emissions from NFR 5.*B.2 Industrial Wastewater* as soon as related QA/QC checks on activity data are finalised.

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[138] 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[139]), 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.

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.

'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 (98%). Some minor amounts of sludge, construction waste and paper with little TOC content (below the threshold for TOC disposal) are landfilled as well. Green waste, paper and wood are mainly composted, recycled or reused due to the implementation of the Waste Management Law, fats and textiles are not deposited any more.

[138] 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).

[139] 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

6.3.1.2 Methodological Issues

The anaerobic degradation of land filled 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). In a first step the amount of methane production 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 303).

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[140].

For the calculation of emissions the IPCC Tier 2 method (First Order Decay) is applied, consisting of two equations: first, calculating the amount of methane accumulated up to the year of the inventory; second, calculating the emitted methane after subtracting the recovered and oxidised methane amounts. As far as available country-specific parameters are taken (e.g. the recovered landfill gas).

Activity data

For emissions calculation waste deposited from 1950 onwards has been taken into account. Table 298 presents the waste amounts considered 1990–2019.

Table 298: Activity data for "Residual waste" and "Non-Residual Waste" 1990–2019.

Year	Non-Residual waste [t]	Residual waste [t]	Total waste [t]
1990	648 702	1 995 747	2 644 448
1991	661 676	1 799 718	2 461 394
1992	674 909	1 614 157	2 289 067
1993	688 407	1 644 718	2 333 126
1994	702 175	1 142 067	1 844 242
1995	716 219	1 049 709	1 765 928
1996	730 543	1 124 169	1 854 713
1997	745 154	1 082 634	1 827 788
1998	760 057	1 081 114	1 841 171
1999	822 179	1 084 625	1 906 804
2000	826 874	1 052 061	1 878 935
2001	772 786	1 065 592	1 838 378
2002	792 753	1 174 543	1 967 296
2003	890 640	1 385 944	2 276 584
2004	344 747	282 656	627 403

140 Most active landfills in Austria have gas collection systems – regulated in §31 Landfill Ordinance (Federal Law Gazette BGBl. Nr 39/2008.

Year	Non-Residual waste [t]	Residual waste [t]	Total waste [t]
2005	389 660	241 733	631 393
2006	425 091	260 068	685 159
2007	464 109	154 517	618 626
2008	319 927	129 324	449 251
2009	256 340	0	256 340
2010	244 969	0	244 969
2011	273 313	0	273 313
2012	166 263	0	166 263
2013	185 156	0	185 156
2014	174 500	0	174 500
2015	131 959	0	131 959
2016	132 182	0	132 182
2017	151 866	0	151 866
2018	163 663	0	163 663
2019	166 659	0	166 659
1990–2019	**-74%**	**-100%**	**-94%**

In 1990, the Austrian Waste Management Law[141] 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 un-treated 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.[142] 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[143] is allowed to be deposited any more.

[141] Waste Management Act of 2002 , Federal Law Gazette I No 102/2002 as amended by Federal Law Gazette I No 9/2011

[142] Regulated in § 76.Abs. 7 AWG 2002

[143] as defined at the beginning of this sub-chapter

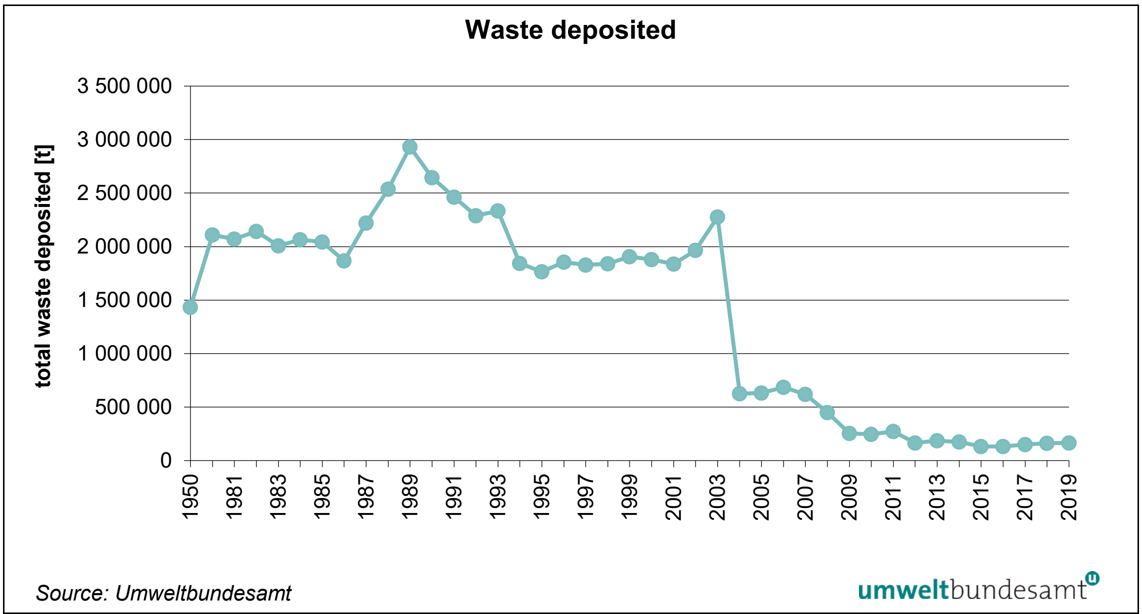

Figure 55: Deposited waste (residual and non-residual waste) 1950–2019.

The quantities of "residual waste" have been taken from the following sources:

- Data for 2008–2019 have been taken from the EDM[144], 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[146].
- Data for 1998–2007 were taken from a database for solid waste disposals called "Deponiedatenbank" ('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 (BMFLUW 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[147] (1998 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

[144] Electronic Data Management

[145] According to § 41 (1) Landfill Ordinance, Federal Law Gazette BGBl. Nr 39/2008

[146] According to §41 (1) Landfill Ordinance, Federal Law Gazette BGBl. Nr 39/2008

[147] Data available from the Federal Waste Management Plan (Bundesabfallwirtschaftsplan - BAWP) as well as from the Austrian landfill database.

were taken from the EDM[148] (Electronic Data Management). Only the amounts of waste with biodegradable lots were considered. Table 299 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 299: Considered types of waste (list of waste[149]).

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
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

[148] 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

[149] 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.

Methodology

Where available, country specific factors are used. If these were not available IPCC default values are taken. Table 300 summarises the parameters used and the corresponding references.

Table 300: Parameters for calculating landfill gas from SWDS.

Waste category/ Parameters	residual waste	wood	paper	sludges	Sorting residues/ output MBT[150]/ bulky waste	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)[151]								
DOC (kt C/kt waste)	see Table 302	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)
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 recovery (R)	see Figure 58 (UMWELTBUNDESAMT 2004b, 2008, 2014b, 2019b)								
Process start (M)	13 Delay time of 6 months, with an average residence time of 6 months (IPCC default)								

[150] MBT: **M**echanical-**b**iological **t**reatment

[151] 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).

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 300. 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.

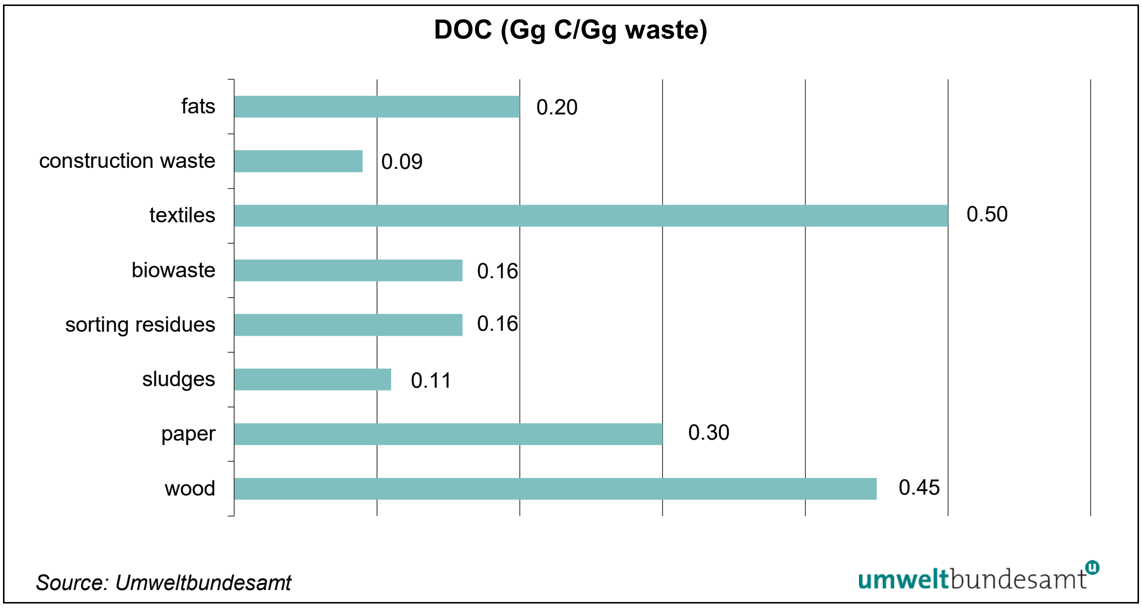

Figure 56: DOC of non-residual waste fractions.

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 updated information on the composition of residual waste published in the Annual update (2009) of the Federal Waste Management Plan 2006 (BMLFUW 2006a), 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.

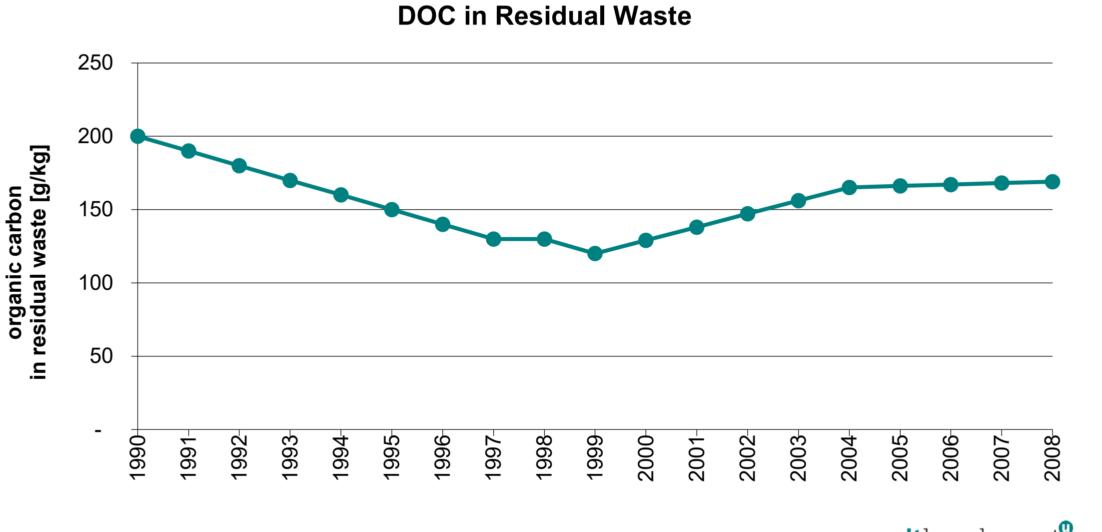

Figure 57: Development of DOC in residual waste.

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 301 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 302). For the years before 1990, the same DOC as in 1990 was used.

Table 301: 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
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 2006a)*

[3)] *Annual update (2009) of the Federal Waste Management Plan (BMLFUW 2006a)*

Table 302: Time series of bio-degradable organic carbon content (DOC) of residual waste (mixed MSW, directly deposited)

Year	kt C/kt Residual Waste	Year	kt C/kt Residual Waste
1950–1959	0.20 [1)]	1998	0.13 [2)]
1960–1969	0.20 [1)]	1999	0.12 [2)]
1970–1979	0.22 [1)]	2000	0.13 [*)]
1980–1989	0.21 [1)]	2001	0.14 [*)]
1990	0.20 [2)]	2002	0.15 [*)]
1991	0.19 [2)]	2003	0.16 [*)]
1992	0.18 [2)]	2004	0.17 [3)]
1993	0.17 [2)]	2005	0.17 [*)]
1994	0.16 [2)]	2006	0.17 [*)]
1995	0.15 [2)]	2007	0.17 [*)]
1996	0.14 [2)]	2008	0.17 [4)]
1997	0.13 [2)]	2009–2019	n.r.**)

1) assumed to be equal to the DOC of 1990

2) (UMWELTBUNDESAMT 2003b)

3) calculated according to waste composition 2001 (BMLFUW 2006a)

4) calculated according to waste composition 2009 (Status Report to BMLFUW 2006a)

**) interpolated values (2000–2003) and (2005–2007)*

***) no deposition of residual waste any more*

Decomposable DOC fraction (DOCf)

The DOCf values used for calculation are shown in Table 300.

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 2005). 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", the predominant waste stream in Austria (86% in 1990, 73% in 2005 and 50% in 2019 of the total emission), a calculation of the DOCf (0.6) was performed based on waste analyses carried out in Austria in 2004[152] (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) were used instead of the default value given of 0.5. The relatively high DOCf for Austria is mainly due to the high share of

152 the analysis of 2004 is used as since 2004 a ban of landfilling of untreated residual waste came into force (with exemptions until 2008)

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 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 "biowaste" in Austria also includes branches, thus a slightly lower DOCf is appropriate.
- The waste category ""sorting residues" does not only include wood, but also compost like output from MBTs. Therefore a higher DOCf is justified.
- The decomposition of "paper", even of newsprints, is higher than of "wood" - again a higher DOCf is 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 and 2018 further surveys were conducted (UMWELTBUNDESAMT 2008, UMWELTBUNDESAMT 2014b, UMWELTBUNDESAMT 2019b) to get new 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 (2008, 2013 and 2018 so far). For the most current years not covered by a survey update, assumptions have to be made on the collected gas quantities. Until the 2020 submission a mean value of the annual decreases between 2008 and 2017 was used for the calculation (minus 0.12 percentage points compared to the previous year). In the 2021 submission, however, individual assumptions were made based on historical trends of data in the federal provinces of Austria, leading to more plausible results.

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
- the slightly decreasing methane concentration in recovered landfill gas – an effect that is due to the extensive capturing of landfill gas which can lead to the dilution of the landfill gas captured.

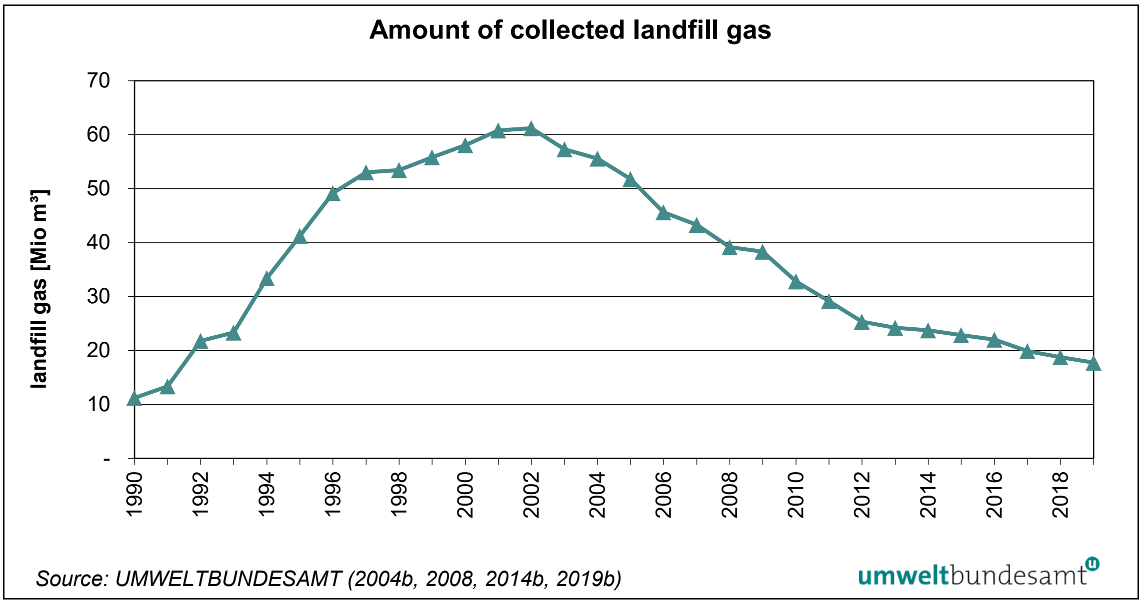

Figure 58: Amount of collected landfill gas 1990 to 2019.

Compared to 2002 (maximum amount of landfill gas captured), landfill gas collected decreased by 71% by 2019.

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).[153]

Table 303: 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

The landfill gas calculation model was revised in response to an issue raised during the comprehensive 2020 ESD review of the greenhouse gas inventory (EEA 2020). The fraction of CH_4 in the landfill gas formed (factor "F") was adjusted for 2009 and subsequent years to avoid a potential overestimation of emissions. The CS Factor "F" applied so far for the whole time series (0.55) was questioned, because – from the TERT's point of view – it was based on measured CH_4 in gas emitted from the solid waste disposal sites rather than related to the amount of landfill gas formed. The following approach was finally accepted by the TERT:

- From 2018 on, a factor "F" of 0.50 is applied, taken from the 2006 IPCC GL;
- For 2008 and the historical years before, the country-specific value (0.55) was retained as a higher methane concentration can be assumed in any case due to the landfilling of untreated waste until 2004 or, with exceptions, until 2008 (before the Landfill Ordinance came into force);
- For the years between 2008 and 2018 a linear reduction was assumed for factor "F"

[153] according to UMWELTBUNDESAMT (2001b)

In addition, the method for extrapolating the amount of collected landfill gas was improved by taking the data from Austria's federal provinces into consideration.

Both improvements together led to reduced landfill gas amounts and subsequent downward revisions of NMVOC (–0.45 t in 2018), NH_3 (–0.01 t in 2018), CO (–34 t in 2018) as well as heavy metal (Cd and Pb: –0.004 kg, Hg: –0.00003 kg) emissions.

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[154]. 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 304: 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
2001	43 911	352 403	4 380 050	54 386
2002	147 484	407 571	5 505 821	32 987
2003	172 444	480 221	6 515 947	24 665
2004	96 182	585 360	8 690 991	14 475
2005	156 764	685 349	9 643 097	16 555
2006	159 642	914 500	9 234 534	21 805
2007	150 822	860 544	10 957 137	14 465
2008	163 684	716 616	9 049 317	3 486

[154] Electronic Data Management

Year	residues from iron and steel production (slags, dusts)	clinker, dust and ashes	mineral waste	construction waste
	[t]	[t]	[t]	[t]
2009	85 798	668 522	8 663 035	350
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
2019	78 257	754 668	31 951 641	7
1998–2019	**19%**	**149%**	**704%**	**-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 305: 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

Recalculations are reported for particulate matter emissions from waste disposal (+12.9 t TSP, +6.1 t PM_{10}, +1.9 t $PM_{2.5}$ in 2018) due to a correction of a transcription error.

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 is 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 or in home composting plants have increased strongly between 1990 and 2005 (+273%). Between 2005 and 2019 the increase is moderate (+ 23%). 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.

NH_3 emissions from composting and from mechanical biological treatment only amount to 1 275 t in 2019.

NH_3 emissions from the anaerobic digestion (manure and energy crops) have been considered, and reported under category 5.B.2. For further information on the methodology used please refer to sector 3 Agriculture, chapter 5.3.4.

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 overestimation 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 306.

Since 2008, the 'Electronic Data Management' (EDM) is the primary data basis[155], providing data for the 'Federal Waste Management Plan' 'BAWP' (BMLFUW 2011, BMNT 2017), which is (in part) updated annually ('Status Reports' 2012, 2013, 2014, 2015, 2018, 2020). 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.

Home composted amounts are calculated based on a per-capita value of 215 kg/person/a, whereas for Vienna only 15% of the population is considered due to the lower number of gardens in this urban area. This approach is in line with the method applied for the BAWP (BMNT 2017).

Mechanical-biologically treated waste for most recent years is 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.

155 In subcategory *5.A Solid Waste Disposal* waste amounts have been taken from EDM reports already since 2008.

Table 306: Activity data for NFR Category 5.B Composting.

	Total waste	Mechanical-Biological Treatment (MBT)		Composting				Anaerobic treatment	
				Composting plants		Home composting			
	[kt]	[kt]	Data source	[kt]	Data source	[kt]	Data source	[kt]	Data source
1990	763	345	BAUMELER et al 1998	48	sum of data reported by the Austrian Federal Provinces, (AMLINGER 2003)	370	AMLINGER 2003	0	Activity not occurring
1991	798	345		78		375		0	
1992	942	345		137		460		0	
1993	1 161	345		306		510		0	
1994	1 373	345		444		585		0	
1995	1 446	295	ANGERER 1997	551		600		0	
1996	1 515	281	interpolated	617		616		0	
1997	1 488	244	UMWELTBUNDESAMT 1998b	582		663		0	
1998	1 541	240	UMWELTBUNDESAMT 2000c	604		696		0	
1999	1 621	266	UMWELTBUNDESAMT 2001d	623		732		0	
2000	1 721	254	Interpolated	695	interpolated	772	AMLINGER et al 2005	0	
2001	1 953	242		767		944	interpolated	0	
2002	2 186	230		834		1 117		5	intrapolated based on EJ by Umweltbundesamt (2015)
2003	2 418	218	UMWELTBUNDESAMT 2008a	871		1 290		39	
2004	2 932	488		899		1 462	calculated based on BMLFUW 2008a	83	
2005	3 150	623		903		1 472		152	
2006	3 266	660		874		1 480		252	
2007	3 367	684		884		1 485	BMLFUW 2008a	314	
2008	3 387	619	interpolated	919		1 498	BMLFUW 2011	350	
2009	3 401	555	EDM	977		1 505		364	
2010	3 452	551		1 035		1 488	calculated on basis of BMLFUW 2011	378	
2011	3 495	519		1 118	EDM + EJ UMWELTBUNDESAMT (2015)	1 491		367	EDM
2012	3 573	453		1 239		1 496		385	
2013	3 416	379		1 168		1 502		367	
2014	3 538	413		1 215		1 511		399	
2015	3 596	439		1 194		1 524		438	
2016	3 728	442		1 300		1 540		447	
2017	3 708	414		1 303		1 548		443	
2018	3 747	412		1 294		1 554		486	
2019	3 868	430		1 345		1 561		532	

Activity data on agricultural feedstock treated in anaerobic plants is provided within NFR sector 3 Agriculture (please refer to Table 277).

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 307: 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 et al. 2003, 2005) (ANGERER & FRÖHLICH 2002) (DOEDENS et al. 1999)
Composted waste (bio-waste, gardening waste, home composting)	0.4	(AMLINGER et al. 2003, 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 2019 (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 emissions reported in *5.B.2 Anaerobic digestion at biogas facilities* (+ 17 t in 2018) are due to new information on input materials for Austria's biogas plants (E-CONTROL 2020[156]). See also Chapter 5.3.4 on recalculations in the agriculture sector.

For *5.B.1 Composting* no recalculations were conducted.

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

[156] E-CONTROL (2020): https://www.e-control.at/documents/1785851/1811582/E-Control-Oekostrombericht_2020.pdf/053b8bbf-402e-c568-cb07-7315a6573c32?t=1600782405474 accessed in November 2020.

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 categories 3.F. 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%[157] in 1990 (about 10 k of incinerations) to 24% in 2004 and to 35% in 2011. The percentage 2012–2019 has been linearly extrapolated to 47% in 2019 (about 39k cremations), following a general trend in Austria which has been reported by market dominating funeral companies of larger cities.

Table 308: 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
2010–2019	NO	NO	NO	500	500

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 309 shows emission factors of main pollutants.

[157] Estimate from (HÜBNER 2001b)

Table 309: 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 310: 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 311: 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

<table>
<tr><th>Clinical waste</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>1994</td><td>1.64</td><td>1.98</td><td>186.00</td><td>0.00</td><td>0.00</td><td>0.19</td></tr>
<tr><td>1995–2005</td><td>0.62</td><td>0.71</td><td>7.75</td><td>0.00</td><td>0.00</td><td>0.19</td></tr>
<tr><td>2006</td><td>0.50</td><td>0.58</td><td>6.25</td><td>0.00</td><td>0.00</td><td>0.16</td></tr>
<tr><td>2007</td><td>0.40</td><td>0.46</td><td>5.00</td><td>0.00</td><td>0.00</td><td>0.12</td></tr>
<tr><td>2008</td><td>0.30</td><td>0.35</td><td>3.75</td><td>0.00</td><td>0.00</td><td>0.09</td></tr>
<tr><td>2009</td><td>0.20</td><td>0.23</td><td>2.50</td><td>0.00</td><td>0.00</td><td>0.06</td></tr>
<tr><td>2010–2019</td><td>0.10</td><td>0.12</td><td>1.25</td><td>0.00</td><td>0.00</td><td>0.03</td></tr>
<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>1995–2019</td><td>13.0</td><td>60.0</td></tr>
</table>

Table 312: 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)					
		1 000(7)					

0(1)for all years
(2) for 1990–1992
(3) for 1993–2019
(4) for 1990
(5) for 1991
(6) for 1992–1995
(7) for 2000–2019
(8) EMEP/EEA Guidebook 2019

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)

6.5.3 Category-specific Recalculations

No recalculations have been carried out for the submission 2021.

6.6 NFR 5.D Wastewater handling

6.6.1 Source Category Description

In this category NMVOC emissions from domestic wastewater handling (*5.D.1*) are included, covering wastewater of domestic origin – treated in municipal wastewater treatment plants, domestic wastewater treatment plants and cesspools – as well as commercial and industrial wastewater treated together with domestic wastewater in municipal wastewater 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 (m3)

EF emission factor

Activity data

The activity data used to calculate NMVOC emissions consider only the waste water volumes treated in **municipal wastewater treatment plants**, and exclude wastewater treated in individual septic systems (as recommended by the ERT in 2017). Therefore the domestic wastewater volumes are deducted from the total municipal waste water volumes.

Waste water volumes treated in **municipal wastewater treatment** plants are collected in the Electronic Emission Register of Surface Water Bodies ("Emissionsregister – Oberflächenwasserkörper", abbreviated "EMREG-OW"[158]), an electronic register of material emissions to surface water bodies from point sources, especially municipal sewage treatment plants. It is administered by the Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK)[159] 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 for the years 2010 to 2018 are retrieved from this emission register and used in the inventory. For 2009 interpolation was carried out.

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 1993–2002); data in between were interpolated.

Data on volumes of wastewater collected in **domestic wastewater treatment** plants and cesspools are calculated based on the Austrian population not connected to municipal wastewater treatment plants and the factor 135 litre per population equivalent per day (ÖWAV 2015). Data on wastewater disposal routes and connection rates were taken from the situation reports on municipal wastewater (BMLFUW 2006b, BMLFUW 2008b, BMLFUW 2010, BMLFUW 2012, BMLFUW

[158] 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)

[159] (the former Federal Ministry of Sustainability and Tourism (BMNT) respectively former Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)

2014a, BMLFUW 2016, BMNT 2018b, BMLRT 2020a) The connection rate of 2019 was extrapolated based on the population number.

Concerning the latrine use, Austria has ensured that all households have proper wastewater treatment, either smaller wastewater treatment plants, individual sewage treatment or septic tanks (BMLFUW 2016). Latrines are therefore not used in Austria, and if, it is to a negligible extent.

Table 313: Activity data for 5.D Wastewater handling.

Year	Total waste water volumes [m³]	Domestic wastewater treatment [m³]	Wastewater treated in municipal WWTP [m³]
1990	811 786 584	172 213 666	639 572 918
1991	819 806 717	169 699 210	650 107 507
1992	827 826 850	157 100 332	670 726 519
1993	835 846 983	143 804 467	692 042 516
1994	843 867 116	129 706 029	714 161 087
1995	851 887 250	115 229 335	736 657 915
1996	927 538 166	104 644 768	822 893 398
1997	1 003 189 083	94 011 010	909 178 073
1998	1 078 840 000	83 350 000	995 490 000
1999	1 075 226 667	79 566 667	995 660 000
2000	1 071 613 333	75 783 333	995 830 000
2001	1 068 000 000	72 000 000	996 000 000
2002	1 064 500 000	64 388 229	1 000 111 771
2003	1 061 000 000	56 776 457	1 004 223 543
2004	1 070 201 502	49 164 686	1 021 036 816
2005	1 079 403 004	41 552 914	1 037 850 090
2006	1 088 604 506	33 941 143	1 054 663 363
2007	1 110 000 339	34 021 586	1 075 978 754
2008	1 091 435 720	30 054 497	1 061 381 223
2009	1 114 220 585	27 735 147	1 086 485 437
2010	1 137 005 449	25 415 798	1 111 589 652
2011	1 020 826 719	24 160 697	996 666 022
2012	1 081 559 943	22 905 597	1 058 654 346
2013	1 187 433 343	22 091 808	1 165 341 536
2014	1 131 070 586	21 278 018	1 109 792 568
2015	1 060 093 444	20 974 704	1 039 118 740
2016	1 135 233 391	20 671 389	1 114 562 002
2017	1 090 421 705	19 186 011	1 071 235 694
2018	1 065 971 869	17 655 085	1 048 316 784
2019	1 106 750 620	17 655 085	1 089 095 536

In the year 2018[160] 95.9% of the Austrian population is connected to municipal wastewater treatment plants. The remaining wastewater is treated either in septic tanks (2.5%), domestic wastewater handling systems (1.4%), or disposed otherwise ('unspecified disposal routes': 0.2%).

6.6.3 Category-specific Recalculations

Recalculations were necessary for NMVOC from *5.D.1 domestic wastewater* (– 0.03 t in 2018), as new data on wastewater volumes as well as on the level of connection to the sewer system were available for 2018, also affecting the emission data for 2017 (due to interpolation).

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 unwanted fires in cars and various types of houses (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

The activity data for **car fires** are from a national fire statistic and include car and truck fires for the years 1996 until 2011, as well as 2015, 2016, 2017 (ÖBFV 2017), 2018 (ÖBFV 2019) and 2019 (ÖBFV 2020). For missing years, 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. From 1990 to 2005, the number of industrial building fires was derived as the mean values of fires during the years 2005 until 2015. The number of civil fires during 1990-2005 was extrapolated based on the mean value of fires during 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

[160] the latest year for which data on connection rate is currently available

2010 and 2015. Of the categories used in the EMEP/EEA Guidebook 2016, values are available for detached, apartments and industrial buildings; undetached houses are included in the detached 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 the years 2005 to 2018 data on national fire statistics are available for civil and industrial buildings (BV 2015, BV 2018). For 2019 the data of 2018 had to be used as no new statistics was available at the time of inventory compilation. 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 314: 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
1991	1 602	1 373	944	694
1992	1 620	1 373	955	702
1993	1 633	1 373	963	708
1994	1 639	1 373	966	710
1995	1 642	1 373	968	711
1996	1 437	1 373	969	712
1997	1 379	1 373	970	713
1998	1 510	1 373	971	714
1999	1 584	1 373	973	715
2000	1 682	1 373	976	717
2001	1 619	1 373	979	720
2002	1 900	1 373	984	723
2003	1 868	1 373	989	727
2004	1 844	1 373	995	731
2005	1 759	1 161	839	617
2006	1 753	1 193	820	603
2007	1 869	1 401	1 072	788
2008	1 552	1 327	1 050	772
2009	1 485	1 401	1 028	756
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	1 186	943	693

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 315: 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

No recalculations were made for this years' submission.

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 2018 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[161]. The last In-depth (Stage 3) review of the Austrian Inventory took place in 2017 (UNITED NATIONS 2017); the findings are summarised in Table 330. The next Stage 3 review is currently not scheduled, but is expected to be within the next five years.

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 2020 for Austria are summarised and commented in Table 331.

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 2019 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 332.

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 7.4.

[161] http://www.ceip.at/ms/ceip_home1/ceip_home/review_process/stage3_review_ae/

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-1.A.2.g and 1.A.4.a-1.A.4.c

7.3.1.1 Revision of the energy balance

The Austrian Federal statistics office ("Statistik Austria") has revised the energy balance for the years 1990 to 2018 with the following main implications for energy consumption as shown in the inventory:

- Natural gas gross inland consumption has been revised for 1999–2004 (between – 0.3 and 1.3 PJ), 2014–2016 (between 1 and 5.2 PJ) and 2018 (– 1.3 PJ). In addition, natural gas consumption has been shifted from 'energy sector use' to 'final energy consumption' for the years 1994–1996 (between 0.1 to 1.3 PJ) and 1999–2018 (up to 2.6 PJ in 2018). Final energy consumption has also been shifted to different sectors.

For liquid fuels, gross inland consumption has been revised for the year 2018 for motor gasoline only (by – 0.2 PJ).

In the inventory, considerable amounts of LPG fuel consumed in the period 1990–2018 have been removed from category 1.A.1.a and included in 'oil refinery' instead (use of energy sector).

- For solid fuels, gross inland consumption has been revised for the years 2017 (+ 0.2 PJ) and 2018 (+ 0.7 PJ), mainly because of an increased amount of hard coal having been moved to category 1.A.2 manufacturing industries.
- For solid biomass fuels, gross inland consumption has been revised for 2005–2018 (between – 1.7 and + 1.6 PJ). The main revisions for 2018 affect category 1.A.1.a (+ 1.1PJ from wood waste), category 1.A.2 (– 1.4 PJ from wood waste) and 1A4b (– 2.6 PJ from wood waste, + 3.6 PJ from wood pellets).

7.3.1.2 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 (emissions factors and data sources) remain unchanged. For 1.A.1.a, double counting of emissions from LPG has been corrected for the whole time series, mainly affecting NO_X emissions. Changes to NO_X and $PM_{2.5}$ emissions 2018 are mainly due to a revision of biomass consumption data. Changes to SO_2 emissions are mainly due to a revision of residual fuel oil as well as biomass consumption data.

7.3.1.3 Mobile Combustion in Manufacturing Industries and Construction (1.A.2.g.7)

Specific emission factors were applied for the Stage IIIB – V emission standards according to a new Off Road study[162].

7.3.1.4 Commercial/Institutional: stationary (1.A.4.a.1) and Residential: stationary (1.A.4.b.1)

The HCB biomass emission factors have been revised due to significant deviation between the results from national measurements (HÜBNER et al. 2002) and the recommended value according to EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019. For further information, see chapter 3.1.9.4.

7.3.1.5 Coal mining and handling (1.B.1.a)

Recalculations of TSP, PM_{10} and $PM_{2.5}$ emissions in the category *Coal Mining and Handling (1.B.1.a)* for the years 2014 and 2016-2018 are due to a revision of the energy balance by Statistik Austria. This revision leads to an increase of 0.002 kt TSP emissions, 0.001 kt PM_{10} emissions and 0.0004 kt $PM_{2.5}$ emissions in 2018.

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[162] Schwingshackl M., Rexeis M., Weller K. (2020): Update der Emissionsfaktoren und Aktivitätsdaten von NRMM für die Inventur (OLI2020). Erstellt im Auftrag der Umweltbundesamt GmbH. Bericht Nr. I-18/20/Schwings EM 20/05/679 vom 09.12.2020

7.3.2 TRANSPORT (1.A.3)

7.3.2.1 Road Transport (1.A.3.b)

7.3.2.2 Update of activity data

To update the energy data (LPG, biogas) in accordance with the energy balance, the mileage model for the vehicle categories had to be recalibrated. This has led to minor changes in the activity data and emissions for each vehicle category over the entire time series.

According to the bottom-up/top-down methodology applied for the calculation of domestic fuel consumption and fuel exports, an increased use of domestic fuels always results in a reduction of exported fuel quantities, and vice versa.

7.3.2.3 Domestic navigation (1.A.3.d)

Domestic fuel consumption data has been slightly updated on the basis of a new study on Austria's off-road emissions. A special focus was placed on shipping, especially passenger ships, which had not been sufficiently considered or analysed before because of poor data availability. The activity data was revised upwards, which has increased the emissions over the entire time series.
Specific emission factors for freight and passenger transport were applied according to the new Off Road study mentioned above.

7.3.2.4 Residential – mobile combustion (1.A.4.b.2)

The activity data was adjusted according to the new Off Road study mentioned above. The update for garden tools caused a noticeable change in fuel consumption (FC) over the whole time series, leading to revised emission estimates across the whole time series.
Specific emission factors were applied for the Stage IIIB – V emission standards according to a new Off Road study as mentioned above.

7.3.2.5 Agriculture: Off-road Vehicles and Other Machinery – mobile combustion (1.A.4.c.2)

Specific emission factors were applied for the Stage IIIB – V emission standards according to a new Off Road study as mentioned above.

7.3.3 INDUSTRIAL PROCESSES (2)

7.3.3.1 Quarrying and mining of minerals other than coal (2.A.5.a)

Recalculations for 2016 for NFR 2.A.5.a have been carried out on SNAP level as updated activity data had been provided for dolomite and limestone by the Austrian mining handbook. This has resulted in a change in the estimates of particular matter emissions since 2016 (+ 0.0001 kt $PM_{2.5}$ for 2018).

7.3.3.2 Construction and demolition (2.A.5.b)

Due to recalculations of the statistical data on building costs, the activity data had to be updated. This has resulted in a change in the estimates of particular matter emissions since 2001 (+ 0.003 kt $PM_{2.5}$ for 2018).

7.3.3.3 Iron and Steel Production (2.C.1)

The four individual PAHs are estimated for the first time in this year's submission.

7.3.3.4 Aluminium production (2.C.3)

Verified CO_2 emissions for the years 2016, 2017 and 2018 for secondary aluminium production became available from the ETS. As activity data was calculated based on the verified emissions and an CS EF this led to recalculations of Pb, Dioxine, HCB and particular matter emissions (+0.0002kt $PM_{2.5}$ for 2018).

For 1990-1993 data on the individual PAHs occurring in primary aluminium production were estimated for the first time in this year's submission.

7.3.3.5 Solvent Use (2.D.3)

Due to the Covid-19 pandemic and its economic impact, it was decided to base the planned update on bottom-up data for 2019 rather than 2020. All district authorities were contacted for solvent balances available from companies obliged to report under the IED Directive. The response rate achieved was estimated to be approximately 85 %, which was higher than in the last bottom-up survey for the year 2015. For the 2019 update of the model, the allocation of companies into different categories was re-evaluated. As a scale up approach (for sectors where not all companies are obliged to report) is used to cover economic sectors, the allocation was refined and is now also based on the economic rather than only on the technical activity of a company (e.g. a company producing printed cardboard is now allocated to cardboard production and not to the printing sector).

The resulting changes to the allocations were made consistently for 2015 and 2019. The improved allocations are also more consistent with the approach used for 2000. Data for the periods 2001-2015 and 2015-2019 were interpolated as before. This led to changes in the AD and emissions allocated to each NFR category and therefore also the EF/category for all years from 2001 onwards.

Due to these improvements in allocation and scaling up, the total AD from the bottom-up estimate for 2019, together with the AD for domestic solvent use based on statistical data, is equal to 96 % of the top-down total solvent consumption data derived from the statistics. For 2015, the gap - previously equal to 18 % - is now 13 %. In a final step, the “missing” 4 % of the AD were then added to those categories where no full survey had taken place. Emissions were calculated using the IEFs from the bottom-up survey.

It should be noted that there are no changes in the total AD (compared to the last submission) in any of the years. The changes in the emission estimates result from improved allocations of AD to the different categories, combined with higher/lower IEFs: e.g. for 2005 emissions are 1.5 % lower, and at the end of the time series the improved methodology has led to an increase in the emissions from solvent use (e.g. + 6.3 % for 2018).

7.3.3.6 Food and Beverages Industry (2.H.2)

In this year's submission an estimate of the PAH fractions BAP, BBF, BKF, IND in Sector 2.H.2 have been included.

7.3.3.7 Wood processing (2.I)

Due to recalculations of the energy balances, the activity data had to be updated. This has resulted in a change in the estimates of particular matter emissions since 2005 (– 0.002 kt $PM_{2.5}$ for 2018).

7.3.4 AGRICULTURE (3)

7.3.4.1 3.B Manure Management, 3.D Agricultural Soils

In 2020, new information on input materials for Austria's biogas plants became available (E-CONTROL 2020), resulting in slightly revised amounts of digested manure and energy crops for 2018.

7.3.4.2 Agricultural Soils (3.D) – NH_3

Inorganic N fertilizers (3.D.a.1)

Revised emissions from inorganic N fertilizers are due to the implementation of a new EF for N-stabilised fertilizers. Information became available about stabilised urea fertilizers being included in the fertilizer category "Other Straight N Compounds" in Austria. Thus, the EF of 0.013 kg NH_3/kg N applied in previous inventories was too low. As stabilised urea fertilizers are more efficient than urea fertilizers due to urease inhibitors, ammonia losses can be reduced by 70 % according to (UNECE 2015). Consequently, the urea EF of 0.158 kg NH_3/kg N has been adjusted by 70 %, resulting in an EF of 0.047 kg NH_3/kg N applied for "Other Straight N Compounds". This revision resulted in higher NH_3 emissions from synthetic fertilizer applications for the entire time series (+ 0.2 kt NH_3 in 2018).

7.3.4.3 Agricultural Soils (3.D) – NMVOC

Cultivated crops (3.D.e)

Due to adjustments of grassland and cropland areas in the LULUCF sector, NMVOC emissions for most of the years between 1991 and 2018 have been recalculated (– 0.02 kt NMVOC in 2018).

7.3.4.4 Agricultural Soils (3.D) – PM

On-farm storage, handling and transport of agricultural products (3.D.c)

Due to adjustments of grassland and cropland areas in the LULUCF sector, PM emissions for most of the years between 1991 and 2018 have been recalculated (– 0.001 kt $PM_{2.5}$ in 2018).

7.3.4.5 Field burning of agricultural residues (3.F) – NO_x, SO_2, NMVOC, PM, HM, PAH

The correction of a linkage error for 2017 and 2018 resulted in marginal downward revisions to NO_x, SO_2, NMVOC, NH_3 and PM emissions for both years.

Furthermore, Benzo(a)pyrene, Benzo(b)flouranthene, Benzo(k)flouranthene and Indeno(1,2,3-c,d)pyrene emissions have been reported for the first time separately in submission 2021. In previous years, PAH emissions have been reported only as total.

7.3.5 WASTE (5)

7.3.5.1 Waste disposal on land (5.A)

The landfill gas calculation model was revised in response to an issue raised during the comprehensive ESD review of the greenhouse gas inventory in 2020. More precisely, the fraction of CH_4 in landfill gas (factor "F") was adjusted for 2009 and subsequent years. In addition, the method for extrapolating the amount of collected landfill gas was improved. These improvements led to reduced landfill gas amounts and subsequent downward revisions of NMVOC (– 0.4 t in 2018) and NH_3 (– 0.01 t in 2018) emissions.

Recalculations are reported for particulate matter emissions (+12.9 t TSP, +6.1 t PM_{10}, +1.9 t $PM_{2.5}$ in 2018) due to a correction of a transcription error.

7.3.5.2 Biological treatment of waste (5.B)

Recalculations of NH_3 reported for *5.B.2 anaerobic digestion at biogas facilities* (+ 17 t in 2018) are due to new information available on input materials for Austria's biogas plants (E-CONTROL 2020). See also Chapter 5.3.8 on recalculations in the agriculture sector.

7.3.5.3 Wastewater treatment (5.D)

Recalculations were necessary for NMVOC from *5.D.1 domestic wastewater* (– 0.03 t in 2018), due to new data becoming available on wastewater volumes for 2018 and new data on the level of connection of the with sewer systems in 2018, which also affected emission data for 2017 (due to interpolation).

7.4 Recalculations per Pollutant

The following tables present the changes in emissions[163] for all relevant pollutants compared to the previous submission (IIR 2020). Detailed explanations are provided in the sectoral chapters.

Table 316: Recalculation difference of SO_2 emissions [kt] with respect to submission 2020.

		1990			2018			Absolute Diff.	
SO_2 emissions [kt]		**Δ%**	**Subm. 2020**	**Subm. 2021**	**Δ%**	**Subm. 2020**	**Subm. 2021**	**1990**	**2018**
1.A.1	Energy Industries	=	14.07	14.07	*2.0%*	1.62	1,65	-	0.03
1.A.2	Manufacturing Industries & Construction	*0.0%*	17.83	17.83	*-2.2%*	7.81	7,64	0.00	-0.17
1.A.3	Transport	*0.1%*	5.13	5.13	*-0.2%*	0.29	0,29	0.00	-0.00
1.A.4	Other Sectors	*0.0%*	32.66	32.66	*-0.7%*	1.42	1,41	0.00	-0.01
1.A.5	Other	=	0.01	0.01	=	0.02	0,02	-	-
1.B	Fugitive Emissions	=	2.00	2.00	=	0.02	0,02	-	-
2	Industrial Processes and Product Use	=	1.93	1.93	=	0.57	0,57	-	-
3	Agriculture	=	0.01	0.01	*-17.2%*	0.00	0,00	-	-0.00
5	Waste	=	0.07	0.07	=	0.01	0,01	-	-
	Total Emissions	***0.0%***	**73.70**	**73.70**	***-1.3%***	***11.77***	***11.62***	***0.01***	***-0.15***

163 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;

Table 317: Recalculation difference of NO_x emissions [kt] with respect to submission 2020.

		1990			2018			Absolute Diff.	
NO_x emissions [kt]		**∆%**	**Subm. 2020**	**Subm. 2021**	**∆%**	**Subm. 2020**	**Subm. 2021**	**1990**	**2018**
1.A.1	Energy Industries	*-0.2%*	17.82	17.78	*1.0%*	10.66	10.76	-0.04	0.10
1.A.2	Manufacturing Industries & Construction	*0.0%*	33.03	33.04	*-3.0%*	26.32	25.52	0.00	-0.80
1.A.3	Transport	*0.1%*	120.02	120.19	*1.5%*	83.80	85.08	0.17	1.28
1.A.4	Other Sectors	*0.0%*	29.85	29.85	*-0.3%*	18.82	18.77	0.00	-0.05
1.A.5	Other	=	0.07	0.07	=	0.08	0.08	-	-
1.B	Fugitive Emissions	=	IE	IE	=	IE	IE	-	-
2	Industrial Processes and Product Use	=	4.27	4.27	=	0.41	0.41	-	-
3	Agriculture	=	12.05	12.05	*0.2%*	10.75	10.77	-	0.02
5	Waste	=	0.10	0.10	=	0.02	0.02	-	-
	Total Emissions	***0.1%***	**217.22**	**217.35**	***0.4%***	**150.86**	**151.42**	**0.13**	**0.55**

Table 318: Recalculation difference of NMVOC emissions [kt] with respect to submission 2020.

		1990			2018			Absolute Diff.	
NMVOC emissions [kt]		**∆%**	**Subm. 2020**	**Subm. 2021**	**∆%**	**Subm. 2020**	**Subm. 2021**	**1990**	**2018**
1.A.1	Energy Industries	*-0.1%*	0.32	0.32	*2.1%*	0.31	0.32	-0.00	0.01
1.A.2	Manufacturing Industries & Construction	*0.0%*	1.68	1.68	*13.1%*	1.03	1.17	0.00	0.14
1.A.3	Transport	*0.1%*	97.78	97.88	*6.4%*	5.62	5.98	0.10	0.36
1.A.4	Other Sectors	*3.0%*	47.85	49.27	*-2.1%*	27.40	26.82	1.42	-0.58
1.A.5	Other	=	0.01	0.01	*-9.5%*	0.02	0.02	-	-0.00
1.B	Fugitive Emissions	=	15.49	15.49	=	2.17	2.17	-	-
2	Industrial Processes and Product Use	=	118.54	118.54	*5.7%*	33.63	35.54	-	1.91
3	Agriculture	=	52.19	52.19	*0.0%*	36.97	36.96	-	-0.01
5	Waste	=	0.16	0.16	*-0.9%*	0.06	0.06	-	-0.00
	Total Emissions	***0.5%***	**334.02**	**335.54**	***1.7%***	**107.22**	**109.03**	**1.52**	**1.81**

Table 319: Recalculation difference of NH_3 emissions [kt] with respect to submission 2020.

		1990			2018			Absolute Diff.	
NH_3 emissions [kt]		**∆%**	**Subm. 2020**	**Subm. 2021**	**∆%**	**Subm. 2020**	**Subm. 2021**	**1990**	**2018**
1.A.1	Energy Industries	*0.0%*	0.20	0.20	*0.8%*	0.43	0.43	0.0%	0.20
1.A.2	Manufacturing Industries & Construction	*0.0%*	0.33	0.33	*-2.6%*	0.41	0.39	0.0%	0.33
1.A.3	Transport	*-0.3%*	0.80	0.80	*0.4%*	1.12	1.12	-0.3%	0.80
1.A.4	Other Sectors	*0.0%*	0.63	0.63	*1.3%*	0.58	0.59	0.0%	0.63
1.A.5	Other	=	0.00	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	=	0.34
3	Agriculture	*0.2%*	59.06	59.18	*0.4%*	60.36	60.59	0.2%	59.06
5	Waste	=	0.37	0.37	*1.1%*	1.60	1.62	=	0.37
	Total Emissions	***0.2%***	**61.73**	**61.84**	***0.4%***	**64.63**	**64.88**	**0.11**	**0.25**

Table 320: Recalculation difference of CO emissions [kt] with respect to submission 2020.

		1990			2018			Absolute Diff.	
CO emissions [kt]		**Δ%**	**Subm. 2020**	**Subm. 2021**	**Δ%**	**Subm. 2020**	**Subm. 2021**	**1990**	**2018**
1.A.1	Energy Industries	*0.0%*	6.10	6.10	*1.9%*	4.27	4.35	0.0%	6.10
1.A.2	Manufacturing Industries & Construction	*0.0%*	231.22	231.22	*-0.2%*	147.59	147.36	0.0%	231.22
1.A.3	Transport	*-0.3%*	537.13	535.43	*1.1%*	68.77	69.50	-0.3%	537.13
1.A.4	Other Sectors	*1.5%*	426.00	432.19	*-2.5%*	251.64	245.25	1.5%	426.00
1.A.5	Other	=	0.22	0.22	=	0.30	0.30	=	0.22
1.B	Fugitive Emissions	=	IE	IE	=	IE	IE	=	IE
2	Industrial Processes and Product Use	=	37.19	37.19	=	14.22	14.22	=	37.19
3	Agriculture	=	1.23	1.23	*-12.3%*	0.35	0.31	=	1.23
5	Waste	=	10.31	10.31	*-1.1%*	2.96	2.93	=	10.31
	Total Emissions	***0.4%***	**1 249.41**	**1 253.89**	***-1.2%***	**490.09**	**484.21**	**4.48**	**-5.88**

Table 321: Recalculation difference of Cd emissions [t] with respect to submission 2020.

		1990			2018			Absolute Diff.	
Cd emissions [t]		**Δ%**	**Subm. 2020**	**Subm. 2021**	**Δ%**	**Subm. 2020**	**Subm. 2021**	**1990**	**2018**
1.A.1	Energy Industries	*0.2%*	0.33	0.33	*0.5%*	0.28	0.28	0.00	0.00
1.A.2	Manufacturing Industries & Construction	*0.0%*	0.31	0.31	*-1.4%*	0.25	0.24	-0.00	-0.00
1.A.3	Transport	*0.0%*	0.02	0.02	*0.0%*	0.03	0.03	-0.00	0.00
1.A.4	Other Sectors	*-0.1%*	0.40	0.40	*1.8%*	0.29	0.29	-0.00	0.01
1.A.5	Other	=	0.00	0.00	*0.0%*	0.00	0.00	-	-0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	-	-
2	Industrial Processes and Product Use	=	0.63	0.63	=	0.29	0.29	-	-
3	Agriculture	=	0.01	0.01	*-28.1%*	0.00	0.00	-	-0.00
5	Waste	=	0.06	0.06	*-0.2%*	0.00	0.00	-	-0.00
	Total Emissions	***0.0%***	**1.75**	**1.76**	***0.3%***	**1.13**	**1.14**	**0.00**	**0.00**

Table 322: Recalculation difference of Hg emissions [t] with respect to submission 2020.

		1990			2018			Absolute Diff.	
Hg emissions [t]		**Δ%**	**Subm. 2020**	**Subm. 2021**	**Δ%**	**Subm. 2020**	**Subm. 2021**	**1990**	**2018**
1.A.1	Energy Industries	*-0.2%*	0.35	0.35	*0.8%*	0.16	0.16	-0.00	0.00
1.A.2	Manufacturing Industries & Construction	*0.0%*	0.79	0.79	*-0.6%*	0.29	0.29	-0.00	-0.00
1.A.3	Transport	*0.0%*	0.00	0.00	*0.0%*	0.00	0.00	-0.00	0.00
1.A.4	Other Sectors	*0.0%*	0.43	0.43	*1.5%*	0.16	0.17	0.00	0.00
1.A.5	Other	=	0.00	0.00	*0.0%*	0.00	0.00	-	-0.00
1.B	Fugitive Emissions	=	NA	NA	=	0.00	0.00	-	-
2	Industrial Processes and Product Use	=	0.53	0.53	=	0.30	0.30	-	-
3	Agriculture	=	0.00	0.00	*-22.8%*	0.00	0.00	-	-0.00
5	Waste	=	0.05	0.05	*0.0%*	0.04	0.04	-	-0.00
	Total Emissions	***0.0%***	**2.17**	**2.16**	***0.2%***	**0.96**	**0.96**	**-0.00**	**0.00**

Table 323: Recalculation difference of Pb emissions [t] with respect to submission 2020.

Pb emissions [t]		1990			2018			Absolute Diff.	
		Δ%	Subm. 2020	Subm. 2021	Δ%	Subm. 2020	Subm. 2021	1990	2018
1.A.1	Energy Industries	*-1.1%*	1.47	1.45	*1.4%*	2.38	2.41	-0.02	0.03
1.A.2	Manufacturing Industries & Construction	*0.0%*	5.59	5.59	*-1.4%*	2.25	2.21	-0.00	-0.03
1.A.3	Transport	*-0.3%*	179.54	178.94	*0.0%*	4.81	4.81	-0.60	0.00
1.A.4	Other Sectors	*10.0%*	7.38	8.12	*1.7%*	2.04	2.08	0.74	0.04
1.A.5	Other	=	0.00	0.00	*0.0%*	0.00	0.00	-	-0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	-	-
2	Industrial Processes and Product Use	=	37.41	37.41	*-0.1%*	7.78	7.77	-	-0.01
3	Agriculture	=	0.00	0.00	*-2.0%*	0.00	0.00	-	-0.00
5	Waste	=	1.02	1.02	*-0.2%*	0.00	0.00	-	-0.00
	Total Emissions	***0.1%***	**232.41**	**232.54**	***0.2%***	**19.26**	**19.29**	**0.12**	**0.03**

Table 324: Recalculation difference of PAH emissions [t] with respect to submission 2020.

PAH emissions [t]		1990			2018			Absolute Diff.	
		Δ%	Subm. 2020	Subm. 2021	Δ%	Subm. 2020	Subm. 2021	1990	2018
1.A.1	Energy Industries	*-2.5%*	0.01	0.01	*2.1%*	0.03	0.03	-0.00	0.00
1.A.2	Manufacturing Industries & Construction	*0.0%*	0.06	0.06	*-2.2%*	0.22	0.21	-0.00	-0.00
1.A.3	Transport	*0.1%*	0.29	0.29	*2.0%*	0.34	0.35	0.00	0.01
1.A.4	Other Sectors	*0.9%*	11.45	11.55	*-6.3%*	5.96	5.59	0.10	-0.37
1.A.5	Other	=	0.00	0.00	*-0.1%*	0.00	0.00	-	-0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	-	-
2	Industrial Processes and Product Use	=	7.14	7.14	=	0.21	0.21	-	-
3	Agriculture	=	0.08	0.08	*-3.8%*	0.04	0.04	-	-0.00
5	Waste	=	0.00	0.00	=	0.00	0.00	-	-
	Total Emissions	***0.5%***	**19.03**	**19.13**	***-5.5%***	**6.80**	**6.42**	**0.10**	**-0.37**

Table 325: Recalculation difference of Dioxin/Furan (PCDD/F) emissions [g] with respect to submission 2020.

Dioxin/Furan emissions [g]		1990			2018			Absolute Diff.	
		Δ%	Subm. 2020	Subm. 2021	Δ%	Subm. 2020	Subm. 2021	1990	2018
1.A.1	Energy Industries	*0.0%*	12.14	12.14	*3.1%*	1.34	1.38	-0.00	0.04
1.A.2	Manufacturing Industries & Construction	*0.0%*	1.68	1.68	*-3.4%*	3.62	3.50	0.00	-0.12
1.A.3	Transport	*-0.3%*	4.16	4.15	*1.7%*	1.57	1.60	-0.01	0.03
1.A.4	Other Sectors	*0.2%*	43.87	43.95	*-3.1%*	19.05	18.47	0.09	-0.59
1.A.5	Other	=	0.00	0.00	*1.4%*	0.00	0.00	-	0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	-	-
2	Industrial Processes and Product Use	=	42.85	42.85	*-3.4%*	6.40	6.18	-	-0.22
3	Agriculture	=	0.18	0.18	=	0.05	0.05	-	-
5	Waste	=	20.29	20.29	=	2.37	2.37	-	-
	Total Emissions	***0.1%***	**125.17**	**125.24**	***-2.5%***	**34.41**	**33.55**	**0.07**	**-0.86**

Table 326: Recalculation difference of HCB emissions [kg] with respect to submission 2020.

HCB emissions [kg]		1990			2018			Absolute Diff.	
		Δ%	Subm. 2020	Subm. 2021	Δ%	Subm. 2020	Subm. 2021	1990	2018
1.A.1	Energy Industries	*0.0%*	0.28	0.28	*1.7%*	0.49	0.50	-0.00	0.01
1.A.2	Manufacturing Industries & Construction	*0.0%*	0.29	0.29	*-3.3%*	0.60	0.58	0.00	-0.02
1.A.3	Transport	*-0.3%*	0.83	0.83	*1.9%*	0.31	0.32	-0.00	0.01
1.A.4	Other Sectors	*-4.8%*	53.49	50.94	*-71.5%*	27.29	7.78	-2.55	-19.51
1.A.5	Other	=	0.00	0.00	*1.4%*	0.00	0.00	-	0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	-	-
2	Industrial Processes and Product Use	=	20.07	20.07	*-2.0%*	5.36	5.25	-	-0.11
3	Agriculture	=	10.15	10.15	=	1.52	1.52	-	-
5	Waste	=	0.39	0.39	=	0.06	0.06	-	-
	Total Emissions	***-3.0%***	**85.50**	**82.95**	***-55.1%***	**35.63**	**16.00**	**-2.56**	**-19.62**

Table 327: Recalculation difference of TSP emissions [kt] with respect to submission 2020.

TSP emissions [kt]		1990			2018			Absolute Diff.	
		Δ%	Subm. 2020	Subm. 2021	Δ%	Subm. 2020	Subm. 2021	1990	2018
1.A.1	Energy Industries	*0.0%*	1.06	1.06	*2.8%*	1.23	1.27	-0.00	0.03
1.A.2	Manufacturing Industries & Construction	*0.0%*	2.37	2.37	*-3.0%*	1.00	0.97	0.00	-0.03
1.A.3	Transport	*-0.8%*	9.15	9.07	*0.5%*	6.74	6.78	-0.07	0.04
1.A.4	Other Sectors	*-0.1%*	15.16	15.15	*-1.1%*	8.06	7.98	-0.01	-0.09
1.A.5	Other	=	0.02	0.02	=	0.02	0.02	-	-
1.B	Fugitive Emissions	=	0.85	0.85	*0.6%*	0.37	0.38	-	0.00
2	Industrial Processes and Product Use	=	19.31	19.31	*0.5%*	15.66	15.74	-	0.08
3	Agriculture	=	4.95	4.95	*-0.8%*	4.54	4.50	-	-0.04
5	Waste	=	0.35	0.35	*1.9%*	0.69	0.71	-	0.01
	Total Emissions	***-0.2%***	**53.21**	**53.12**	***0.0%***	**38.32**	**38.33**	**-0.09**	**0.01**

Table 328: Recalculation difference of PM_{10} emissions [kt] with respect to submission 2020.

PM_{10} emissions [kt]		1990			2018			Absolute Diff.	
		Δ%	Subm. 2020	Subm. 2021	Δ%	Subm. 2020	Subm. 2021	1990	2018
1.A.1	Energy Industries	*0.0%*	1.00	1.00	*2.7%*	1.12	1.15	-0.00	0.03
1.A.2	Manufacturing Industries & Construction	*0.0%*	2.18	2.18	*-3.1%*	0.92	0.89	0.00	-0.03
1.A.3	Transport	*-1.0%*	7.41	7.33	*0.8%*	4.42	4.45	-0.07	0.04
1.A.4	Other Sectors	*-0.1%*	14.21	14.20	*-1.0%*	7.56	7.48	-0.02	-0.08
1.A.5	Other	=	0.02	0.02	=	0.02	0.02	-	-
1.B	Fugitive Emissions	=	0.40	0.40	*0.6%*	0.18	0.18	-	0.00
2	Industrial Processes and Product Use	=	11.16	11.16	*0.5%*	7.86	7.90	-	0.04
3	Agriculture	=	4.24	4.24	*-1.0%*	3.90	3.86	-	-0.04
5	Waste	=	0.28	0.28	*1.4%*	0.44	0.44	-	0.01
	Total Emissions	***-0.2%***	**40.90**	**40.81**	***-0.1%***	**26.40**	**26.37**	**-0.09**	**-0.03**

Table 329: Recalculation difference of $PM_{2.5}$ emissions [kt] with respect to submission 2020.

$PM_{2.5}$ emissions [kt]		1990			2018			Absolute Diff.	
		Δ%	Subm. 2020	Subm. 2021	Δ%	Subm. 2020	Subm. 2021	1990	2018
1.A.1	Energy Industries	*0.0%*	0.85	0.85	*2.8%*	0.95	0.98	-0.00	0.03
1.A.2	Manufacturing Industries & Construction	*0.0%*	1.90	1.90	*-3.2%*	0.78	0.76	0.00	-0.02
1.A.3	Transport	*-1.2%*	6.48	6.40	*1.2%*	3.01	3.05	-0.07	0.04
1.A.4	Other Sectors	*-0.2%*	13.41	13.39	*-1.0%*	7.17	7.10	-0.02	-0.07
1.A.5	Other	=	0.02	0.02	=	0.02	0.02	-	-
1.B	Fugitive Emissions	=	0.11	0.11	*0.6%*	0.06	0.06	-	0.00
2	Industrial Processes and Product Use	=	3.82	3.82	*0.3%*	1.72	1.73	-	0.01
3	Agriculture	=	0.36	0.36	*-1.7%*	0.27	0.27	-	-0.00
5	Waste	=	0.23	0.23	*0.7%*	0.28	0.28	-	0.00
	Total Emissions	***-0.3%***	**27.17**	**27.07**	***-0.2%***	**14.26**	**14.23**	**-0.10**	**-0.03**

7.5 Planned improvements, including in response to the review process, and planned improvements to the inventory

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) are summarized in Table 330. The improvements made in response to the review process under the NEC Directive 2020 are indicated in Table 331.

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 2014 CLRTAP Reporting Guidelines and 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 Monitoring Mechanism, 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 330: 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.	-
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

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
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 in table 65.	Chapter 3.1.3.1
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

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
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
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	-

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
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			
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 214 and Table 215) in the current IIR) were corrected and completed to ensure consistency with the NFR tables.	Chapters 3.3.3, 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 plans to include information on the comparison of the applied country-specific EF with the GB factors for next submission.	-

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 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 4.1.4
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 4.2.1
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	Austria plans to include information on the comparison of the applied country-specific EF with the GB factors for next submission. The notation key of source category *2.A.5.c* was changed to IE (since submission 2018).	NFR tables; Chapter 4.2.1

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
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	Austria plans to include information on the comparison of the applied country-specific EF with the GB factors for next submission.This improvement is planned for the next submission. Currently, data on different types of buildings are not being fully investigated.	Chapter 4.2.2
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 4.3.2
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 4.4.1
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 4.4.2
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 4.4.2

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
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 4.1.4, 4.5.2
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 are as well as information on per capita EFs per SNAP are included in the respective chapter.	Chapters 4.1.4, 4.5.2
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 4.5.2

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
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 4.5.4
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
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)

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
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 331: Improvements made in response to the NEC Review in 2020.

Finding NEC Review 2020	Reference	Improvement made	Chapter
National Total			
0A National Total - National Total for the Entire Territory - Based on Fuel Sold/Fuel Used, BaP, PAHs, 1990-2018: The TERT recommends that Austria reports benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene emissions for all sectors in the 2021 submission.	AT-0A-2020-0001	The required emissions are included in submission 2021 and the methodologies applied are described in the relevant sectoral chapters.	NFR Tables, chapters 3-6
LPS data			
General, 2015: The TERT notes that in 2015, the same pair of longitude and latitude coordinates were assigned to more than one differently named LPS in 1 case(s). The correct reporting format requires LPS named differently to have unique longitude and latitude coordinates. As such two LPS named differently cannot have the same longitude and latitude. In its response to the review question, Austria indicated that in this case two power stations are located at the same site, although they have different owners/operators and therefore different national E-PRTR IDs (20000.00126 and 20000.00133). The TERT recommends that Austria ensures that it provides unique longitude and latitude coordinates for each LPS in its future submissions.	AT-LPS-GEN-2020-0005	It is not possible for Austria's inventory team to change the master data (locations) officially reported by operators as part of the E-PRTR reporting obligation. We request the EEA to address this issue in the annual E-PRTR review process.	-
General, 2015: The TERT notes that in 2015, 1 combination(s) of LPS name, GNFR code and stack height class were reported two or more times. The correct reporting format requires that each combination of LPS, GNFR and height class must appear only once. In its response to the review question, Austria indicated that in this case one operator has two plants with different locations under the same name. The TERT recommends that Austria ensures that it provides unique references to the LPS name in order to differentiate LPS in its future submissions.	AT-LPS-GEN-2020-0004	It is not possible for Austria's inventory team to change the master data (facility names) officially reported by operators as part of the E-PRTR reporting obligation. We request the EEA to address this issue in the annual E-PRTR review process.	-

Table 332: Improvements made in response to the National Air Pollutant Projections Review in 2019.

Finding NACP Review 2019	Reference	Improvement made	Chapter
National Total			
NATIONAL TOTAL National Total for the entire territory: The TRT notes that Austria does not include estimates of a With Additional Measures (WAM) scenario. The WM scenario is projecting non-compliance with several emission reduction commitments, and hence there is a need for a WAM scenario to show how all of the emission reduction commitments will be met.	AT-NATIONAL TOTAL-2019-0005	The WAM scenario is included in the current submission.	Chapter 8, Report "Austria's National Air Emission Projections 2021 for 2020, 2025 and 2030" (UMWELTBUNDESAMT 2021b)
NATIONAL TOTAL National Total for the entire territory: The TRT notes that Austria only provides a few overview pages on its projections and extremely limited information on methods, data sources and assumptions used to estimate projected emissions scenarios in its IIR. However, as part of their submission, Austria did also provide a document on "Austria's National Air Emission Projections 2019 for 2020, 2025 and 2030" with detailed information on projections. The TRT noted that this document provided sufficient detail of the methods, data sources and assumptions for most sectors but did not include information on a sensitivity analysis and for specific agriculture categories (see AT-3D-2019-0001 and AT-3B-2019-0001). During the review Austria provided details of a report with detailed information on sensitivity analyses (WIFO & BOKU 2018). The TRT recommends that Austria continues to bring together its information on projections methods, data sources and assumptions as well as information on sensitivities and trends into a single document such as the IIR.	AT-NATIONAL TOTAL-2019-0001	Chapter "Projections" of Austria´s IIR 2021 has been improved accordingly. However, for detailed information please refer to the report "Austria's National Air Emission Projections 2021 for 2020, 2025 and 2030" (UMWELTBUNDESAMT 2021b), reported as a single document.	Chapter 8, Report "Austria's National Air Emission Projections 2021 for 2020, 2025 and 2030" (UMWELTBUNDESAMT 2021b)

Finding NACP Review 2019	Reference	Improvement made	Chapter
Agriculture			
3B Animal husbandry and manure management: For category 3B (Animal husbandry and manure management) and pollutants NOX, NMVOC and NH3 for all future years, the TRT noted that the trends of the projected emissions were not fully explained by the methodology text in Austria's reporting, and that it was not clear whether the methodologies were fully capturing expected changes to the agriculture sector. In response to a question raised during the review, Austria explained that they were using a detailed methodology which did capture expected changes in the agriculture sector, and that the model was comparable to that used for estimating historical emission estimates. The TRT agreed with the explanation provided by Austria. The TRT recommends that Austria provide more information in their projections reporting to transparently explain that the methodologies used for estimating emission projections are sophisticated enough to accurately capture the impact of expected changes in the agriculture sector (and that this might include referencing the relevant section of the IIR).	AT-3B-2019-0001	The required information is included in report "Austria's National Air Emission Projections 2021 for 2020, 2025 and 2030" (UMWELTBUNDESAMT 2021b).	Chapter 4.5 of (UMWELTBUNDESAMT 2021b)
3D Plant production and agricultural soils: For category 3D (Plant production and agricultural soils) and pollutants NH3 for all future years, the TRT noted that the trends of the projected emissions were not fully explained by the methodology text in Austria's reporting, and that it was not clear whether the methodologies were fully capturing expected changes to the agriculture sector. In response to a question raised during the review, Austria explained that they were using a detailed methodology which did capture expected changes in the agriculture sector, and that the model was comparable to that used for estimating historical emission estimates. The TRT agreed with the explanation provided by Austria. The TRT recommends that Austria provide more information in their projections reporting to transparently explain that the methodologies used for estimating emission projections are sophisticated enough to accurately capture the impact of expected changes in the agriculture sector (and that this might include referencing the relevant section of the IIR).	AT-3D-2019-0001	The required information is included in report "Austria's National Air Emission Projections 2021 for 2020, 2025 and 2030" (UMWELTBUNDESAMT 2021b).	Chapter 4.5 of (UMWELTBUNDESAMT 2021b)

8 PROJECTIONS

As outlined in the 'Guidelines for Reporting Emission Data under the Convention on Long-Range Transboundary Air Pollution' (ECE/EB.AIR/125, Update on 13 March 2014)

§ 44 Parties to the Gothenburg Protocol within the scope of EMEP shall regularly update their projections and report every four years from 2015 onward their updated projections for the years 2020, 2025 and 2030 and, where available, also for 2040 and 2050. Parties to the Protocols are encouraged to regularly update their projections and report every four years from 2015.

§ 45 Projected emissions for substances listed in paragraph 7 (i.e. sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3), $PM_{2.5}$ and non-methane volatile organic compounds (NMVOCs etc.) and, where appropriate black carbon should be reported using the template within Annex IV to these Guidelines. Parties should complete the tables at the requested level of aggregation. Where values for individual categories or aggregated NFR categories are not available, the notation keys defined in paragraph 12 to these Guidelines should be used.

§ 46 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 submitted on 15th March 2021 for the scenarios 'with existing measures' and 'with addtional measures' for the year 2020, 2025 and 2030 are published in the report 'Austria's National Air Emission Projections 2021 for 2020, 2025 and 2030' (UMWELTBUNDESAMT 2021b). 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 2019 (UMWELTBUNDESAMT 2019d).

The following table shows Austria´s national total emissions and projections based on fuel sold as well as on fuel used. Emissions have to be reported based on fuel sold under the UNECE/ LRTAP Convention as well as under the NEC Directive 2016/2284/EU. With respect to compliance under the NEC Directive, Austria reports emissions and projections based on fuel used. When referring to emissions based on 'fuel used', 'fuel exports in the vehicle tank' are not considered. The revised NEC Directive sets ceilings for five air pollutants: nitrogen oxides (NO_x), sulphur dioxide (SO_2), non-methane volatile organic compounds (NMVOC), ammonia (NH_3) and particulate matter ($PM_{2.5}$).

The scenario "with existing measures" results in significant emission reductions by 2030 for all pollutants except NH_3. The most substantial reduction (about 65% for 'fuel sold' and 57% for 'fuel used') from 2005 until 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 the other pollutants are in the range of 33% to 53%; NH_3 emissions, however, are projected to increase by 10% (see Table 333).

Table 333: Austrian national total emissions in kt and trend in comparison with the base year 2005 in % based on (a) fuel sold and (b) fuel used for the scenario "with existing measures" (Source: Umweltbundesamt).

Pollutant [kt]	**Emission inventory 2020**				**Emission scenario**			**Scenario**
	1990	**2005**	**2010**	**2019**	**2020**	**2025**	**2030**	
NO_x	217.35	247.33	204.45	144.20	137.54	106.65	87.19	fuel sold (WEM)
		0%	-17%	-42%	-44%	-57%	-65%	
	200.40	190.30	168.97	130.66	125.15	99.16	82.02	fuel used (WEM)
		0%	-11%	-31%	-34%	-48%	-57%	
SO_2	73.70	25.93	15.99	10.93	11.94	12.38	12.25	fuel sold (WEM)
		0%	*-38%*	*-58%*	*-54%*	*-52%*	*-53%*	
	72.92	25.88	15.96	10.89	11.91	12.34	12.20	fuel used (WEM)
		0%	*-38%*	*-58%*	*-54%*	*-52%*	*-53%*	
NMVOC	335.54	157.73	137.91	108.59	108.51	105.53	102.91	fuel sold (WEM)
		0%	*-13%*	*-31%*	*-31%*	*-33%*	*-35%*	
	331.03	153.26	135.90	108.01	107.94	105.01	102.42	fuel used (WEM)
		0%	*-11%*	*-30%*	*-30%*	*-31%*	*-33%*	
NH_3	61.84	60.08	62.89	63.82	63.54	64.81	65.91	fuel sold (WEM)
		0%	*5%*	*6%*	*6%*	*8%*	*10%*	
	61.79	59.46	62.39	63.57	63.29	64.53	65.60	fuel used (WEM)
		0%	*5%*	*7%*	*6%*	*9%*	*10%*	
$PM_{2.5}$	27.07	22.56	19.81	14.06	13.96	12.71	11.72	fuel sold (WEM)
		0%	*-12%*	*-38%*	*-38%*	*-44%*	*-48%*	
	26.52	20.97	18.94	13.86	13.78	12.59	11.63	fuel used (WEM)
		0%	*-10%*	*-34%*	*-34%*	*-40%*	*-45%*	

The scenario "with additional measures" results in emission reductions by 2030 for all pollutants until 2030. The most substantial reduction (about 66% for 'fuel sold' and 59% for 'fuel used') from 2005 until 2030 is projected for NO_x, assuming that the latest and new emission standards for road vehicles meet their specifications under real-world driving conditions.

Emission reductions for the other pollutants are in the range of 0.1% to 52% (see Table 334).

Table 334 Austrian national total emissions in kt and trend in comparison with the base year 2005 in % based on (a) fuel sold and (b) fuel used for the scenario "with addtional measures" (Source: Umweltbundesamt).

Pollutant [kt]	Emission inventory 2020				Emission scenario			Scenario
	1990	**2005**	**2010**	**2019**	**2020**	**2025**	**2030**	
NO_x	217.35	247.33	204.45	144.20	136.90	104.49	83.01	fuel sold (WAM)
		0%	-17%	-42%	-45%	-58%	-66%	
	200.40	190.30	168.97	130.66	124.63	97.39	78.34	fuel used (WAM)
		0%	-11%	-31%	-35%	-49%	-59%	
SO_2	73.70	25.93	15.99	10.93	11.98	12.56	12.52	fuel sold (WAM)
		0%	*-38%*	*-58%*	*-54%*	*-52%*	*-52%*	
	72.92	25.88	15.96	10.89	11.94	12.52	12.47	fuel used (WAM)
		0%	*-38%*	*-58%*	*-54%*	*-52%*	*-52%*	
NMVOC	335.54	157.73	137.91	108.59	109.10	105.78	102.27	fuel sold (WAM)
		0%	*-13%*	*-31%*	*-31%*	*-33%*	*-35%*	
	331.03	153.26	135.90	108.01	108.54	105.24	101.70	fuel used (WAM)
		0%	*-11%*	*-30%*	*-29%*	*-31%*	*-34%*	
NH_3	61.84	60.08	62.89	63.82	63.64	62.18	59.75	fuel sold (WAM)
		0%	*5%*	*6%*	*6%*	*3%*	*-1%*	
	61.79	59.46	62.39	63.57	63.38	61.89	59.43	fuel used (WAM)
		0%	*5%*	*7%*	*7%*	*4%*	*0%*	
$PM_{2.5}$	27.07	22.56	19.81	14.06	14.08	12.49	11.72	fuel sold (WAM)
		0%	*-12%*	*-38%*	*-38%*	*-45%*	*-48%*	
	26.52	20.97	18.94	13.86	13.90	12.38	11.64	fuel used (WAM)
		0%	*-10%*	*-34%*	*-34%*	*-41%*	*-45%*	

8.1 Nitrogen Oxides (NO_x)

In 1990, national total NO_x emissions amounted to 217.4 kt (including fuel exports in the vehicle tank, i.e. based on 'fuel sold'). After an all-time high between 2003 and 2005, emissions have since followed a continuously decreasing trend. In 2019, NO_x emissions amounted to 144.2 kt and were about 33.7% lower than in 1990.

Compared to 2005 levels, emissions in 2019 were about 41.7% lower. When considering inland fuel consumption without 'fuel exports in the vehicle tank', NO_x emissions amounted to only 130.7 kt in 2019, corresponding to a 31.3% decrease since 2005. The gradual replacement of vehicles with new vehicles with lower fuel consumption and lower NO_x emissions (and well-functioning after-treatment devices) contributed to the decreasing trend in the last few years.

The main source of NO_x emissions in Austria (with a share of 92.5% in 2019) is Sector 1.A Fuel Combustion Activities. Within this sector, 1.A.3.b Road transport ('fuel sold') accounts for the highest share (51.7%) of the total NO_x emissions. Further major sources are 1.A.2 Industry (17.2%), 1.A.4 Other Sectors (13.2%) and 1.A.1 Energy Industry (7.2%). Sector 3 Agriculture contributes 7.2%.

In the scenario "with existing measures" the national total emissions (including 'fuel export') are expected to decrease to 87.2 kt by 2030 (–64.7% compared to 2005). Without 'fuel export' they are expected to decrease to 82.0 kt by 2030 (–56.1% compared to 2005).

The main drivers for the NOx emissions trend until 2030 are expected to be road transport, households and the energy industry. The decrease of the emissions from the Manufacturing Industries is less pronounced.

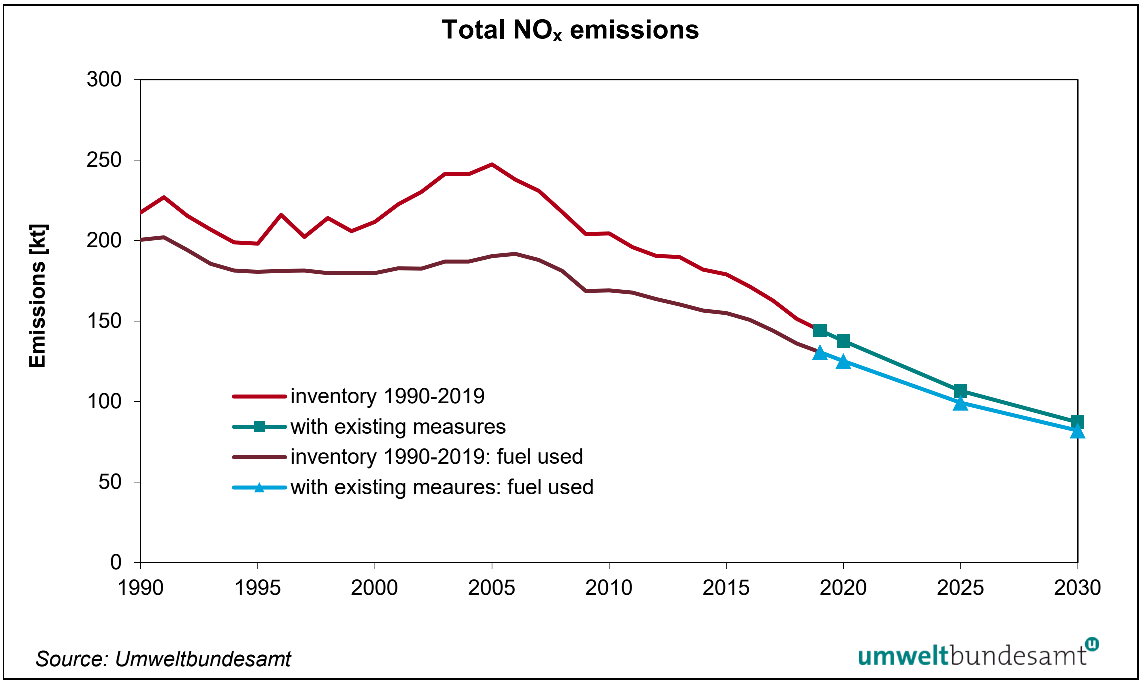

Figure 59: Historical (1990 to 2019) and projected emissions WEM (2020–2030) of NO_x based on (a) fuel sold and (b) fuel used.

NO_x emissions from Road Transport (especially cars and heavy-duty vehicles) are projected to decrease by 65.0% (i.e. 48.5 kt) from 2019 to 2030. This decline is based on the following assumptions:

- modernisation of the vehicle fleet in combination with decreasing specific emission factors and introduction of the latest emission classes Euro VI (HDV), Euro 6d_temp and EURO 6d (PC)
- an increased share of e-mobility by 2030 as a substitute for conventionally fuelled cars

Emissions from 1.A.4. Other Sectors (households, commercial and agriculture) are projected to decrease by –27.2% (i.e. 5.2 kt) from 2019 to 2030. This is mainly due to a modernisation of (and decline in emissions from) non-road mobile machinery (NRMM, or so-called off-road vehicles) and a switch to low-emission technology. It is not assumed that there will be a switch from fossil to electric propulsion in these categories. Mobile sources in households and agriculture (off-road) show a decrease by 40.5% (–2.7 kt) by 2030. Stationary sources decrease by –19.9% (–2.4 kt) by 2030 because of a decrease in the use of fuel oil, ongoing stock replacement with condensing boilers and the effects of 'ecodesign' provisions for the installation of new heating systems.

Reduced fuel inputs of coal and oil to thermal power stations are responsible for lower emissions in 1.A.1 Energy Industry (–21.5%, i.e. –2.24 kt) by 2030.

Emissions from 1.A.2 Manufacturing Industries and Construction decreased by –27.2% between 2005 and 2019 due to the installation of primary and secondary NO_x abatement measures. More of these measures will be implemented until 2030, but the effect is expected to be offset by an increase of emissions due to economic growth.

In the scenario "with additional measures" the national total emissions (including 'fuel export') are expected to decrease to 83 kt by 2030 (–66.4% compared to 2005). Without 'fuel export' they are expected to decrease to 78.3 kt (–58.8% compared to 2005).

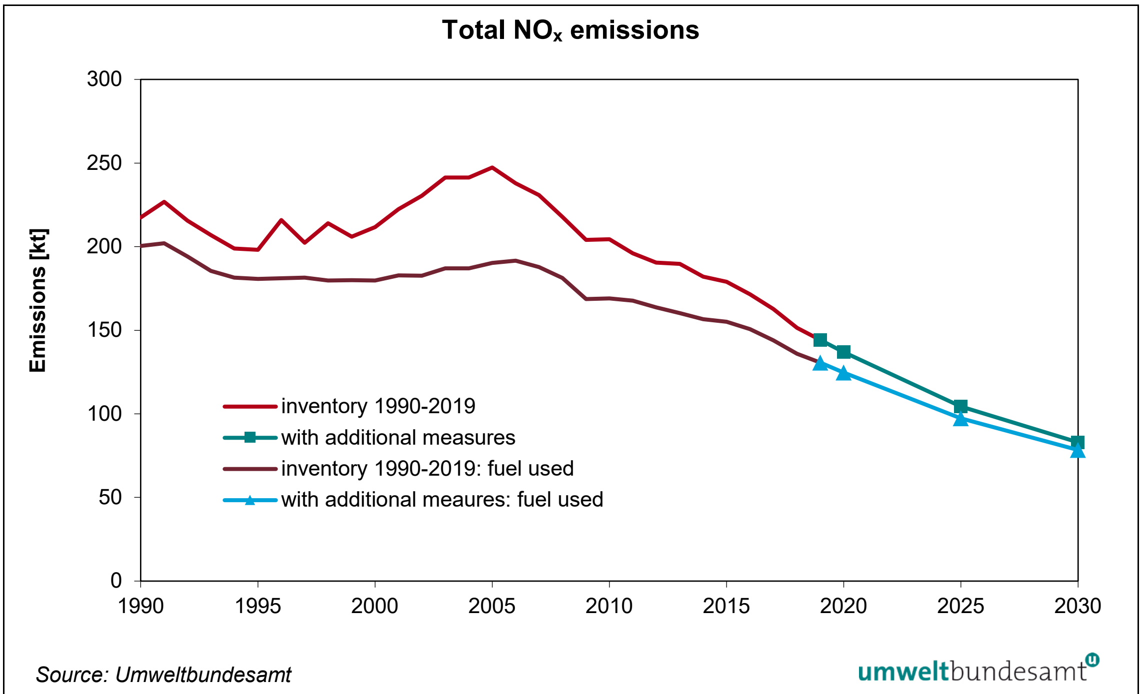

Figure 60: Historical (1990 to 2019) and projected emissions WAM (2020–2030) of NO_x based on (a) fuel sold and (b) fuel used.

NO_x emissions from Road Transport (especially cars and heavy-duty vehicles) are projected to decrease by 69.7% (i.e. –52.0 kt) from 2019 to 2030.

Emissions from 1.A.4. Other Sectors (households, commercial and agriculture) are projected to decrease by 27.2% (i.e. –5.2 kt) from 2019 to 2030. Mobile sources in households and agriculture (off-road) show a decrease by 41.1% (–2.8 kt) by 2030. Stationary sources decrease by 20.8% (–2.55 kt) by 2030.

Reduced fuel inputs of coal and oil to thermal power stations and higher consumption of biomass in 1.A.1 Energy Industry results in a decrease of 13.9%, (i.e. –1.44 kt) by 2030.

Table 335: Austrian national NOx emissions in kt and trend based on (a) 'fuel sold' and (b) 'fuel used' (Source: Umweltbundesamt).

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Scenario
		1990	2005	2010	2019	2020	2025	2030	
	Total	217.3	247.3	204.4	144.2	137.5	106.7	87.2	fuel sold (WEM)
		217.3	247.3	204.4	144.2	136.9	104.5	83.0	fuel sold (WAM)
	Total	200.4	190.3	168.9	130.6	125.1	99.1	82.0	fuel used (WEM)
		200.4	190.3	168.9	130.6	124.6	97.4	78.3	fuel used (WAM)
1.A.1	Energy Industries	17.78	14.30	12.80	10.39	9.63	8.75	8.16	WEM
1.A.1	Energy Industries	17.78	14.30	12.80	10.39	10.29	9.33	8.95	WAM
1.A.2	Manufacturing Industries and Construction	33.04	33.98	32.15	24.75	24.55	25.10	24.52	WEM
1.A.2	Manufacturing Industries and Construction	33.04	33.98	32.15	24.75	24.37	25.11	24.70	WAM
1.A.3. a,.c,.d, .e	Off-Road Transport	3.94	5.93	5.03	4.54	4.12	3.91	3.76	WEM
1.A.3. a,.c,.d, .e	Off-Road Transport	3.94	5.93	5.03	4.54	4.12	3.96	3.91	WAM
1.A.3. b	Road Transportation	116.3	155.6	120.1	74.61	69.70	41.89	26.09	fuel sold (WEM)
		116.3	155.6	120.1	74.61	68.51	39.93	22.58	fuel sold (WAM)
1.A.3. b	Road Transportation	99.29	98.57	84.63	61.07	57.31	34.40	20.93	fuel used (WEM)
		99.29	98.57	84.63	61.07	56.24	32.83	17.91	fuel used (WAM)
1.A.4	Other Sectors	29.85	26.55	23.93	18.98	18.57	16.10	13.82	WEM
1.A.4	Other Sectors	29.85	26.55	23.93	18.98	18.64	16.06	13.66	WAM
1.A.5	Other	0.07	0.09	0.08	0.08	0.08	0.08	0.08	WEM
1.A.5	Other	0.07	0.09	0.08	0.08	0.08	0.07	0.08	WAM
1.B	Fugitive Emissions	IE	IE	IE	IE	IE	IE	IE	WEM
1.B	Fugitive Emissions	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	0.48	0.50	0.50	0.50	WEM
2.A,B, C,H,I,J ,K,L	Industrial Processes	4.24	0.67	0.52	0.48	0.50	0.50	0.50	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
2.D,	Solvent and Other	0.03	0.03	0.03	0.02	0.02	0.02	0.02	WAM

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Scenario
		1990	2005	2010	2019	2020	2025	2030	
2.G	Product Use								
3.B	Manure Management	0.60	0.58	0.56	0.55	0.55	0.53	0.51	WEM
3.B	Manure Management	0.60	0.58	0.56	0.55	0.55	0.52	0.49	WAM
3.D	Agricultural Soils	11.40	9.50	9.18	9.76	9.79	9.73	9.68	WEM
3.D	Agricultural Soils	11.40	9.50	9.18	9.76	9.79	8.95	8.08	WAM
3.F,I	Field Burning and other agriculture	0.05	0.04	0.04	0.02	0.02	0.02	0.02	WEM
3.F,I	Field Burning and other agriculture	0.05	0.04	0.04	0.02	0.02	0.02	0.02	WAM
5	Waste	0.10	0.05	0.02	0.02	0.02	0.02	0.02	WEM
5	Waste	0.10	0.05	0.02	0.02	0.02	0.02	0.02	WAM

**Data source: Austrian Air Emission Inventory 2020 (Umweltbundesamt 2021b)*

IE … included elsewhere; NA … not applicable; NO … not occurring

8.2 Sulphur Dioxide (SO_2)

In 1990, national total SO_2 emissions amounted to 73.7 kt. Since then, emissions have decreased quite steadily. By the year 2019, emissions had decreased by 85.2% compared to 1990 (amounting to 10.9 kt), mainly due to lower emissions from residential heating, combustion in industry and energy industries. A sharp decrease observed in 2008 was due to a further reduction of the sulphur content to 10ppm in domestic heating oil. In 2019, emissions were about 57.9% lower than 2005.

The main source of SO2 emissions in Austria is NFR Sector 1.A Fuel Combustion Activities with 94.4% in 2019. Within this sector, the main contributors to the total SO2 emissions are 1.A.2 Manufacturing Industries with 66.7% (more than the half of the emissions arise from iron and steel industry), 1.A.1 Energy Industries with 11.9% and 1.A.4 Other Sectors (residential heating) with 12.9% of the total emissions.

In the scenario "with existing measures" (WEM) the national total emissions including 'fuel export' are expected to decrease to 12.2 kt by 2030 (–52.8% compared to 2005). Without 'fuel export' they are expected to decrease to 12.2 kt (–52.9% compared to 2005).

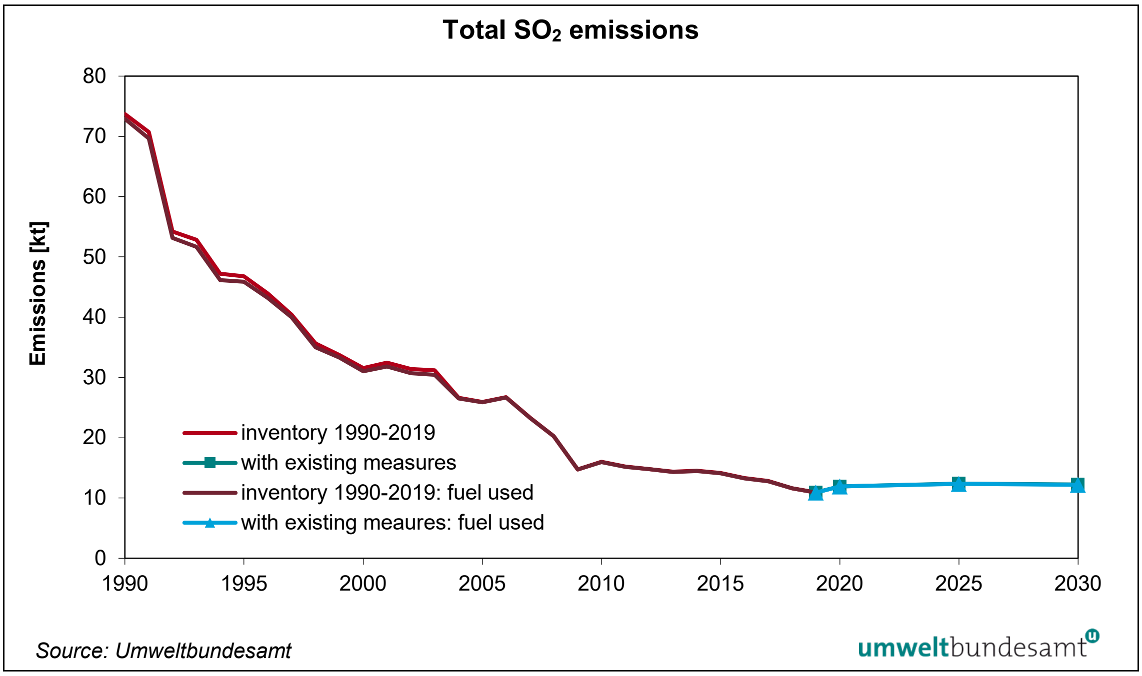

Figure 61: Historical (1990 to 2019) and projected emissions WEM (2020–2030) of SO_2 based on (a) fuel sold and (b) fuel used.

In the scenario "with additional measures" (WAM) the national total emissions including 'fuel export' are expected to decrease to 12.5 kt by 2030 (–51.7% compared to 2005). Without 'fuel export' they are expected to decrease to 12.5 kt (–51.8% compared to 2005).

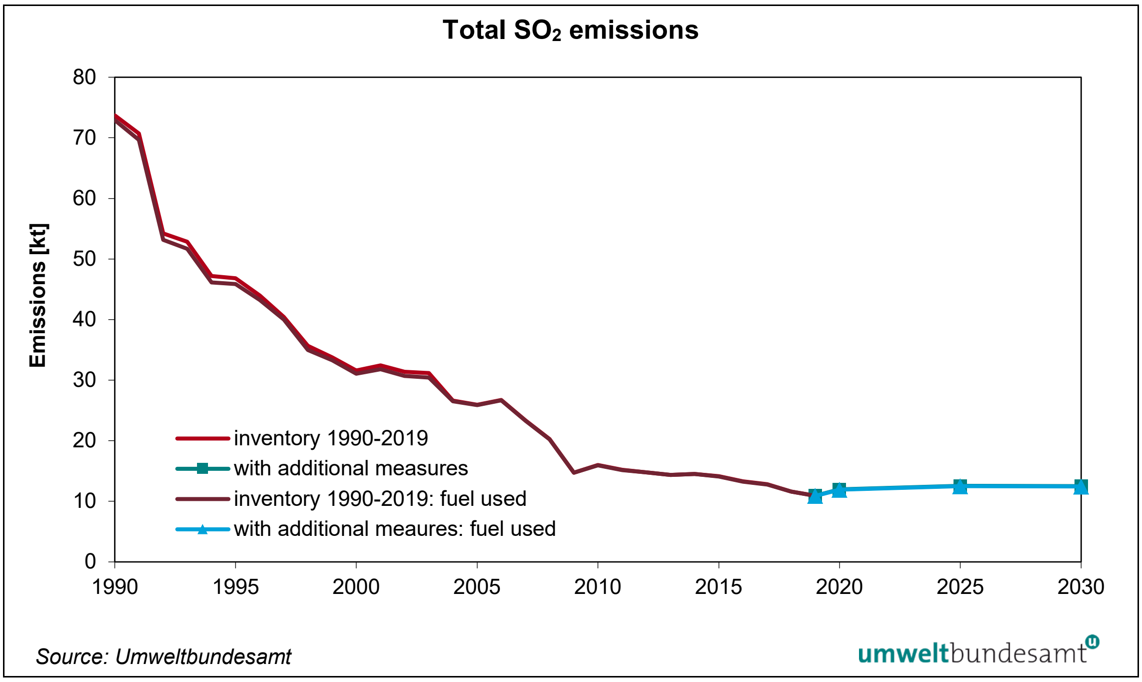

Figure 62: Historical (1990 to 2019) and projected emissions WAM (2020–2030) of SO_2 based on (a) fuel sold and (b) fuel used.

Total SO_2 emissions are expected to increase slightly over the period from 2019 to 2030. A large part of appropriate mitigation measures (e.g. reduction of sulphur content in liquid fuels, waste gas treatment) have already been implemented. Therefore, the remaining reduction potential remains small.

Minor effects can be expected at the sectoral level from 2019 to 2030: Emissions from Energy Industries (1.A.1) are expected to decrease due to less fuel input. (WEM: -21.1%, i.e. –0.28 kt; WAM: –20.9%, i.e. –0.27 kt) and those from Other Sectors (1.A.4) are expected to decrease (WEM: –29.3%-, i.e. –0.41 kt; WAM: –25.8%, i.e. –0.36 kt) by 2030 due to a shift from fossil fuels (oil, coal) to renewables. Emissions from Manufacturing Industries and Construction (1.A.2) are expected to increase (WEM: +27.7%, i.e.2.0 kt WAM: 30.9%, i.e. 2.25 kt).

Table 336: Austrian national SO_2 emissions in kt and trend based on (a) fuel sold and (b) fuel used (Source: Umweltbundesamt).

NFR	**Description**	**Emission inventory 2019* [kt]**				**Emission scenario [kt]**			**Scenario**
		1990	**2005**	**2010**	**2019**	**2020**	**2025**	**2030**	
	Total	73.70	25.93	15.99	10.93	11.94	12.38	12.25	fuel sold (WEM)
		73.70	25.93	15.99	10.93	11.98	12.56	12.52	fuel sold (WAM)
	Total	72.92	25.88	15.96	10.89	11.91	12.34	12.20	fuel used (WEM)
		72.92	25.88	15.96	10.89	11.94	12.52	12.47	fuel used (WAM)
1.A.1	Energy Industries	14.07	6.71	2.74	1.30	1.37	1.17	1.03	WEM
1.A.1	Energy Industries	14.07	6.71	2.74	1.30	1.39	1.15	1.03	WAM
1.A.2	Manufacturing Industries and Construction	17.83	10.14	9.40	7.29	8.25	9.11	9.31	WEM
1.A.2	Manufacturing Industries and Construction	17.83	10.14	9.40	7.29	8.25	9.29	9.54	WAM
1.A.3.a, c, d, e	Off-Road transport	0.36	0.18	0.18	0.17	0.15	0.15	0.16	WEM
1.A.3.a, c, d, e	Off-Road transport	0.36	0.18	0.18	0.17	0.14	0.15	0.16	WAM
1.A.3.b	Road Transportation	4.77	0.16	0.13	0.14	0.14	0.15	0.15	fuel sold (WEM)
		4.77	0.16	0.13	0.14	0.14	0.14	0.13	fuel sold (WAM)

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Scenario
		1990	2005	2010	2019	2020	2025	2030	
1.A.3.b	Road Transportation	3.99	0.11	0.09	0.11	0.11	0.11	0.10	fuel used (WEM)
		3.99	0.11	0.09	0.11	0.11	0.10	0.09	fuel used (WAM)
1.A.4	Other Sectors	32.66	7.91	2.77	1.41	1.39	1.18	1.00	WEM
1.A.4	Other Sectors	32.66	7.91	2.77	1.41	1.43	1.22	1.05	WAM
1.A.5	Other	0.01	0.01	0.01	0.02	0.02	0.02	0.02	WEM
1.A.5	Other	0.01	0.01	0.01	0.02	0.01	0.01	0.02	WAM
1.B	Fugitive Emissions	2.00	0.04	0.05	0.02	0.03	0.02	0.01	WEM
1.B	Fugitive Emissions	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	0.56	0.56	0.56	0.56	WEM
2.A,B,C, H,I,J,K,L	Industrial Processes	1.93	0.72	0.70	0.56	0.56	0.56	0.56	WAM
2.D, 2.G	Solvent and Other Product Use	0.00	0.01	0.01	0.00	0.00	0.00	0.01	WEM
2.D, 2.G	Solvent and Other Product Use	0.00	0.01	0.01	0.00	0.00	0.00	0.01	WAM
3.B	Manure Management	NA	NA	NA	NA	NA	NA	NA	WEM
3.B	Manure Management	NA	NA	NA	NA	NA	NA	NA	WAM
3.D	Agricultural Soils	NA	NA	NA	NA	NA	NA	NA	WEM
3.D	Agricultural Soils	NA	NA	NA	NA	NA	NA	NA	WAM
3.F,.I	Field Burning and Other Agriculture	0.01	0.00	0.00	0.00	0.00	0.00	0.00	WEM
3.F,I	Field Burning and Other Agriculture	0.01	0.00	0.00	0.00	0.00	0.00	0.00	WAM
5	Waste	0.07	0.06	0.01	0.01	0.01	0.01	0.01	WEM
5	Waste	0.07	0.06	0.01	0.01	0.01	0.01	0.01	WAM

**Data source: Austrian Air Emission Inventory 2020 (Umweltbundesamt 2021b)*

IE … included elsewhere; NA … not applicable; NO … not occurring

8.3 Non-Methane Volatile Organic Compounds (NMVOCs)

In 1990, Austria's total NMVOC emissions amounted to 335.5 kt. Emissions have decreased steadily since then and by the year 2019 emissions had decreased by 67.6% to 108.6 kt (compared to 1990). In 2019, emissions were about 31.2% lower than in 2005.

The main reasons for the emission reductions is the implementation of EU Directives relating to the use of solvents (e.g. "The Paints Directive"), the modernisation of boilers in households and the usage of catalytic converters in petrol fuelled cars together with a shift to diesel fuelled cars.

The main sources of NMVOC emissions in Austria are NFR 2.D.3 Solvent Use with a share of 29.9% in 2019, 1.A.4 Other Sectors (24.8%) and 3.B Manure Management (24.5%).

In the scenario 'with existing measures' (WEM) the national total emissions including 'fuel export' are expected to decrease to 102.9 kt by 2030 (–34.8% compared to 2005). Without 'fuel export' they are expected to decrease to 102.4 kt (–33.2% compared to 2005).

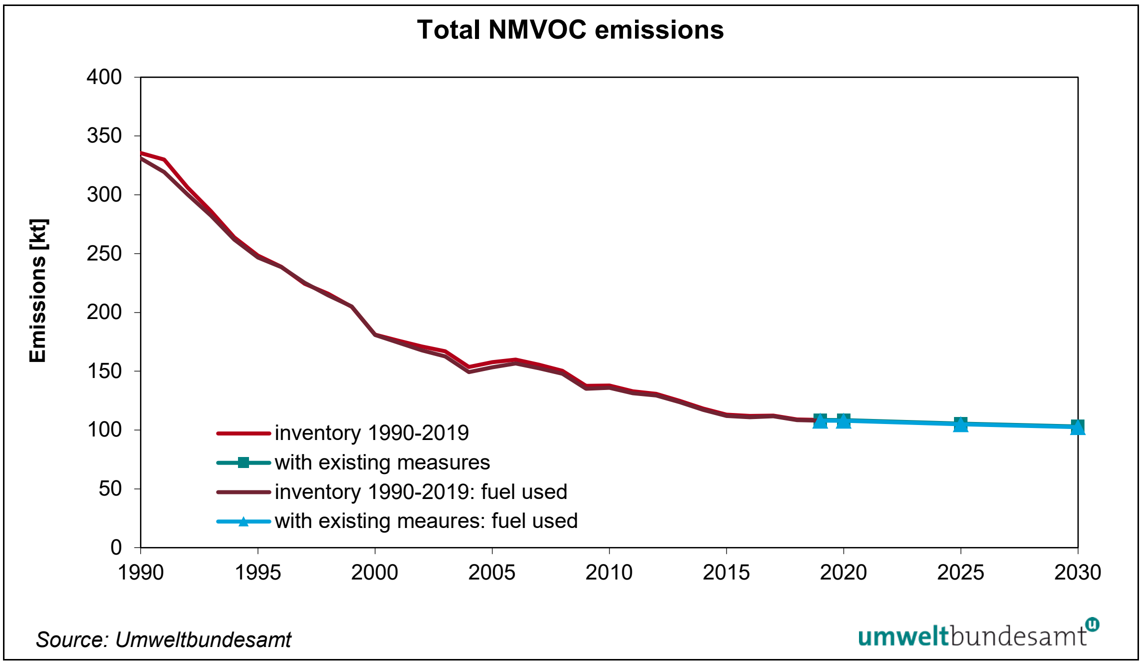

Figure 63: Historical (1990 to 2019) and projected emissions WEM (2020–2030) of NMVOC based on (a) fuel sold and (b) fuel used.

Total NMVOC emissions are projected to decrease by 5.2% until 2030 (compared to 2019). The largest reduction is expected to be achieved in Sector 1.A.4 (mainly households and commercial), with a decrease of 20.5% (i.e. –5.5 kt) from 2019 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 buildings sector (see also 'ecodesign' requirements in Chapter 3 of (UMWELTBUNDESAMT 2021b)), as well as a decrease in the use of fuelwood as a source of energy.

Emissions in the sector Road Transport are projected to fall by 27.5% (i.e. 1.29 kt) by 2030, especially owing to state-of-art exhaust gas treatment (regulated catalytic converter) and an increased share of diesel and electric vehicles.

On the other hand, emissions from 2.D.3 'Solvent Use' are expected to increase by 4.9% by 2030 (i.e. 1.59 kt) due to an increase in the consumption of solvents. Emission regulations for the relevant sectors have been enacted at EU level (while some of the legal requirements in Austria are even stricter). The requirements for paints and varnishes have been harmonised at EU level; existing regulations do not provide a further tightening of emission standards. The model for calculating emissions has been revised: calculations are now based on solvent balances from companies, and linked to economic projections for each NACE code.

Emissions in Agriculture are projected to increase by 0.8% (i.e. 0.30 kt) by 2030, mainly caused by the developments of livestock in Austria.

In the scenario "with addtional measures" (WAM) the national total emissions including 'fuel export' are expected to decrease to 102.3 kt by 2030 (–35.2% compared to 2005). Without 'fuel export' they are expected to decrease to 101.7 kt (–33.6% compared to 2005).

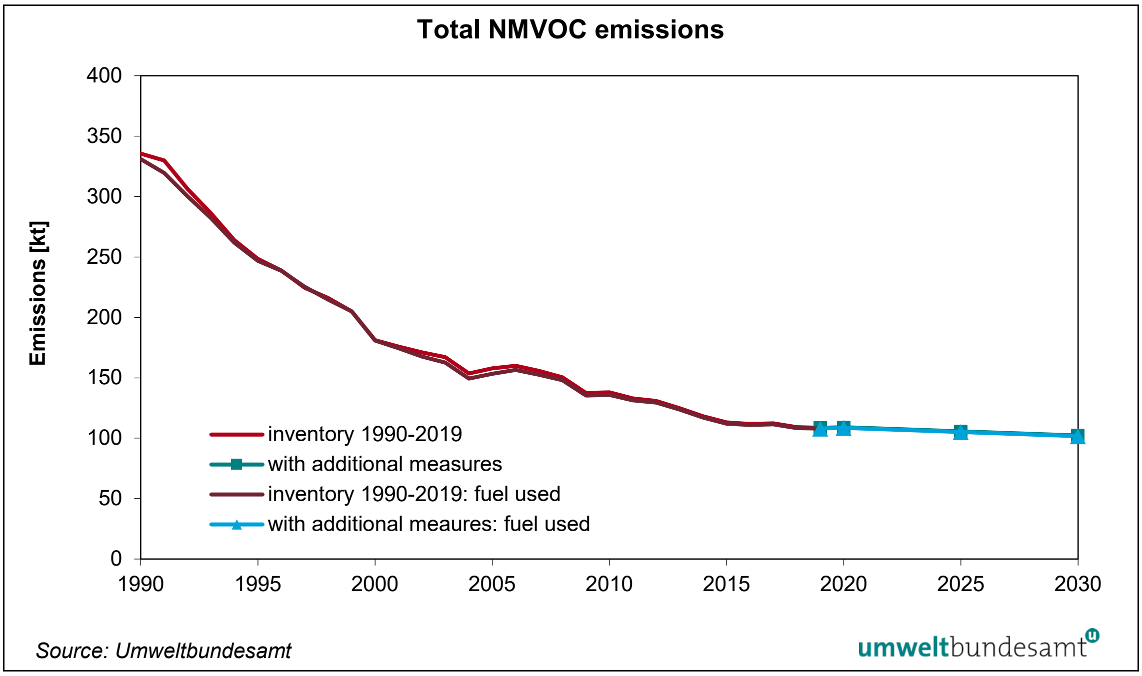

Figure 64: Historical (1990 to 2019) and projected emissions WAM (2020–2030) of NMVOC based on (a) fuel sold and (b) fuel used.

NMVOC Emissions in Agriculture are projected to decrease by 4.8% (i.e. –1.77 kt) by 2030, mainly caused by the developments of livestock in Austria.

Table 337: Austrian national NMVOC emissions in kt and trend based on (a) fuel sold and (b) fuel used (Source: Umweltbundesamt).

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Scenario
		1990	2005	2010	2019	2020	2025	2030	
	Total	335.5	157.7	137.9	108.5	108.5	105.5	102.9	fuel sold (WEM)
		335.5	157.7	137.9	108.5	109.1	105.7	102.2	fuel sold (WAM)
	Total	331.0	153.2	135.9	108.0	107.9	105.0	102.4	fuel used (WEM)
		331.0	153.2	135.9	108.0	108.5	105.2	101.7	fuel used (WAM)
1.A.1	Energy Industries	0.32	0.24	0.35	0.30	0.30	0.30	0.30	WEM
1.A.1	Energy Industries	0.32	0.24	0.35	0.30	0.30	0.30	0.30	WAM
1.A.2	Manufacturing Industries and Construction	1.68	2.06	1.94	1.03	0.90	0.84	0.82	WEM
1.A.2	Manufacturing Industries and Construction	1.68	2.06	1.94	1.03	0.88	0.83	0.82	WAM
1.A.3.a,c,d,e	Off-Road transport	1.51	1.78	1.44	0.90	0.80	0.72	0.70	WEM

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Scenario
		1990	2005	2010	2019	2020	2025	2030	
1.A.3.a,c,d ,e	Off-Road transport	1.51	1.78	1.44	0.90	0.80	0.73	0.71	WAM
1.A.3.b	Road Transportation	96.37	20.44	10.19	4.70	4.59	3.89	3.41	fuel sold (WEM)
		96.37	20.44	10.19	4.70	4.69	4.12	3.71	fuel sold (WAM)
1.A.3.b	Road Transportation	91.87	15.97	8.18	4.12	4.02	3.38	2.92	fuel used (WEM)
		91.87	15.97	8.18	4.12	4.12	3.57	3.14	fuel used (WAM)
1.A.4	Other Sectors	49.27	33.74	34.80	26.94	27.36	24.32	21.42	WEM
1.A.4	Other Sectors	49.27	33.74	34.80	26.94	27.87	25.15	22.53	WAM
1.A.5	Other	0.01	0.02	0.02	0.02	0.02	0.02	0.02	WEM
1.A.5	Other	0.01	0.02	0.02	0.02	0.02	0.02	0.02	WAM
1.B	Fugitive Emissions	15.49	3.34	2.45	2.23	2.20	2.00	1.82	WEM
1.B	Fugitive Emissions	15.49	3.34	2.45	2.23	2.20	2.00	1.82	WAM
2A,B,C,H,I, J,K,L	Industrial Processes	4.02	3.04	3.22	3.42	3.43	3.47	3.50	WEM
2.A,B,C,H,I ,J,K,L	Industrial Processes	4.02	3.04	3.22	3.42	3.43	3.47	3.50	WAM
2.D, 2.G	Solvent and Other Product Use	114.52	53.48	44.84	32.48	32.65	33.41	34.07	WEM
2.D, 2.G	Solvent and Other Product Use	114.52	53.48	44.84	32.48	32.65	33.41	34.07	WAM
3.B	Manure Management	35.42	28.18	27.82	26.60	26.38	26.66	26.95	WEM
3.B	Manure Management	35.42	28.18	27.82	26.60	26.38	26.32	26.00	WAM
3.D	Agricultural Soils	16.71	11.27	10.73	9.90	9.82	9.83	9.85	WEM
3.D	Agricultural Soils	16.71	11.27	10.73	9.90	9.82	9.38	8.73	WAM
3.F, I	Field Burning and Other Agriculture	0.06	0.04	0.03	0.01	0.01	0.01	0.01	WEM
3.F, I	Field Burning and Other Agriculture	0.06	0.04	0.03	0.01	0.01	0.01	0.01	WAM
5	Waste	0.16	0.11	0.08	0.05	0.05	0.04	0.04	WEM
5	Waste	0.16	0.11	0.08	0.05	0.05	0.04	0.04	WAM

**Data source: Austrian Air Emission Inventory 2020 (Umweltbundesamt 2021b)*

IE … included elsewhere; NA … not applicable; NO … not occurring

8.4 Ammonia (NH_3)

In 1990, national total NH3 emissions amounted to 61.8 kt; emissions slightly increased over the period from 1990 to 2019. In 2019, emissions were 3.2% above 1990 levels, amounting to 63.8 kt.

The main source of ammonia is the agricultural sector, contributing 93.2% of the total NH_3 emissions in 2019. Agricultural NH_3 emissions mainly result from animal husbandry and the application of organic and mineral N fertilizers.

The sub-sector 3.B Manure Management has a share of 45.2% in Austria's total NH_3 emissions in 2019. The emissions result from animal husbandry and the storage of manure. Within manure management cattle has the highest share with 61.2%. Emissions are related to livestock numbers but also to housing systems and manure treatment (e.g. NH_3 emissions from loose housing systems are considerably higher than those from tied housing systems). Since 1990, emissions from agriculture have increased by 0.5%, mainly due to higher emissions from cattle resulting from a continued increase of loose housing systems after 2005 for reasons of animal welfare.

The sub-sector 3.D Agricultural Soils (with a share of 47.9%) has the largest share in the national total NH_3 emissions in 2019. These emissions result from the application of mineral N fertilizers as well as organic fertilizers (including animal manure, sewage sludge, digestate 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) the national total emissions including 'fuel export' are expected to increase to 65.9kt by 2030 (+9.7% compared to 2005). Without 'fuel export' they are expected to increase to 65.6 kt (+10.3% compared to 2005).

For the period between now and 2030, the NH_3 projections show an increase in the WEM scenario (+3.3%). Based on national forecasts for agricultural production in Austria (WIFO & BOKU 2018), animal numbers of dairy cattle are expected to increase (+2.5% compared to 2019). The rise in the number of cattle kept in loose housing systems (to comply with animal welfare regulations) offsets the reduction effects of existing measures, resulting in an increase in emissions of 2.8% (i.e. 0.82 kt) in the sub-sector 3.B *Manure Management.* Furthermore, emissions in sub-sector 3.D *Agricultural Soils* are projected to increase by 3.8% (i.e. 1.16 kt) by 2030 due to the increased amounts of animal manures applied to soils.

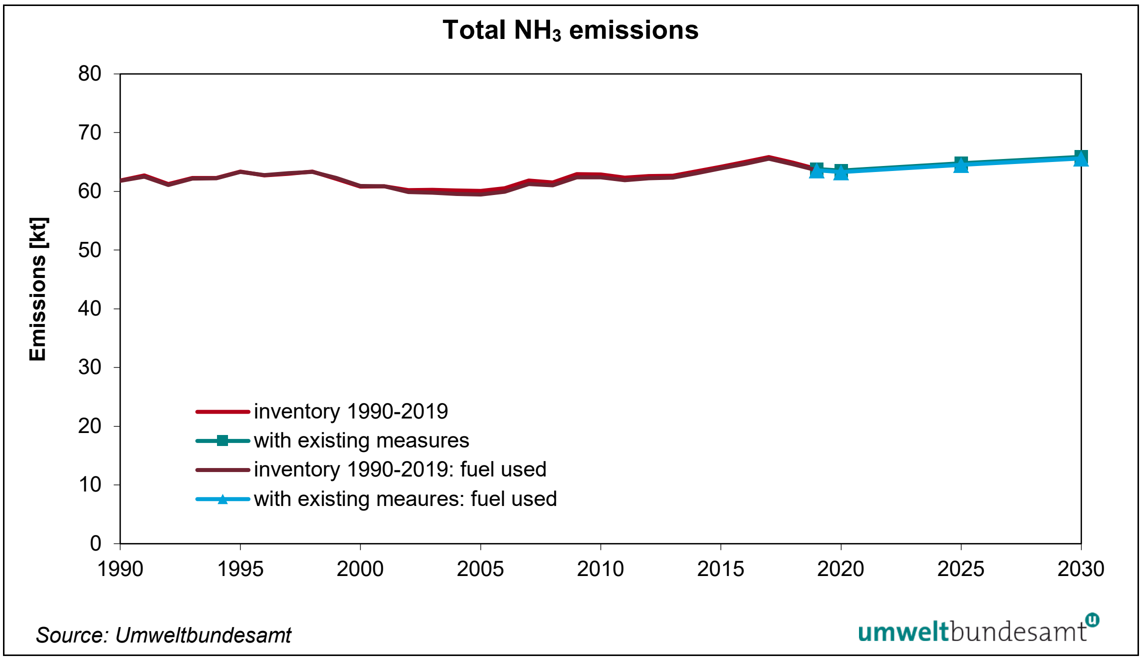

Figure 65: Historical (1990 to 2019) and projected emissions WEM (2020–2030) of NH_3 based on (a) fuel sold and (b) fuel used

In the scenario 'with addtional measures' (WAM) the national total emissions including 'fuel export' are expected to decrease to 59.7 kt by 2030 (–0.6% compared to 2005). Without 'fuel export' they are expected to decrease to 59.4 kt (–0.1% % compared to 2005).

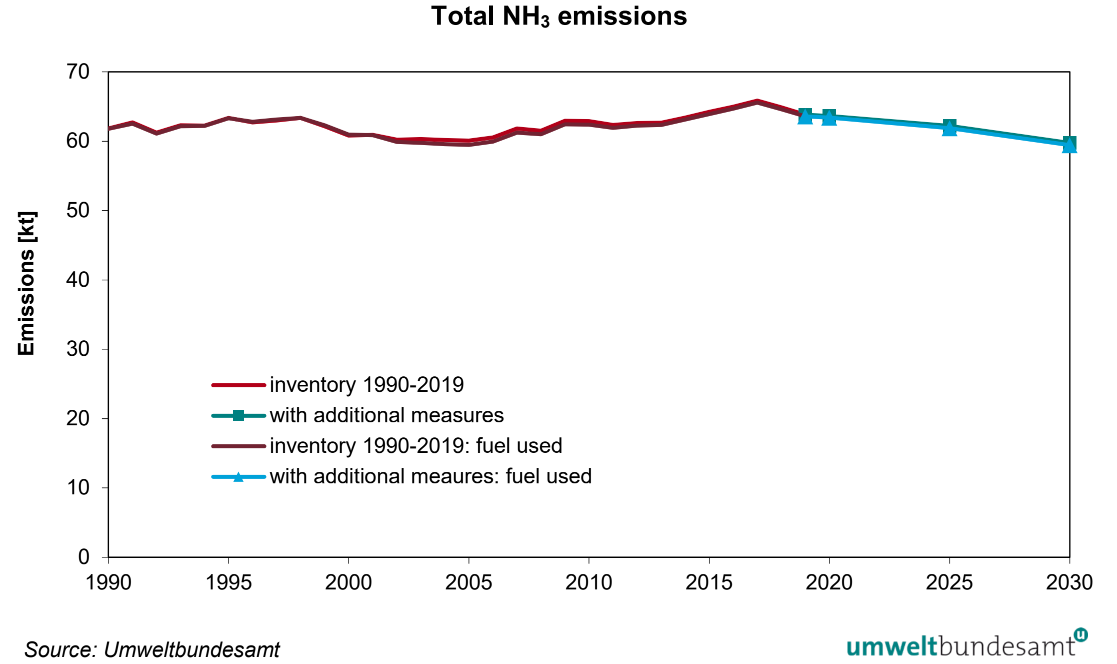

Figure 66: Historical (1990 to 2019) and projected emissions WAM (2020–2030) of NH_3 based on (a) fuel sold and (b) fuel used

In the scenario WAM for the period between now and 2030, the NH_3 emissions are expected to decrease by 6.4%. The main reason for the emission reductions is the implementation of the additional measures listed the Austrian NAPCP and NECP. Measures in the areas of herd management, animal feeding, animal husbandry and slurry storage will reduce emissions by 6.0% (i.e. –1.72 kt) in the sub-sector 3.B *Manure Management.* Furthermore, emissions in sub-sector 3.D *Agricultural Soils* will decrease by 11.2% (i.e. –3.43 kt) by 2030, mainly due to an increased use of emission reducing manure application techniques and the decreased need for mineral N-fertilizers.

Table 338: Austrian national NH_3 emissions in kt and trend based on (a) fuel sold and (b) fuel used (Source: Umweltbundesamt).

NFR	**Description**	**Emission inventory 2021 [kt]**				**Emission scenario [kt]**			**Scenario**
		1990	**2005**	**2010**	**2019**	**2020**	**2025**	**2030**	
	Total	27.07	22.56	19.81	14.06	13.96	12.71	11.7	fuel sold (WEM)
		27.07	22.56	19.81	14.06	14.08	12.49	11.7	fuel sold (WAM)
	Total	26.52	20.97	18.94	13.86	13.78	12.59	11.6	fuel used (WEM)
		26.52	20.97	18.94	13.86	13.90	12.38	11.6	fuel used (WAM)
1.A.1	Energy Industries	0.85	0.80	1.12	0.93	0.95	0.93	0.90	WEM
1.A.1	Energy Industries	0.85	0.80	1.12	0.93	0.98	0.90	0.91	WAM
1.A.2	Manufacturing Industries and Construction	1.90	1.85	1.52	0.71	0.71	0.79	0.82	WEM

NFR	Description	Emission inventory 2021 [kt]				Emission scenario [kt]			Scenario
		1990	2005	2010	2019	2020	2025	2030	
1.A.2	Manufacturing Industries and Construction	1.90	1.85	1.52	0.71	0.71	0.81	0.83	WAM
1.A.3.a, c, d, e	Off-Road Transport	0.70	0.66	0.52	0.42	0.58	0.57	0.55	WEM
1.A.3.a, c, d, e	Off-Road Transport	0.70	0.66	0.52	0.42	0.58	0.57	0.55	WAM
1.A.3.b	Road Transportation	5.70	7.23	4.90	2.47	2.32	1.94	1.83	fuel sold (WEM)
		5.70	7.23	4.90	2.47	2.32	1.59	1.65	fuel sold (WAM)
1.A.3.b	Road Transportation	5.15	5.65	4.03	2.26	2.14	1.83	1.74	fuel used (WEM)
		5.15	5.65	4.03	2.26	2.14	1.17	0.96	fuel used (WAM)
1.A.4	Other Sectors	13.39	9.05	9.18	7.11	7.05	6.11	5.20	WEM
1.A.4	Other Sectors	13.39	9.05	9.18	7.11	7.15	6.25	5.36	WAM
1.A.5	Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	WEM
1.A.5	Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	WAM
1.B	Fugitive Emissions	0.11	0.09	0.07	0.06	0.06	0.05	0.04	WEM
1.B	Fugitive Emissions	0.11	0.09	0.07	0.06	0.06	0.05	0.04	WAM
2.A,B,C,H, I,J,K,L	Industrial Processes	3.29	1.83	1.37	1.36	1.25	1.26	1.26	WEM
2.A,B,C,H, I,J,K,L	Industrial Processes	3.29	1.83	1.37	1.36	1.25	1.26	1.26	WAM
2.D, 2.G	Solvent and Other Product Use	0.54	0.49	0.50	0.43	0.44	0.45	0.45	WEM
2.D, 2.G	Solvent and Other Product Use	0.54	0.49	0.50	0.43	0.44	0.45	0.45	WAM
3.B	Manure Management	0.13	0.11	0.11	0.11	0.11	0.11	0.11	WEM
3.B	Manure Management	0.13	0.11	0.11	0.11	0.11	0.11	0.11	WAM
3.D	Agricultural Soils	0.14	0.15	0.14	0.14	0.13	0.13	0.13	WEM
3.D	Agricultural Soils	0.14	0.15	0.14	0.14	0.13	0.13	0.13	WAM
3.F, I	Field Burning and Other Agriculture	0.09	0.08	0.06	0.02	0.02	0.02	0.02	WEM
3.F, I	Field Burning and Other Agriculture	0.09	0.08	0.06	0.02	0.02	0.02	0.02	WAM
5	Waste	0.23	0.21	0.29	0.29	0.31	0.33	0.38	WEM
5	Waste	0.23	0.21	0.29	0.29	0.31	0.33	0.38	WAM

**Data source: Austrian Air Emission Inventory 2020 (Umweltbundesamt 2021b)*

IE … included elsewhere; NA … not applicable; NO … not occurring

8.5 Fine Particulate Matter ($PM_{2.5}$)

National total $PM_{2.5}$ emissions amounted to 27.1 kt in 1990 and have decreased steadily ever since: from 1990 to 2019, emissions (with 'fuel exports') decreased by 48.1% to 14.1 kt. Emissions from fuel used amounted to 26.5 kt in 1990 and decreased to 13.9 kt in 2019 (–47.7%).

In 2019, $PM_{2.5}$ emissions in Austria mainly arose from combustion activities in the energy sector, which accounted for 82.6% of the national total emissions. Within this sector, 1.A.4 Other Sectors (50.5%), 1.A.3 Transport (20.5%), 1.A.2 Industry (5.1%) are the main contributors to $PM_{2.5}$ emissions. Sector 2 IPPU is responsible for 12.8%.

In Sector 1.A.4 (mainly households and commercial), substantial emission reductions have been achieved as a result of the replacement of old installations with new low emission heating systems, a decrease in the use of fuelwood as a source of energy, the installation of energy-saving combustion plants, by connecting buildings to district heating networks or to other public energy and heating networks.

The reduction in 1.A.3 Transport since 2005 has been due to improvements in drive and exhaust gas after-treatment technologies and tax incentives (fuel consumption-based car registration tax: lower tax rates for diesel passenger cars equipped with particulate filter systems).

In the scenario "with existing measures" (WEM) the national total emissions including 'fuel export' are expected to decrease to 11.7 kt by 2030 (–48.0% compared to 2005). Without 'fuel export' they are expected to decrease to 11.6 kt (–44.6% compared to 2005).

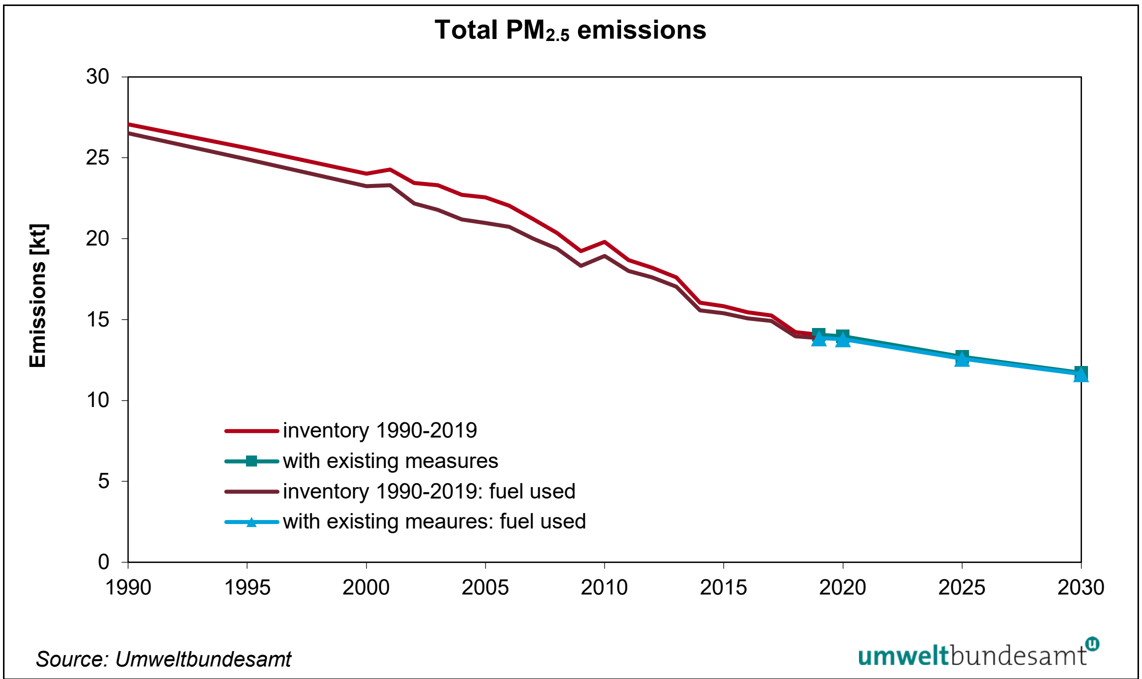

Figure 67: Historical (1990 to 2019) and projected emissions WEM (2020–2030) of $PM_{2.5}$ based on (a) fuel sold and (b) fuel used.

In the WEM scenario, $PM_{2.5}$ emissions of 1.A.4 Other Sectors are expected to decrease by 26.8% (i.e –1.91 kt) by 2030 compared to 2019. $PM_{2.5}$ emission reductions are mainly due to an increased efficiency of buildings and heating systems and a trend away from manually fed fuel wood boilers and ovens. A decreasing energy demand for solid fuel (fuel wood, coal) is also responsible for $PM_{2.5}$ reductions. Furthermore, projected emission factors for new boilers in buildings are lower for future installations (see also 'ecodesign' requirements in Chapter 3 of (UMWELTBUNDESAMT 2021b)).

Total $PM_{2.5}$ emissions of the sector Road Transport (including 'fuel export') are expected to decrease by about 25.8% (i.e. –0.64 kt) compared to 2019. Without 'fuel export' they are expected to decrease by about 23.0% (i.e. –0.52 kt) compared to 2019. Whereas exhaust emission from cars and trucks are expected to decrease by 2030 (due to penetration of vehicles fitted with filters), emissions from automobile road abrasion are set to increase slightly because of an increase in the total vehicle kilometres driven.

In the sector Energy Industries a slight decrease in $PM_{2.5}$ emissions is generally due to a decrease in biomass usage for electricity and heat generation.

Emissions from 1.A.2 Manufacturing Industries and Construction decreased by 61.6% between 2005 and 2019 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.

Mobile sources in industry (off-road) show a decrease by 74.5% (i.e. –0.08 kt) by 2030, mainly due to penetration of industrial off-road machinery fitted with particulate filters.

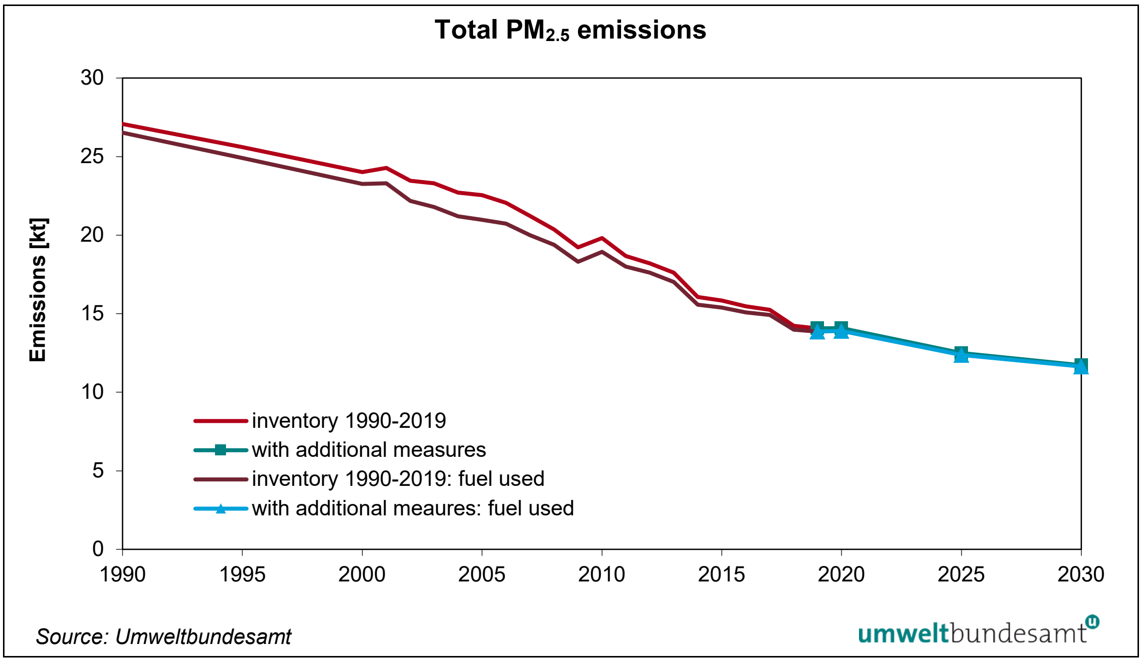

Figure 68: Historical (1990 to 2019) and projected emissions WAM (2020–2030) of $PM_{2.5}$ based on (a) fuel sold and (b) fuel used

In the scenario 'with additional measures' (WAM), the national total emissions including 'fuel export' are expected to decrease to 11.7 kt by 2030 (–48.0% compared to 2005). Without 'fuel export' they are expected to decrease to 11.6 kt (–44.5% compared to 2005).

$PM_{2.5}$ emissions of 1.A.4 Other Sectors are expected to decrease by 24.5% (i.e. –1.74 kt) by 2030 compared to 2019. Total $PM_{2.5}$ emissions of the sector Road Transport (including 'fuel export') are expected to decrease by about 33.1% (i.e. –0.82 kt) compared to 2019.

Due to a higher input of biomass in the energy consumption the $PM_{2.5}$ emissions in some combustion related sectors (e.g. 1.A.2) are slightly higher than in the WEM scenario.

Table 339: Austrian national $PM_{2.5}$ emissions in kt and trend based on (a) fuel sold and (b) fuel used (Source: Umweltbundesamt).

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Scenario
		1990	2005	2010	2019	2020	2025	2030	
	Total	27.07	22.56	19.81	14.06	13.96	12.71	11.7	fuel sold (WEM)
		27.07	22.56	19.81	14.06	14.08	12.49	11.7	fuel sold (WAM)
	Total	26.52	20.97	18.94	13.86	13.78	12.59	11.6	fuel used (WEM)
		26.52	20.97	18.94	13.86	13.90	12.38	11.6	fuel used (WAM)
1.A.1	Energy Industries	0.85	0.80	1.12	0.93	0.95	0.93	0.90	WEM
1.A.1	Energy Industries	0.85	0.80	1.12	0.93	0.98	0.90	0.91	WAM
1.A.2	Manufacturing Industries and Construction	1.90	1.85	1.52	0.71	0.71	0.79	0.82	WEM
1.A.2	Manufacturing Industries and Construction	1.90	1.85	1.52	0.71	0.71	0.81	0.83	WAM
1.A.3.a, c, d, e	Off-Road Transport	0.70	0.66	0.52	0.42	0.58	0.57	0.55	WEM
1.A.3.a, c, d, e	Off-Road Transport	0.70	0.66	0.52	0.42	0.58	0.57	0.55	WAM
1.A.3.b	Road Transportation	5.70	7.23	4.90	2.47	2.32	1.94	1.83	fuel sold (WEM)
		5.70	7.23	4.90	2.47	2.32	1.59	1.65	fuel sold (WAM)
1.A.3.b	Road Transportation	5.15	5.65	4.03	2.26	2.14	1.83	1.74	fuel used (WEM)
		5.15	5.65	4.03	2.26	2.14	1.17	0.96	fuel used (WAM)
1.A.4	Other Sectors	13.39	9.05	9.18	7.11	7.05	6.11	5.20	WEM
1.A.4	Other Sectors	13.39	9.05	9.18	7.11	7.15	6.25	5.36	WAM
1.A.5	Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	WEM
1.A.5	Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	WAM
1.B	Fugitive Emissions	0.11	0.09	0.07	0.06	0.06	0.05	0.04	WEM
1.B	Fugitive Emissions	0.11	0.09	0.07	0.06	0.06	0.05	0.04	WAM
2.A,B,C,H, I,J,K,L	Industrial Processes	3.29	1.83	1.37	1.36	1.25	1.26	1.26	WEM
2.A,B,C,H, I,J,K,L	Industrial Processes	3.29	1.83	1.37	1.36	1.25	1.26	1.26	WAM
2.D, 2.G	Solvent and Other	0.54	0.49	0.50	0.43	0.44	0.45	0.45	WEM

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Scenario
		1990	2005	2010	2019	2020	2025	2030	
	Product Use								
2.D, 2.G	Solvent and Other Product Use	0.54	0.49	0.50	0.43	0.44	0.45	0.45	WAM
3.B	Manure Management	0.13	0.11	0.11	0.11	0.11	0.11	0.11	WEM
3.B	Manure Management	0.13	0.11	0.11	0.11	0.11	0.11	0.11	WAM
3.D	Agricultural Soils	0.14	0.15	0.14	0.14	0.13	0.13	0.13	WEM
3.D	Agricultural Soils	0.14	0.15	0.14	0.14	0.13	0.13	0.13	WAM
3.F, I	Field Burning and Other Agriculture	0.09	0.08	0.06	0.02	0.02	0.02	0.02	WEM
3.F, I	Field Burning and Other Agriculture	0.09	0.08	0.06	0.02	0.02	0.02	0.02	WAM
5	Waste	0.23	0.21	0.29	0.29	0.31	0.33	0.38	WEM
5	Waste	0.23	0.21	0.29	0.29	0.31	0.33	0.38	WAM

**Data source: Austrian Air Emission Inventory 2020 (UMWELTBUNDESAMT 2021b)*

IE … included elsewhere; NA … not applicable; NO … not occurring

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 revised 2014 CLRTAP Reporting Guidelines (ECE/EB.AIR.125) both datasets shall be reported every four years from 2017 onwards for the year x-2.

In the current submission 2021 Austria reports data on gridded emissions based on fuel sold and on fuel used for the latest 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 are 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[164].

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 revised 2014 CLRTAP Reporting Guidelines (ECE/EB.AIR.125) the new "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 current Austrian Air Emission Inventory had to be adapted accordingly. 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 340 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).

[164] https://cdr.eionet.europa.eu/at/un/CLRTAP_AT/envt2haba/

Table 340: 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 341 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[165] as well as within the INSPIRE service infrastructure[166]. Therefore, it was possible to find contact persons and to clarify licensing issues.

Table 341: 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)[167]	2002–2019	Cadaster
River network	Danube, Shipping area	BMLRT[168]	2019	Vector data
Employees in the manufacturing industries sector	Economic activities on municipal level (NACE classification), register census 2011	Statistik Austria[169]	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[170]	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[171] /ÖBB[172]	2016/2019	Vector data
Traffic census points	Geo-referenced information on traffic census on motorways	ASFINAG[173]	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

[165] Austrian Open data Portal https://www.data.gv.at/ (23.4.2021)

[166] https://geometadatensuche.inspire.gv.at/metadatensuche/srv/ger/catalog.search#/home (23.4.2021)

[167] https://www.bev.gv.at/ (23.4.2021)

[168] Federal Ministry of Agriculture, Regions and Tourism https://www.bmlrt.gv.at/ (23.4.2021)

[169] https://www.statistik.at/web_de/statistiken/index.html (23.4.2021)

[170] https://www.umweltbundesamt.at/ (23.4.2021)

[171] http://www.gip.gv.at/ (23.4.2021)

[172] Austrian federal railways (ÖBB)

[173] http://www.asfinag.at/home-en (23.4.2021)

Data set	Data description	Data source	Year	Resolution/data specification
Animal livestock numbers	INVEKOS data base (Integrated Administration and Control) System (IACS)	Agrarmarkt Austria (AMA)[174]	2015, 2019	Points coordinates
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[175]	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:

[174] https://www.ama.at/Intro (23.4.2021)

[175] https://www.austrocontrol.at/ (23.4.2021)

- 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.
- 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 2020c).

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 1.2.

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 341). 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.

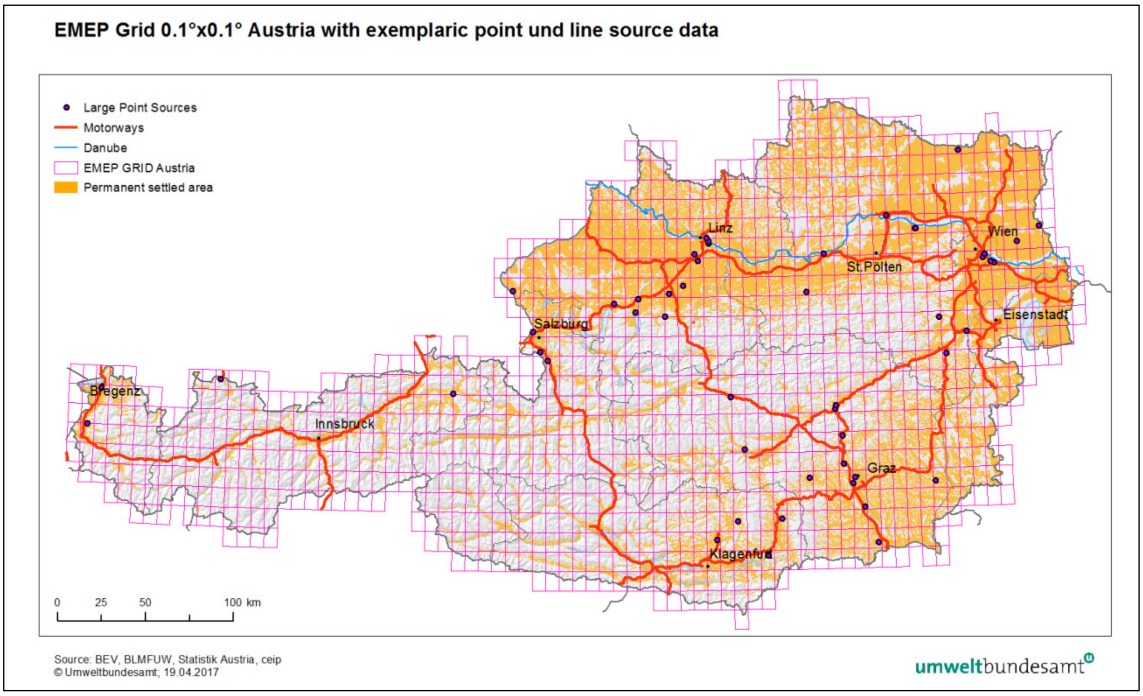

Figure 69: EMEP Grid Austria – example for allocation of the motorway network and waterways (Danube).

A short and simple example of the allocation of the motorway network and waterways (Danube) is illustrated in Figure 69 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

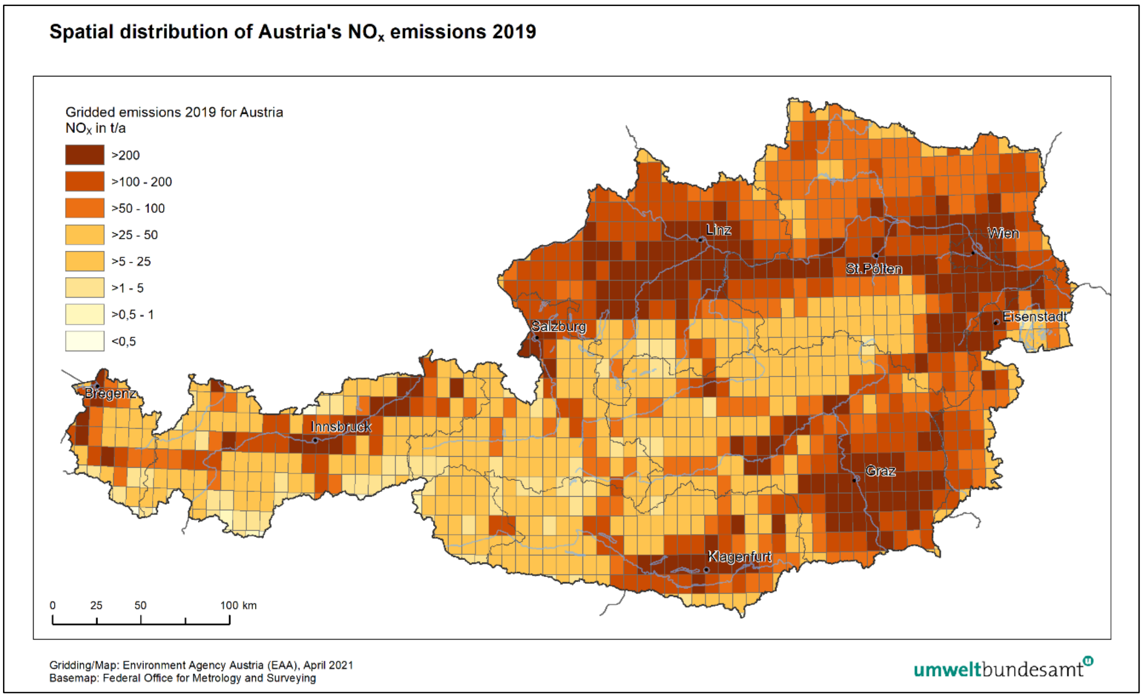

Figure 70: Spatial distribution of Austria´s NO_x emissions 2019 based on fuel sold.

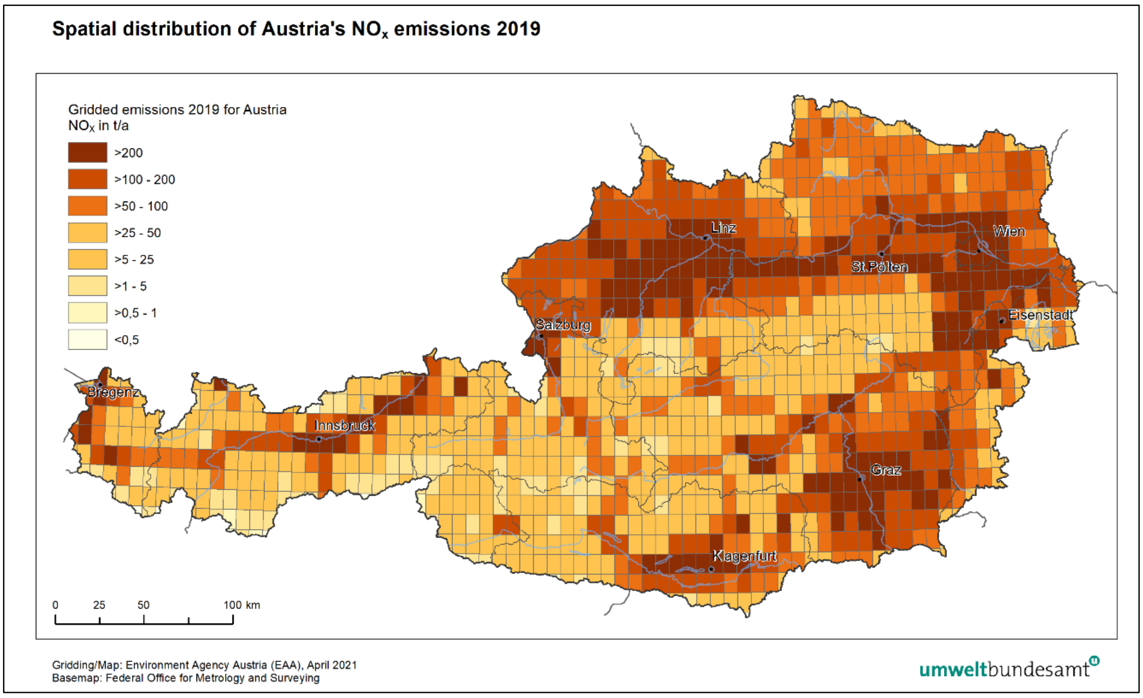

Figure 71: Spatial distribution of Austria´s NO_x emissions 2019 based on fuel used.

9.1.4.2 Spatial distribution of SO_2 emissions in 2019

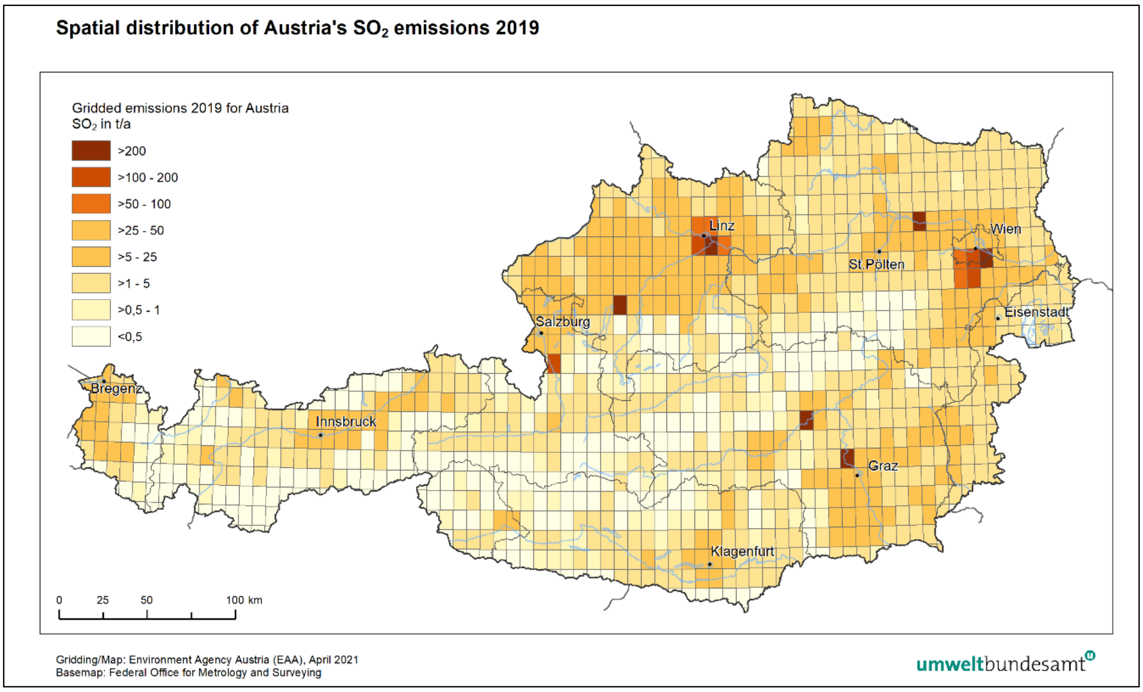

Figure 72: Spatial distribution of Austria´s SO_2 emissions 2019 based on fuel sold.

9.1.4.3 Spatial distribution of NMVOC emissions in 2019

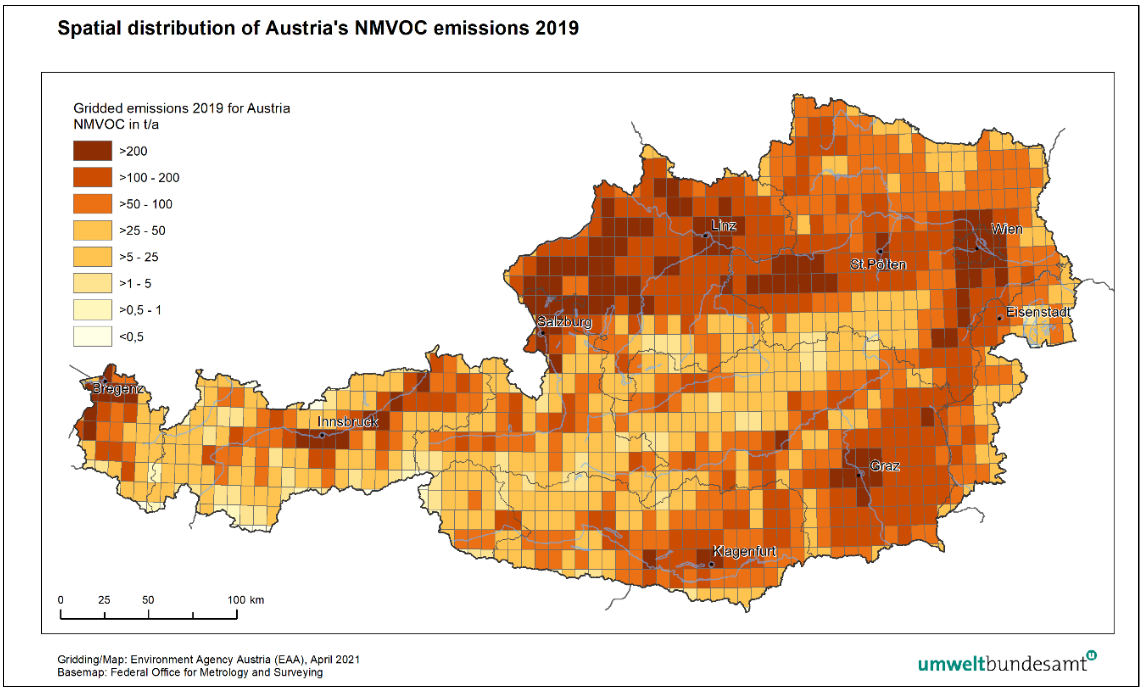

Figure 73: Spatial distribution of Austria´s NMVOC emissions 2019 based on fuel sold.

9.1.4.4 Spatial distribution of NH_3 emissions in 2019

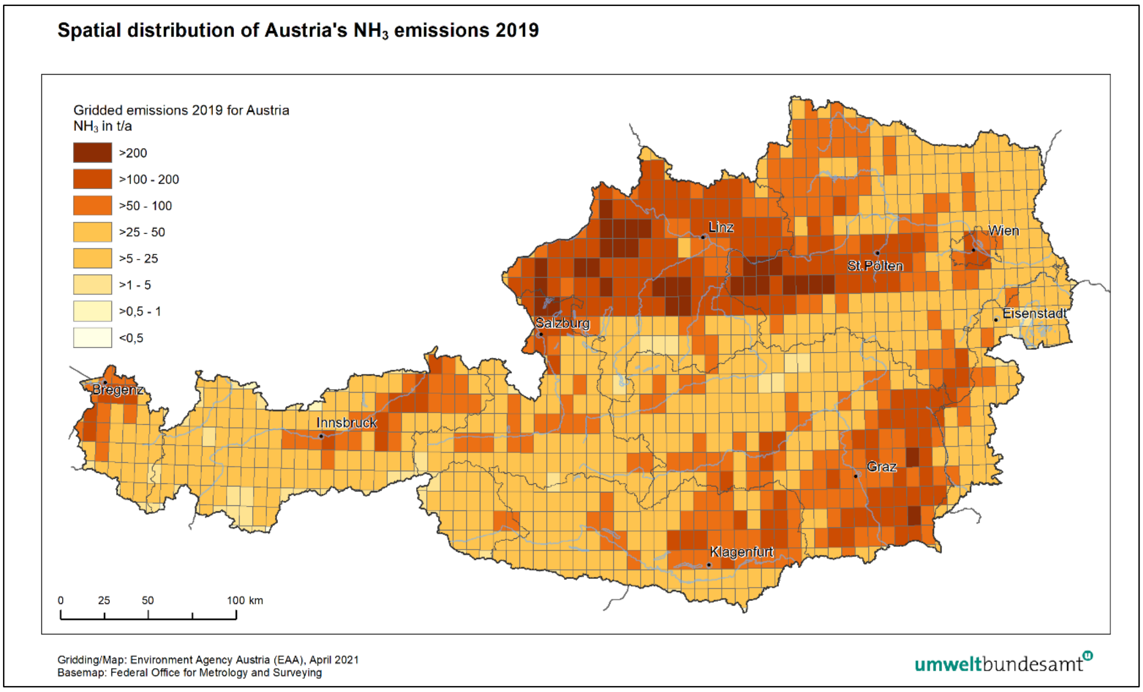

Figure 74: Spatial distribution of Austria´s NH_3 emissions 2019 based on fuel sold.

9.1.4.5 Spatial distribution of $PM_{2.5}$ emissions in 2019

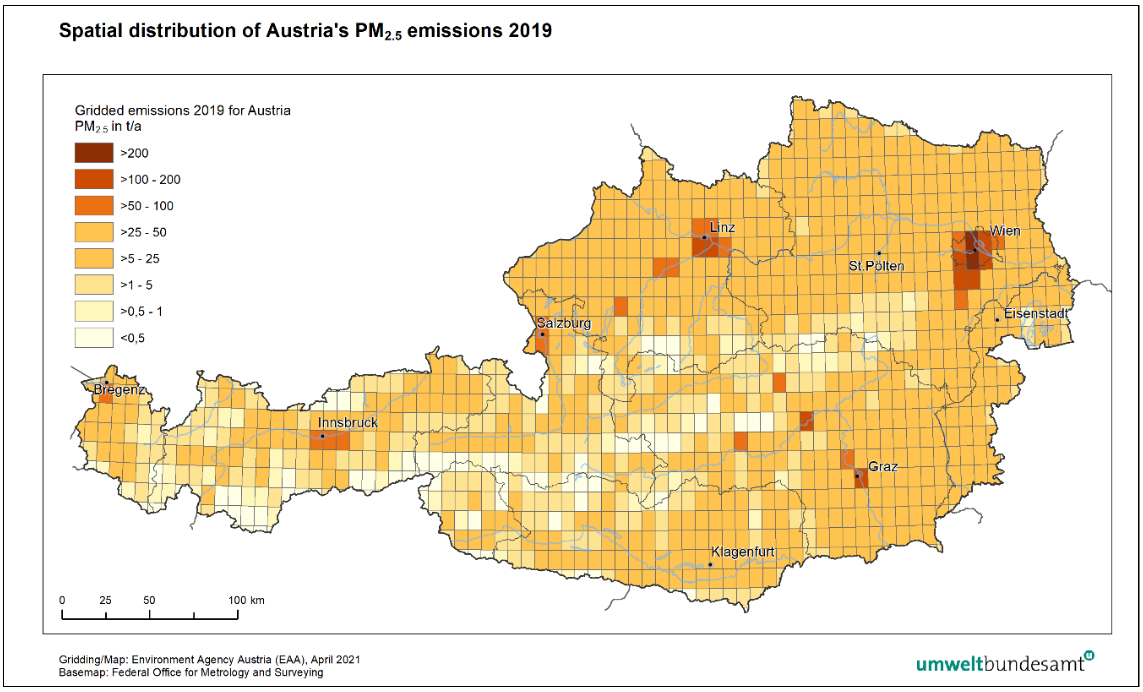

Figure 75: Spatial distribution of Austria´s $PM_{2.5}$ emissions 2019 based on fuel sold.

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 342: 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
Height Class (1-5)	LCP[176] 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[177]
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

Currently, no improvements are planned.

176 Large Combustion Plants

177 https://cdr.eionet.europa.eu/at/un/CLRTAP_AT/envt2haba/

10 REFERENCES

AMA (2020): Daten & Fakten der AgrarMarkt Austria für den Bereich Getreide und Ölsaaten. Düngemittelabsatzmengen in Österreich für 2015 bis 2019. Agrarmarkt Austria. Wien, September 2020.

AMANN, A. & DÄMON, M. (2011): Emissionsinventur für Festgesteinstagebaue in Österreich. Vertraulicher Endbericht. Fachverband Steine-Keramik, Bergbau-Stahl, Maria Enzersdorf/Bad Aussee.

AMLINGER (2003): information from Dipl. Ing. Florian Amlinger – Compost Consulting & Development. Hochbergstrasse A-2380, Perchtoldsdorf.

AMLINGER, F.; PEYR, S.; HILDEBRANDT, U.; MÜSKEN, J.; CUHLS, C. & CLEMENS, J. (2005): Stand der Technik der Kompostierung. Grundlagenstudie. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien. http://www.umweltnet.at/article/articleview/30919/1/6954.

AMON, B.; HOPFNER- SIXT, K. & AMON, T. (2002): Emission Inventory for the Agricultural Sector in Austria – Manure Management, Institute of Agricultural, Environmental and Energy Engineering (BOKU – University of Agriculture, Vienna), July 2002.

AMON, B.; FRÖHLICH, M.; WEIßENSTEINER, R.; ZABLATNIK, B. & AMON, T. (2007): Tierhaltung und Wirtschaftsdüngermanagement in Österreich. Endbericht Projekt Nr. 1441.Auftraggeber: Bundesministerium für Land- und Forstwirtschaft, Umwelt- und Wasserwirtschaft, Wien.

AMON, B. & HÖRTENHUBER, S. (2008): Revision der österreichischen Luftschadstoff-Inventur (OLI) für NH_3, NMVOC und NO_x; Sektor Landwirtschaft. Universität für Bodenkultur, Institut für Landtechnik im Auftrag vom Umweltbundesamt. Wien.

AMON, B. & HÖRTENHUBER, S. (2010): Revision of Austria's National Greenhouse Gas Inventory, Sector Agriculture. Final Report. Division of Agricultural Engineering (DAE) of the Department for Sustainable Agricultural Systems of the University of Natural Resources and Applied Life Sciences (BOKU), study on behalf of Umweltbundesamt GmbH. Wien (unpublished).

AMON, B. & HÖRTENHUBER, S. (2014): Implementierung der 2006 IPCC Guidelines und Aktualisierung von Daten zur landwirtschaftlichen Praxis in der Österreichischen Luftschadstoffinventur (OLI), Sektor Landwirtschaft. Endbericht. Universität für Bodenkultur, Institut für Landtechnik im Auftrag vom Umweltbundesamt. Wien 2014 (unpublished).

AMON, B. & HÖRTENHUBER, S. (2019): Implementierung der TIHALO II Ergebnisse sowie des EMEP/EEA Guidbooks 2016 in das Landwirtschafts-Emissionsmodell für die OLI 2018. Endbericht. Priv. Doz. Dr. nat. techn. Barbara Amon und Dr. nat. techn. Stefan Hörtenhuber (Forschungsinstitut für Biologischen Landbau FiBL) im Auftrag vom Umweltbundesamt. Wien 2019 (unpublished).

ANGERER, T. (1997): Stand der Mechanisch-Biologischen Restabfallbehandlung vor der Deponierung (MBRVD) in Österreich – November 1997 – MUL, Leoben.

ANGERER, T. & FRÖHLICH, M. (2002): Thermisch Regenerative Oxidation als Verfahren der Abluftreinigung bei mechanisch-biologischen Anlagen zur Behandlung von Abfällen. Schriftenreihe des BMLFUW.[178]

ASFINAG (2020): Analysis of mileage on Austrian highways for the years 2011 - 2019– nonstandard analysis (not published). ASFINAG data edited by Austrian Federal Ministry of Transport (bmvit), Wien, 2020.

[178] Study has not been published but can be made available upon request.

AUSTRIAN CHAMBER OF AGRICULTURE (2020): Statistical data of burning straw. Mag. Längauer (email), November 2020.

AUSTROCONTROL (2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019): Flight movements Austria – nonstandard analysis (not published). Austro Control.

AUSTROPAPIER (2002–2019): Jahresbericht Papierindustrie 2002 bis 2019. Fachverband der Österreichischen Papierindustrie. Internetdownloads. http://www.austropapier.at

BAAS, J. et al. (1995): Technical Paper to the OSPARCOM-HELCOM-UN/ECE Emission Inventory of Heavy Metals and Persistent Organic Pollutants. TNO-Report TNO-MEP-R 95/247, Delft/Berlin 1995.

BAILEY (2001): Global hexachlorobenzene emissions. Chemosphere 43, pp167–182.

BAUMGARTEN et al (2019): Baumgarten, A.; Spiegel, H.; Stüger, H. P.; Aldrian, U.; Stickler, Y.; Tribl, C; Anderl, M.; Haider, S.; Springer, J.: Anwendung von Harnstoff in der österreichischen Landwirtschaft. Endbericht zum Forschungsprojekt Nr. 101400. Agentur für Gesundheit und Ernährungssicherheit, Bundesanstalt für Agrarwirtschaft und Bergbauernfragen, Umweltbundesamt, Niederösterreichische Landes-Landwirtschaftskammer. Wien, 2019.

BAUMELER; BRUNNER; FEHRINGER; KISLIAKOVA & SCHACHMAYER (1998): Reduktion von Treibhausgasen durch Optimierung der Abfallwirtschaft (CH4). Schriftenreihe der Energieforschungsgemeinschaft im Verband der E-Werke Österreichs, Wien 1998.

BÄUMER et. al (2017): Fahrleistungserhebung 2014 – Inländerfahrleistung; Berichte der Bundesanstalt für Straßenwesen, Verkehrstechnik Heft V 290, August 2017.

BAYERISCHES LANDESAMT FÜR UMWELT (2008): Polychlorierte Biphenyle (PCB). http://www.lfu.bayern.de/umweltwissen/doc/uw_53_polychlorierte_biphenyle_pcb.pdf

BICHLER (2001): CORINAIR Emissionsinventur 1985–1999. FTU Forschungsgesellschaft Technischer Umweltschutz GmbH. Interner Bericht, Bd. IB-650. Umweltbundesamt, Wien.

BMLFUW – Bundesministerium für Umwelt (1995): Bundes-Abfallwirtschaftsplan Bundesabfallbericht 1995, Wien

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2001): Bundesabfallwirtschaftsplan. Bundesabfallbericht 2001, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2002a): Gewässerschutzbericht 2002.Gemäß § 33e Wasserrechtsgesetz BGBl. Nr. 215/1959 in der Fassung BGBl. I Nr. 156/2002, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2002b): Stubenvoll, J., Böhmer, S. & Szednyi, I.: Stand der der Technik in Abfallverbrennungsanlagen. Schriftenreihe des BMLFUW, Band 24/2002, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (1993–2002): Gewässerschutzbericht gemäß § 33e Wasserrechtsgesetz BGBl. Nr. 215/1959 i.d.F. BGBl. I Nr. 156/2002. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006a): Bundesabfallwirtschaftsplan (BAWP) (2006), Wien. www.bundesabfallwirtschaftsplan.at.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006b): Kommunale Abwasserrichtlinie der EU – 91/271 EWG, Österreichischer Bericht 2006. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2007): Sonderrichtlinie des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW) für das Österreichische Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft. Anlage I, Anhänge zum Agrarumweltprogramm und zur Tierschutzmaßnahme (ÖPUL 2007).

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2008a): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2008. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2008b): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2008. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2010): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2010. Wien

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2011): Bundes-Abfallwirtschaftsplan 2011. Wien. http://www.bundesabfallwirtschaftsplan.at/

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2012): Kommunale Abwasserrichtlinie der EU – 91/271/EWG. Österreichischer Bericht 2012. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2013): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2012. Wien.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2014a): Stork, C.; Windhofer, G. & Zieritz, I.: Kommunales Abwasser: Österreichischer Bericht 2014. Kombinierter Bericht gemäß Artikel 15 und Artikel 16 der Richtlinie 91/271/EWG für den Zeitraum 2011 – 2012. Wien, Juni 2014. http://www.bmlfuw.gv.at/wasser/wasserqualitaet/abwasserreinigung/Lagebericht2014.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2014b): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2013. Wien

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2015a): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2014. Wien, Dezember 2015. http://www.bundesabfallwirtschaftsplan.at/dms/bawp/AW_Statusbericht_2015_final.pdf

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2015b): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2015. Wien

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2016): Kommunales Abwasser. Österreichischer Bericht 2016. Wien. https://www.bmnt.gv.at/service/publikationen/wasser/Kommunales-Abwasser----sterreichischer-Bericht-2016.html

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2017): Richtlinien für die sachgerechte Düngung. 7. Auflage Fachbeirat für Bodenfruchtbarkeit und Bodenschutz. Wien.

BMLRT – Bundesministerium für Nachhaltigkeit und Tourismus (2000-2020): Grüner Bericht 1999, 2000, 2002, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. Grüner Bericht gemäß § 9 des Landwirtschaftsgesetzes BGBl. Nr. 375/1992. Bundesministerium für Landwirtschaft, Regionen und Tourismus, Wien. www.gruenerbericht.at.

BMLRT– Bundesministerium für Landwirtschaft, Regionen und Tourismus (2019, 2020): Österreichisches Montanhandbuch 2012, 2020. Wien

BMLRT – Bundesministerium für Landwirtschaft, Regionen und Tourismus (2020a): Kommunales Abwasser. Österreichischer Bericht 2020. Wien. https://www.bmlrt.gv.at/dam/jcr:40608892-831f-40d1-bc22-106972fb1ef4/Lagebericht_2020.pdf

BMLRT – Bundesministerium für Landwirtschaft, Regionen und Tourismus (2020c): Stickstoffbilanzen 2012-2018: Berechnung auf Grundwasserkörper-Ebene. Harald Loishandl-Weisz, Bettina Schwarzl, Thomas Rosmann, Ingrid Gattringer (Umweltbundesamt GmbH); Ottavia Zoboli (TU Wien, Institut für Wassergüte und Ressourcenmanagement). Gesamtumsetzung: Günter Eisenkölb (Umweltbundesamt GmbH). Wien 2020.

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus (2017): Bundes-Abfallwirtschaftsplan 2017. Wien. http://www.bundesabfallwirtschaftsplan.at/

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus (2018a): Die Bestandsaufnahme der Abfallwirtschaft in Österreich. Statusbericht 2018. Wien.

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus (2018b): Kommunales Abwasser Österreichischer Bericht 2018. Wien.

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus (2019): Österreichisches Montanhandbuch 2018. Wien.

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2020): Winter, R.; Biokraftstoffe im Verkehrssektor 2020 – Gesamtbericht, BMK, Wien 2020. https://www.bmk.gv.at/themen/energie/energieversorgung/biomasse/alternative-kraftstoffe/biokraftstoffbericht.html

BMWA – Bundesministerium für wirtschaftliche Angelegenheiten (1990): Energiebericht (EB) der Österreichischen Bundesregierung, Wien. (BMWA–EB).

BMWA – Bundesministerium für wirtschaftliche Angelegenheiten (1996): Energiebericht (EB) der Österreichischen Bundesregierung, Wien. (BMWA–EB).

BMWA (1999): Energiebericht der Österreichischen Bundesregierung 1999. Bundesministerium für wirtschaftliche Angelegenheiten, Wien. Anhang Emissionsfaktoren. Wien, 1999.

BMWA–EB (2003): Energiebericht der Österreichischen Bundesregierung 2003. Bundesministerium für wirtschaftliche Angelegenheiten, Wien. Anhang 3, Emissionsfaktoren als Grundlage für die österreichische Luftschadstoffinventur. Wien, 2003.

BMWFJ – Bundesministerium für Wirtschaft und Arbeit (1991–2014): Österreichisches Montan-Handbuch 1991–2014. Bergbau – Rohstoffe – Grundstoffe – Energie, Wien 2014.

BMWFW – Bundesministerium für Wissenschaft, Forschung und Wirtschaft (2015, 2016, 2017,2018): Österreichisches Montanhandbuch 2016, 2017. Wien.

BMVIT – Bundesministerium für Verkehr, Innovation und Technologie (2019): Yearly growth rates on Austrian road network; nonstandard analysis (not published). Wien, 2019.

BOOS, R. & C. HÜBNER (1999): PCDD/F-Emissionen aus dem Hausbrand in Wien. Studie im Auftrag der MA22, Fernwärme Wien GmbH. und Wiener Stadtwerke Wiengas.

BOOS, R. (2001): Stand der Technik bei der Herstellung von keramischen Erzeugnissen durch Brennen. Studie im Auftrag des BMLFUW.

BRUNSTERMANN, R. (2007): Übung Biologische Abfallbehandlung Teil 1; Universität Essen. https://www.uni-due.de/imperia/md/content/abfall/__bungbiologie1bsc2007.pdf

BUCHGRABER, K.; AMLINGER, F. & TULNIK, R. (2003) Produktion und Einsatz von Kompost in der Landwirtschaft und im Gemüsebau; Landwirt Heft 12/2003 Sonderbeilage.

BUNDESANSTALT FÜR AGRARWIRTSCHAFT (2020): Federal Institute of Agricultural Economics. Download from data pool. http://www.awi.bmlfuw.gv.at.

BUWAL – Bundesamt für Umwelt, Wald und Landschaft (1995): Emissionsfaktoren für stationäre Quellen, Bern.

BV Oberösterreich (2015): Brandschadenstatistik der österreichischen Brandverhütungsstellen. https://www.bvs-ooe.at/services-und-leistungen/brandschadenstatistiken/

BV Oberösterreich (2018). Brandschadenstatistik der österreichischen Brandverhütungsstellen. https://www.bvs-ooe.at/services-und-leistungen/brandschadenstatistiken/

CONCAWE (2017): CONCAWE Report no. 4/17, Air pollutant emission estimation methods for E-PRTR reporting by refineries, Brussels 2017

CORINAIR (1995): EMEP/CORINAIR Emission Inventory Guidebook, UNECE/EMEP TASK FORCE ON EMISSION INVENTORIES AND PROJECTIONS, Geneva, 1996.

CORINAIR (1997): Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook, European Environment Agency, Copenhagen 1997.

DIPPOLD, M.; REXEIS, M. & HAUSBERGER, S. (2012): NEMO – A Universal and Flexible Model for Assessment of Emissions on Road Networks. 19th International Conference „Transport and Air Pollution", 26.–27.11.2012, Thessaloniki.

DLG – Deutsche Landwirtschafts-Gesellschaft (1997): DLG-Futterwerttabelle für Wiederkäuer. 7. erweiterte und überarbeitete Auflage. DLG-Verlag, Frankfurt/Main, Germany.

DOEDENS, H.; CUHLS, C.; MÖNKEBERG, F.; LEVSEN, K.; KRUPPA, J.; SÄNGER, U. & KOCK, H. (1999): Bilanzierung von Umweltchemikalien bei der biologischen Vorbehandlung von Restabfällen, Phase 2: Emissionen, Schadstoffbilanzen und Abluftbehandlung. BMB+F Verbundvorhaben: Mechanisch-biologische Vorbehandlung von zu deponierenden Abfällen.

DÖHLER, H.; EURICH-MENDEN, B.; DÄMMGEN, U.; OSTERBURG, B.; LÜTTICH, M.; BERGSCHMIDT, A.; BERG, W. & BRUNSCH, R. (2002): BMVEL/UBA-Ammoniak-Emissionsinventar der deutschen Landwirtschaft und Minderungsszenarien bis zum Jahre 2010. Texte 05/02. Umweltbundesamt, Berlin.

E-CONTROL (2008): Ökostrombericht 2008. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. Oktober 2008. Wien.

E-CONTROL (2010): Ökostrombericht 2010. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. Juli 2009. Wien.

E-CONTROL (2011): Ökostrombericht 2011. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. November 2011. Wien.

E-CONTROL (2013): Ökostrombericht 2013. Bericht der Energie-Control GmbH gemäß § 25 Abs 1 Ökostromgesetz. November 2013. Wien.

E-CONTROL (2013): Rohstoffbilanzen für 2011. Personal communication by DI Michael Sorger, 18.09.2013.

E-CONTROL (2014): https://www.e-control.at/documents/20903/388512/Oekostrombericht2014_final.pdf/7e117100-8b19-46e0-97bb-e9dde843fa8f, accessed December 2014.

E-CONTROL (2015): http://www.e-control.at/portal/page/portal/medienbibliothek/publikationen/dokumente/pdfs/Oekostrombericht2014_final.pdf, accessed January 2016.

E-CONTROL (2016): https://www.e-control.at/documents/20903/388512/e-control-oekostrombericht-2016.pdf/bbd26620-e1a3-4243-aed7-33c95e317d7a, accessed in December 2016.

E-CONTROL (2017): https://www.e-control.at/documents/20903/388512/e-control-oekostrombericht-2017.pdf/ce32088b-b8dc-85d3-2585-c6af224b3113 accessed in November 2017.

E-CONTROL (2018): https://www.e-control.at/documents/20903/388512/%C3%96kostrombericht_2018.pdf/6d5a9de6-7b65-5c72-740e-3a8d16282368 accessed in November 2018.

E-CONTROL (2019): https://www.e-control.at/documents/1785851/1811582/%C3%96kostrombericht_FINAL.pdf/f689b909-2088-77b0-0c9e-eeb260effe7b?t=1569999423109 accessed in October 2019.

E-CONTROL (2020): EC_Ökobericht20_08.09_NEU.indd (e-control.at) accessed in October 2020.

EC – European Commission (2017): 2017 Comprehensive Technical Review of National Emission Inventories pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (Directive (EU) 2016/2284). Final Review Report for Austria. 30 November 2017. http://ec.europa.eu/environment/air/reduction/implementation.htm

EC – European Commission (2018): Second phase of review of national air pollution emission inventory data pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (Directive (EU) 2016/2284 or 'NECD'). Final Review Report 2018 for Austria. 30 November 2018. http://ec.europa.eu/environment/air/reduction/implementation.htm

EC – European Commission (2019): Third phase of review of national air pollution inventory data pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (Directive (EU) 2016/2284 or 'NECD'). Final Review Report 2019 for Austria. 22 November 2019. http://ec.europa.eu/environment/air/reduction/implementation.htm

EC – European Commission (2020): Review of National Air Pollutant Emission Inventory Data 2020 under Directive 2016/2284 (National Emission reduction Commitments Directive) Service Contract No. 070201/2019/8159797/SER/ENV.C.3. Final Review Report 2020 for Austria. 20 November 2020. http://ec.europa.eu/environment/air/reduction/implementation.htm

EEA – European Environment Agency (2007): EMEP/CORINAIR Emission Inventory Guidebook – 2006. Technical Report No. 11. Copenhagen 2007.

EEA – European Environment Agency (2009): EMEP/EEA air pollutant emission inventory guidebook — 2009. Technical report No 9/2009. Copenhagen 2009.

EEA – European Environment Agency (2013): EMEP/EEA air pollutant emission inventory guidebook – 2013. EEA Technical report No. 12/2013. http://www.eea.europa.eu/publications/emep-eea-guidebook-2013

EEA – European Environment Agency (2016): EMEP/EEA air pollutant emission inventory guidebook – 2016. EEA Technical report No. 21/2016. http://www.eea.europa.eu/publications/emep-eea-guidebook-2016

EEA – European Environment Agency (2019): EMEP/EEA air pollutant emission inventory guidebook – 2019. EEA Technical report No. 19/2019. https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

EEA (2020): 2020 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 4(3) of Regulation (EU) No 2018/842 and to Article 3 of Decision No 406/2009/EC – Austria. Final Review Report. August 2020.

EIDGENÖSSISCHE FORSCHUNGSANSTALT FÜR AGRARÖKOLOGIE UND LANDBAU ZÜRICH-RECKENHOLZ, INSTITUT FÜR UMWELTSCHUTZ UND LANDWIRTSCHAFT LIEBEFELD (1997): Ammoniak-Emissionen in der Schweiz: Ausmass und technische Beurteilung des Reduktionspotentials. Schriftenreihe FAL 26. Eidgenössische Forschungsanstalt für Agrarökologie und Landbau, Zürich.

EGLE, L.; RECHBERGER, H. & ZESSNER, M. (2014): Phosphorbilanz Österreich Grundlage für ein nachhaltiges Phosphormanagement – gegenwärtige Situation und zukünftige Entwicklung; Hrsg. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Sektion VII Wasser.

EMPA – Eidgenössische Materialprüfungs- und Forschungsanstalt (2004): Fischer, A.; Emmenegger, L. & Künninger, T.: PM_{10}-Emissionen bei Anlagen der Holzbearbeitung in der Schweiz, Forschungsbericht 115/53, Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA), Dübendorf.

EPA – U.S. Environmental Protection Agency (1993): Locating and Estimating Air Emissions from Sources of Cadmium and Cadmium Compounds, U.S. EPA, EPA-A-454/R-93-040, Sep 1993.

EPA – U.S. Environmental Protection Agency (1997): Locating and Estimating Air Emissions from Sources of Mercury and Mercury Compounds. U.S.EPA, EPA-454/R-97-012, Dec 1997.

EPA – U.S. Environmental Protection Agency (1998):The Inventory of Sources of Dioxin in the United States. External Review Draft. EPA/600/P-98/002Aa.

EPA – U.S. Environmental Protection Agency (1999): AP-42. Compilation of Air Pollutant Emission Factors, 5th edition. Chapter 13.2 fugitive dust sources. U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/otaq/ap42.htm

EUROPEAN COMMISSION IPPC BUREAU (2000): BAT-Reference Document in the Non Ferrous Metals Industries. Final Report, May 2000.

FAO AGR. STATISTICAL SYSTEM (2001): FAO Agricultural Statistical System. http://faostat.fao.org/site/339/default.aspx

FEDERAL ASSOCIATION OF VINICULTURE (Bundesweinbauverband Österreich) (2001): Expert Judgement. Dr. Johannes Schima and DI Glatt. Presidential Conference of Austrian Agricultural Chambers (email).

FEDERAL ENVIRONMENT AGENCY GERMANY (2013): Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2013. National Inventory Report for the German Greenhouse Gas Inventory 1990–2011. Dessau, 15.05.2013.

FLÖGL, W. (2002): Klimarelevanz der Deponien in Oberösterreich. Hydro Consulting Engineers. Erstellt im Auftrag für das Amt der OÖ Landesregierung. Abteilung Umweltschutz, UA Abfallwirtschaft. Linz.

FOEN –FEDERAL OFFICE FOR THE ENVIRONMENT (BAFU – Bundesamt für Umwelt) (2015): Faktenblatt Emissionsfaktoren Feuerungen. Schweiz, Juni 2015.

FTU – Forschungsgesellschaft Technischer Umweltschutz (2000): measurements at Austrian plants by FTU. (not published).

FVGW FACHVERBAND DER GAS- UND WÄRMEVERSORGUNGSUNTERNEHMUNGEN (2020): Erhebungen zur Österreichischen Luftschadstoff-Inventur (OLI) 2020 – Auswertung Rohrleitungsnetz GAS in Österreich für die Jahre 2002 bis 2019 (personal communication; Email 27.11.2020)

FVMI – FACHVERBAND DER MINERALÖLINDUSTRIE (1999-2019): Jahresberichte des Fachverbandes der Mineralölindustrie Österreichs. Jeweilige Jahresberichte für die Jahre 1999 bis 2018. Wien. https://www.wko.at/Content.Node/branchen/oe/Mineraloelindustrie/Jahresberichte.html

FVMI – Fachverband der Mineralölindustrie (2019): Erhebungen zur Österreichischen Luftschadstoff-Inventur (OLI) 2018 – Emissionen der Mineralölkette (personal communication; Email 19.11.2019).

GERMAN ENVIRONMENT AGENCY (2008): Struschka, M.; Kilgus, D.; Springmann, M. & Baumbach, G.: Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung. Forschungsbericht 205 42 322. UBA-FB 001217. Umweltbundesamt, 2008.

GEBETSROITHER, E.; STREBEL, F. & ORTHOFER, R. (2002): Greenhouse Gas Emissions from Enteric Fermentation in Austria; ARC Seibersdorf research, July 2002.

GILBERG et al. (2005): Waste management in Europe and the Landfill Directive. Background paper from the ETC/RWM to the ETC/ACC workshop "Inventories and Projections of Greenhouse Gas Emissions from Waste". European Environment Agency, 2005.

GRUBER, L. & PÖTSCH, E. M. (2006): Calculation of nitrogen excretion of dairy cows in Austria. Die Bodenkultur, 2006, Vol. 57, Heft 1-4, Vienna.

HACKL, A. & MAUSCHITZ, G. (1995, 1997, 2001, 2003, 2007, 2017, 2018, 2019): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

HACKL, A. & MAUSCHITZ, G. (1999): Beiträge zum Klimaschutz durch nachhaltige Restmüllbehandlung. Studie im Auftrag des Bundesministeriums für Umwelt, Jugend und Familie, Weitra.

HARTMANN, H., BÖHM, TH. & MAIER, L. (2000): Naturbelassene biogene Festbrennstoffe – umweltrelevante Eigenschaften und Einflussmöglichkeiten. Studie im Auftrag des Bayerischen Landesamt für Umweltschutz. September 2000, pp.94.

HAUSBERGER, S. & KELLER, M. et al. (1998): Handbuch der Emissionsfaktoren des Straßenverkehrs in Österreich. Im Auftrag des Umweltbundesamtes; BMLFUW und BMVIT. Wien.

HAUSBERGER, S. (2000): Emissionen des Off-Road-Verkehrs im Bundesgebiet Österreich für die Bezugsjahre 1990 bis 1999. Institut für Verbrennungskraftmaschinen und Thermodynamik TU Graz, Graz. Unveröffentlicht.

HAUSBERGER, S. (2006): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2005; Erstellt im Auftrag des Umweltbundesamtes GmbH; Bericht Nr. FVT-88/06/ Haus Em 16/06-6790 vom 30.11.2006.

HAUSBERGER, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015a): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2013. FVT – Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2015.

HAUSBERGER, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015b): NEMO Methodenbericht im Rahmen des Projekts NEMO4U. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2015.

HAUSBERGER, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015c): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2014. FVT – Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2015.

MATZER C., WELLER K., DIPPOLD M., LIPP S., RÖCK M., REXEIS M., HAUSBERGER S.(2019): Update of emission factors for HBEFA Version 4.1; Final report, I-05/19/CM EM-I-16/26/679 from 09.09.2019, TU Graz https://www.hbefa.net/d/documents/HBEFA41_Report_TUG_09092019.pdf

HÄUSLER, J. (2009): Das Leistungspotenzial von Fleckviehmutterkühen – Versuchsergebnisse des LFZ Raumberg-Gumpenstein. Fachtag „Erfolgreiche Mutterkuhhaltung“. Fachschule Warth.

HEDMAN, B.; NÄSLUND, M. & MARKLUND, S. (2006): Emission of PCDD/F, PCB and HCB from Combustion of Firewood and Pellets in Residential Stoves and Boilers, Environmental Science & Technology, 2006, 40.

HINZ, T. & VAN DER HOEK, K. (2006): PM Emissions from Arable Agriculture. Paper presented at the Agriculture and Nature expert Panel, 7th Joint Task Force & EIONET Meeting on emission Inventories and Projections, Thessaloniki, Oct. 30 to Nov. 2, 2006.

HÜBNER, C. (2000): CORINAIR Dioxin-Emissionsinventur 1990. Studie im Auftrag des Umweltbundesamt, Wien.

HÜBNER, C. (2001a): Österreichische Emissionsinventur für Cadmium, Quecksilber und Blei 1995–2000. Studie im Auftrag des Umweltbundesamtes. FTU – Forschungsgesellschaft Technischer Umweltschutz GmbH, Wien.

HÜBNER, C. (2001b): Österreichische Emissionsinventur für POPs 1985–1999. Studie im Auftrag des Umweltbundesamt. Interner Bericht, Bd. IB-650. FTU – Forschungsgesellschaft Technischer Umweltschutz GmbH, Wien.

HÜBNER, C. et al. (1996): Emissionen aus mit Heizölen befeuerten Praxisanlagen im stationären Betriebszustand. Teil 1: Kleinfeuerungsanlagen bis 350 kW mit Heizöl Extraleicht, Erdöl, Erdgas, Kohle. 112/4. pp.170–174.

HÜBNER, C & R. BOOS (2000): Dioxinemissionen aus Haushaltsfeuerungen. Forschungsprojekt im Rahmen der Bund-Bundesländerkooperation. BMVIT 11/2000.

HÜBNER, C.; KUNA, R.; KRENAUER, A. & ÖLLER, F. (2002): HCB-Emissionen aus mit Festbrennstoffen betriebenen Kleinfeuerungsanlagen (≤ 50 kW). FTU – Forschungsgesellschaft Technischer Umweltschutz GmbH, Wien.

IEA – International Energy Agency (2020): IEA/EUROSTAT Joint Questionnaire (IEA JQ 2020). Submission 2020. Statistik Austria, Wien.

IPCC GUIDELINES (1997): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 1: Reporting Instructions, Vol. 2: Workbook, Vol. 3: Reference Manual. Intergovernmental Panel on Climate Change, Edited by J.T. Houghton, L.G. Meira Filho, B. Lim, K. Tréanton, I. Mamaty, Y. Bonduki, D.J. Griggs and B.A. Callander, Genf.

IPCC-GPG (2000): Report on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC Good Practice Report). Edited by J. Penman, D. Kruger, I. Galbally, T. Hiraishi, B. Nyenzi, S. Emmanuel, L. Buendia, R. Hoppaus, T. Martinsen, J. Meijer, K. Miwa and K. Tanabe, Japan.

IPCC – Intergovernmental Panel on Climate Change (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and anabe K. (eds). Published: IGES, Japan. http://www.ipcc-nggip.iges.or.jp/public/2006gl/

JENKINS, B.M. (1996): Atmospheric Pollutant Emission Factors from Open Burning of Agricultural and Forest Biomass by Wind Tunnel Simulations; Final Report (3 Vols.); CARB Project A932-126; California Air Resources Board, Sacramento, California.

KALIVODA, M. & KUDRNA, M. (1997): MEET – Methodology for calculating transport emissions and energy consumption. European Commission, DG VII, Belgium, Perchtoldsdorf/Vienna, 1997.

KALIVODA, M. & KUDRNA, M. (2002): Air Traffic Emission Calculation for Austria 1990–2000, study commissioned by Umweltbundesamt GmbH, Perchtoldsdorf, 2002. Study has not been published, but can be made available upon request.

KAKAREKA, S.; KUKHARCHYK, T. & KHOMICH, V. (2004): Research for HCB and PCB Emission Inventory Improvement in the CIS Countries (on an Example of Belarus) / Belarusian Contribution to EMEP. Annual report 2003. Minsk, 2004.

KAUSEL, A. (1998): Ein halbes Jahrhundert des Erfolges, Der ökonomische Aufstieg Österreichs im OECD-Raum seit 1950. Österreichische Nationalbank, Wien 1998.

KECK, M. (1997): Ammonia emission and odour thresholds of cattle houses with exer-cise yards, In: Voermans, J And Monteny, G (Eds): "Ammonia and odour emissions from animal production facilities", Proc. International Symposium, Vinkeloord, NL, 6–10. Oktober 1997, 349–354.

KLIMONT, Z.; J. COFALA, I.; BERTOK, M.; AMANN, C.; HEYES & GYARFAS, F. (2002): Modelling Particulate Emissions in Europe. A Framework to Estimate Reduction Potential and Control Costs, Interim Report IR-02-076, IIASA, Laxenburg.

KONRAD, S. (1995): Die Rinder-, Schweine- und Legehennenhaltung in Österreich aus ethologischer Sicht. WUV Universitätsverlag, Wien.

KRANERT, M. & CORD-LANDWEHR, K. (2010): Einführung in die Abfallwirtschaft; 4 vollständig aktualisierte und erweiterte Auflage; S. 226.

KREUZHUBER, D. (2013): Personal communications, 11.11.2013, 12.11.2013.

LAI-REPORT (1995): Erarbeitung von Anforderungen zur Emissionsbegrenzung von Dioxinen und Furanen. LAI-Schriftenreihe Bd. 9, Erich Schmidt Verlag Berlin 1995.

LANDESBETRIEB LANDWIRTSCHAFT HESSEN (2013): Nährstoffgehalte pflanzlicher Produkte zum Nährstoffvergleich. http://www.llh-hessen.de/pflanzenproduktion/duengung-boden/n-duengung/155-landwirtschaft/pflanzenproduktion/duengung-boden/567-naehrstoffgehalte-pflanzlicher-produkte-zum-naehrstoffvergleich.html (accessed 04.06.2014)

LANG, G.; LEUTGÖB, K. & LUTTER, E. (2003): Abschätzung der Entwicklung der NMVOC-Emissionen im Bereich der Kleinverbraucher. Energieverwertungsagentur, Wien.

LAUNHARDT, T. et al. (1998): PCDD/F- and PAH-Emission from House Heating Systems. Chemosphere Vol. 37. pp. 2013–2020.

LAUNHARDT, T.; HARTMANN, H.; LINK, H. & SCHMID, V. (2000): Verbrennungsversuche mit naturbelassenen biogenen Festbrennstoffen in einer Kleinfeuerungsanlage. Studie im Auftrag des Bayerischen Staatsministeriums für Landesentwicklung und Umweltfragen. September 2000, pp.95.

LEUTGÖB, K.; LANG, G.; LUTTER, E. & BENKE, G. (2003): Entwicklung der NO_x- und SO_2-Emissionen im Hausbrand. Energieverwertungsagentur, Wien.

LFU – Landesanstalt für Umweltschutz Baden-Württemberg (1992): Der Deponiegashaushalt in Altablagerungen – Leitfaden Deponiegas. Materialien zur Altlastenbearbeitung. Handbuch Altlasten und Grundwasserschadensfälle. Baden-Württemberg.

LÖHR, L. (1990): Faustzahlen für den Landwirt. 7. durchgesehene Auflage. Leopold Stocker Verlag, Graz-Stuttgart.

LÜKEWILLE, A.; BERTOK, I.; AMANN, M.; COFALA, J.; GYARFAS, F.; HEYES, C.; KARVOSENOJA, N.; KLIMONT, Z. & SCHOEPP, W. (2001): A Framework to Estimate the Potential and Costs for the Control of Fine Particulate Emissions in Europe. Interim Report IR-01-023, IIASA, Laxenburg.

MAGISTRAT DER LANDESHAUPTSTADT (MA) LINZ (1995): Bilanz der Quecksilberemissionen aus Quellen im Linzer Stadtgebiet. Amt für Umweltschutz, Linz.

MA22 (1998): Meßdaten der Wiener Verbrennungsanlagen, Unterlagen der MA 22; DI Hirhager, Oktober 1998.

MATZER, C.; WELLER, K.; DIPPOLD, M.; LIPP, S.; RÖCK, M.; REXEIS, M. & HAUSBERGER S. (2019): Update of emission factors for HBEFA Version 4.1; Final report, I-05/19/CM EM-I-16/26/679 from 09.09.2019, TU Graz https://www.hbefa.net/d/documents/HBEFA41_Report_TUG_09092019.pdf

MAUSCHITZ, G. (2004): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2003. Institut für Verfahrenstechnik. Umwelttechnik und Technische Biowissenschaften TU-Wien, Wien.

MAUSCHITZ, G. (2008): Emissionen aus Anlagen der österreichischen Zementindustrie. TU Wien.

MAUSCHITZ, G. (2010): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2009. TU Wien. http://www.zement.at/downloads/emissionen_2004_2009.pdf

MAUSCHITZ, G. (2011): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2010. TU Wien. http://www.zement.at/downloads/emissionen_2010.pdf

MAUSCHITZ, G. (2012): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2011. TU Wien. http://www.zement.at/downloads/emissionen_2011.pdf

MAUSCHITZ, G. (2012): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2012. TU Wien. http://www.zement.at/downloads/emissionen_2012.pdf

MAUSCHITZ, G. (2014): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2013. TU Wien. http://www.zement.at/downloads/emissionen_2013.pdf

MAUSCHITZ, G. (2015): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2014. TU Wien. http://www.zement.at/downloads/emissionen_2014.pdf

MAUSCHITZ, G. (2016): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2015. TU Wien. http://www.zement.at/downloads/emissionen_2015.pdf

MAUSCHITZ, G. (2017): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2016. TU Wien. http://www.zement.at/downloads/downloads_2017/Emissionen_2016.pdf

MAUSCHITZ, G. (2018): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2017. TU Wien. http://www.zement.at/downloads/downloads_2017/Emissionen_2017.pdf

MAUSCHITZ, G. (2019): Emissionen aus Anlagen der österreichischen Zementindustrie. Berichtsjahr 2019. TU Wien. https://www.zement.at/downloads/downloads_2020/Emissionen_2019.pdf

MEET – Methodology for calculating transport emissions and energy consumption (1999): European Commission, DG VII, Belgium.

MEISTERHOFER (1986): Reduktion der Kohlenwasserstoffemissionen aus Räucheranlagen (Selchanlagen). Studie im Auftrag des Umweltfonds. BmfGU.

MENZI, H.; RUETTIMANN, L. & REIDY, B. (2003): DYNAMO: A new calculation model for dynamic emission inventories for ammonia Proc Internat Symposium "Gaseous and odour emissions from animal production facilities", Horsens, Denmark, June 1-4 2.

MISSELBROOK, T.; WEBB, J.; CHADWICK, D.; ELIIS, S. & PAIN, B. (2001): Gaseous emissions from outdoor concrete yards used by livestock. Atmospheric Environment 35, 5331–5338.

MOLITOR, R.; HAUSBERGER, S.; BENKE, G. et al. (2004) Abschätzung der Auswirkungen des Tanktourismus auf den Kraftstoffverbrauch und die Entwicklung der CO_2-Emissionen in Österreich, Bericht im Auftrag von Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Trafico, Wien 2004.

MOLITOR, R; SCHÖNFELDER, S.; HAUSBERGER, S.; BENKE, G. et al. (2009) Abschätzung der Auswirkungen des Kraftstoffexports im Tank auf den Kraftstoffabsatz und die Entwicklung der CO_2- und Luftschadstoffemissionen in Österreich – Aktualisierung 2007 und Prognose 2030. Bericht im Auftrag von Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft und Bundesministerium für Verkehr, Innovation und Technologie. Wien 2009. Study has not been published, but can be made available upon request.

NUSSBAUMER, T. (1994): Ergebnisse von Dioxinmessung an Holzfeuerungen in der Schweiz. In: Dioxine bei Feuerungen für Holz und andere Festbrennstoffe. WKI-Bericht Nr.30, R.Marutzky (Hrsg.), 1994.

OBERNBERGER, I. (1995): Sekundärrohstoff Holzasche. Dissertation, Technische Universität Graz, 1994.

OETTL, D. & FUNK, R. (2007): PM emission factors for farming activities by means of dispersion modeling. Paper presented at the International Conference "Particulate Matter in and from Agriculture" 2007, Braunschweig.

ÖBFV – Österreichischer Bundesfeuerwehrverband. Statistik 2017. Ein Kurzüberblick über das Leistungsspektrum der österreichischen Feuerwehren, https://www.bundesfeuerwehrverband.at/wp-content/uploads/2018/03/Statistik-2017-3.pdf

ÖBFV – Österreichischer Bundesfeuerwehrverband (2019). Telefonische Auskunft zu Brandschäden (Pkw und Lkw) im Jahr 2018, eingeholt am 26.11.2019. Wien.

ÖBFV – Österreichischer Bundesfeuerwehrverband (2020). Telefonische Auskunft zu Brandschäden (Pkw und Lkw) im Jahr 2019, eingeholt am 11.12.2020. Wien

ÖFZS – Österreichisches Forschungszentrum Seibersdorf (1991): Orthofer, R.; Knoflacher, M.; Loibl, W. et al.: Abschätzung der Methan-Emissionen in Österreich. Studie im Auftrag des Bundesministeriums für Umwelt, Jugend und Familie (unpubl.), Seibersdorf 1991.

ÖWAV – Österreichischer Wasser- und Abfallwirtschaftsverband (2003): ÖWAV Arbeitsbehelf EPER. Arbeitsbehelf zur Abschätzung von Emissionen in Luft und Wasser. Reststoff- und Massenabfalldeponie gemäß EPER-V (BGBl. II Nr. 300/2002). Wien 2003.

ÖWAV – Österreichischer Wasser- und Abfallwirtschaftsverband (2004): ÖWAV-Regelblatt Nr. 17 – Landwirtschaftliche Verwertung von Klärschlamm 2004 – www.oewav.at

ÖWAV – Österreichischer Wasser- und Abfallwirtschaftsverband (2015): Branchenbild der österreichischen Abwasserwirtschaft 2016. Wien. 2015. https://www.publicconsulting.at/fileadmin/user_upload/media/umweltfoerderung/Dokumente_Betriebe/Wasser_Betriebe/Studien_Wasserwirtschaft/Branchenbild_2016.pdf

ORTHOFER, R. & VESELY, A. (1990): Abschätzung von toxischen Emissionen (PCDD, PCDF, PAK, BaP) aus Verbrennungsprozessen in Österreich. Österreichisches Forschungszentrum Seibersdorf. ÖSTAT Industrie- und Gewerbestatistik: Teil 1, Hefte 850, 948, 1036, 1115, 1188.

ORTHOFER R. (1996): Abschätzung der Emissionen von ausgewählten Schwermetallen in die Atmosphäre für Österreich im Stichjahr 1994 gemäß CORINAIR 1994, Österreichisches Forschungszentrum Seibersdorf, 1996.

ORTHOFER, R.; LOIBL, W. & KÖSTL, M. (2002): Räumliche Disaggregationder österreichischen Luftschadstoffinventur (OLI) für die Jahre 1990, 1995 und 2000 auf das EMEP 50 x 50 km2 Raster. ARC Seibersdorf research Report, ARC S-0166, 66 pp., Juni 2002. (unpublished).

ORTHOFER, R. (2007): Räumliche Disaggregationder österreichischen Luftschadstoffinventur (OLI) für die Jahre 1990, 1995, 2000 und 2005 auf das EMEP 50 x 50 km^2 Raster. ARC Seibersdorf research Report, ARC--sys-0125, 90 pp., April 2007. Projektendbericht. (unpublished).

ÖSTAT INDUSTRIE- UND GEWERBESTATISTIK: Teil 1, Hefte 850, 948, 1036, 1115, 1188: Ni und Nickellegierungen.

ÖNORM EN-1948-1: Edition: 2006-05-01. Stationary source emissions – Determination of the mass concentration of PCDDs/PCDFs and dioxin-like PCBs. Part 1: Sampling of PCDDs/PCDFs.

PFEIFFER, F.; STRUSCHKA, M. & BAUMBACH, G. (2000): Ermittlung der mittleren Emissionsfaktoren zur Darstellung der Emissionsentwicklung aus Feuerungsanlagen im Bereich Haushalte und Kleinverbraucher. UBA Forschungsbericht 295 46 364.

PHILIPPITSCH, R.; GRATH, J.; SCHIMON, W.; GMEINER, C.; DEUTSCH, K.; GRUBER, D.; TOMEK, H.; BONANI, M. & LASSNIG, M. (2001): Wassergüte in Österreich. Jahresbericht 2000 ("Austrian water protection report"). Erhebung der Wassergüte gemäß Hydrographiegesetz (BGBl. Nr. 252/90, i.d.g.F.). Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft in Zusammenarbeit mit der Umweltbundesamt GmbH, Wien.

PÖTSCH, E.M.; GRUBER, L. & STEINWIDDER, A. (2005): Answers and comments on the additional questions, following the meeting in Bruxelles. Internal statement. HBLFA Raumberg-Gumpenstein.

PÖLLINGER, A. (2008): National expert at the Agricultural Research and Education Centre Raumberg-Gumpenstein. Expert judgement to AWMS distribution 1990–2008 carried out in June 2008. Vienna.

PÖLLINGER, A. (2018): National expert at the Agricultural Research and Education Centre Raumberg-Gumpenstein. Expert judgements carried out within (AMON & HÖRTENHUBER 2019). Vienna.

PÖLLINGER, A. et al. (2018): Erhebung zum Wirtschaftsdüngermanagement aus der landwirtschaftlichen Tierhaltung in Österreich. Surveys on manure management from agricultural livstock farmings in Austria. Abschlussbericht TIHALO II. Projekt Nr./Wissenschaftliche Tätigkeit Nr. 3662. Pöllinger, A.; Brettschuh, S.; Lackner, L.; Stickler, Y.; Zentner, A.; HBLFA Raumberg Gumpenstein & Bundesanstalt für Agrarwirtschaft, Wien. Bundesministerium für Nachhaltigkeit und Tourismus (BMNT), Wien 2018.

PRESIDENTIAL CONFERENCE OF AUSTRIAN AGRICULTURAL CHAMBERS (2004): Judgement based on of the experts of Austria's agricultural chambers. E-mail from Dr. Reindl, Vienna.

PRESIDENTIAL CONFERENCE OF THE AUSTRIAN CHAMBERS OF AGRICULTURE (2006): Judgement based on of the experts of Austria's agricultural chambers. E-mail from Dr. Reindl, Vienna.

REIDY, B. & MENZI, H. (2005): Ammoniakemissionen in der Schweiz: Neues Emissionsinventar 1990 bis 2000 mit Hochrechungen bis 2003 Technischer Schlussbericht Schweizerische Hochschule für Zollikofen.

REIDY, B.; RIHM, B. & MENZI, H. (2007): A new Swiss inventory of ammonia emissions from agriculture based on a survey on farm and manure management and farm-specific model calculations, Reference: AEA7495, IN Journal: Atmospheric Environment.

REIDY, B.; DÄMMGEN, U.; DÖHLER, H.; EURICH-MENDEN, B.; EVERT, F. K. VAN; HUTCHINGS, N. J.; LUESINK, H. H.; MENZI, H.; MISSELBROOK, T. H.; MONTENY, G.J. & WEBB, J. (2008): Comparison of models used for national agricultural ammonia emission inventories in Europe : liquid manure systems. Atmospheric environment, Band 42, Heft 14, Seite 3452–3464, englisch. ISSN: 0004-6981.

REIDY, B.; WEBB, J.; MISSELBROOK, T.H.; MENZI, H.; LUESINK, H.H.; HUTCHINGS, N.J.; EURICH-MENDEN, B.; DÖHLER, H. & DÄMMGEN, U. (2009): Comparison of models used for national agricultural ammonia emission inventories in Europe: Litter-based manure systems. Atmospheric environment, Band 43, Heft 9, Seite 1632–1640, englisch. ISSN: 0004-6981.

RESCH, R.; GUGGENBERGER, T.; WIEDNER, G.; KASAL, A.; WURM, K.; GRUBER, L.; RINGDORFER, F. & BUCHGRABER, K. (2006): Futterwerttabellen im Jahr 2006 für das Grundfutter im Alpenraum. Available from Website https://www.raumberg-gumpenstein.at/cm4/de/

REXEIS, M. et al. (2013): Emissionen aus Kalt- und Kühlstarts sowie aus AdBlue-Verwendung in SCR-Katalysatoren von Lkw, LNF, 2-Rädern sowie von mobilen Maschinen. Erstellt im Auftrag des Umweltbundesamtes GmbH. Graz, 2013.

RÖMPP LEXIKON CHEMIE (1996–1999): 10. Auflage, Band 3: H – L.

SCHECHTNER (1991): Wirtschaftsdünger – Richtige Gewinnung und Anwendung. Sonderausgabe des Förderungsdienst 1991. BMLF, Wien.

SCHEIDL, K. (1996): Österreichische Emissionsinventur für Luftschadstoffe PAH. Studie im Auftrag des Umweltbundesamtes, Wien.

SCHMIDT, A.; VITOVEC, W.; PUXBAUM, H. & KNIERIDER, R. (1998): Die ökologischen Auswirkungen der Lösungsmittelverordnung 1991 und 1995. TU Wien. Gesellschaft Österreichischer Chemiker, Wien.

SCHWINGSHACKL, M.; REXEIS, M. & WELLER, K. (2020A): Update der Emissionsfaktoren und Aktivitätsdaten von NRMM für die Inventur OLI2020. Erstellt im Auftrag der Umweltbundesamt GmbH. Bericht Nr. I-18/20/Schwings EM 20/05/679 vom 09.12.2020.

SORGER, A. (1993): Emissionen aus Heizungsanlagen in Österreich. Dissertation BOKU-Wien.

SPITZER, J. et al. (1998): „Emissionsfaktoren für feste Brennstoffe", Johanneum Research Report, Graz, Dezember 1998.

STANZEL, G.; JUNGMEIER, J. & SPITZER, J. (1995): Emissionsfaktoren und Energetische Parameter für die Erstellung von Energie und Emissionsbilanzen im Bereich Raumwärmeversorgung. Joanneum Research Graz, Graz.

STATISTIK AUSTRIA (2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015): Flight movements per aircraft type and airport (national and international) - nonstandard analysis (not published). Statistik Austria. Wien.

STATISIK AUSTRIA (div. Jahre) Wien: Statistisches Jahrbuch Österreich 1990–2019;
Industrie und Gewerbestatistik (1. Teil) 1990–1995;
Konjunkturerhebung im Produzierenden Bereich (Band 2.Bzw. 3) 1997–2019;
Der Außenhandel Österreichs 1. bis 4. Vierteljahr 1980–2019, Spezialhandel nach Waren und Ländern.
Konjunkturstatistik im Produzierenden Bereich ab 2008 – online, 2008–2019.

STATSTIK AUSTRIA (1990–2020): Agrarstrukturerhebungen 1990–2016. Schnellberichte. Statistik Austria. Wien 2018 http://www.statistik.at/web_de/services/publikationen/8/index.html

STATISTIK AUSTRIA (2018a): Derivation of suckling and weaned piglets numbers on the basis of daily weight gain and official livestock data of piglets < 20 kg. E-mail with expert judgement received on June 18th, 2018.

STATISTIK AUSTRIA (2018b): Agrarstrukturerhebung: Stichprobenerhebung 2016. Schnellbericht 1.17, Wien.

STATSTIK AUSTRIA (2000-2020): Verkehrsstatistik 2019. Statistik Austria 2020. Wien.

STATISTIK AUSTRIA (2020a): Allgemeine Viehzählung am 1. Dezember 2018. National livestock counting December 2019 published in: BMLRT 2020.

STEINWIDDER, A. & GUGGENBERGER, T. (2003): Erhebungen zur Futteraufnahme und Nährstoffversorgung von Milchkühen sowie Nährstoffbilanzierung auf Grünlandbetrieben in Österreich. Die Bodenkultur 54 (1). 49–66.

STEINWIDDER, A; HÄUSLER, J.; SCHAUER, A.; MAIERHOFER, G.; GRUBER, L.; GASTEINER, J. & PODSTATZKY, L. (2006): Einfluss des Absetztermins auf die Milchleistung und Körpermasse von Mutterkühen sowie die Zuwachsleistung von Mutterkuh-Jungrindern. Versuchsbericht. Extensively managed beef cows – Effects on animal health, reproductive success, performance of calves and economics. Experiment 2004 to 2008. Interim report. Agricultural Research and Education Centre, HBLFA Raumberg-Gumpenstein.

SYC, M., HORAK, J., HOPAN, F., KRPEC, K., TOMSEJ, T., OCELKA, T. & PEKAREK, V. (2011): Effect of Fuels and Domestic Heating Appliance Types on Emission Factors of Selected Organic Pollutants. Environmental Science & Technology, 2011.

UMWELTBUNDESAMT (1993): Knoflacher, M.; Haunhold, E.; Loibl, W. et al.: Ammoniak-Emissionen in Österreich 1990. Berechnung und Abschätzung sowie Regionalisierung auf Basis politischer Bezirke. Reports, Bd. 92-068, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1995): Boos, R.; Neubacher, F.; Reiter, B.; Schindlbauer, H. & Twrdik, F.: Zusammensetzung und Behandlung von Altölen in Österreich. Monographien, Bd. M-54. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1996): Hobinger G. & Maderner W.: PCB-Stoffbilanz Österreich. Monographien, Bd. M-079.Umweltbundesamt. Wien.

UMWELTBUNDESAMT (1997): Scharf, S.; Schneider, M. & Zethner, G.: Zur Situation der Verwertung und Entsorgung des kommunalen Klärschlamms in Österreich. Monographien, Bd. M-095. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1998a): GÖTZ, B.: Stickstoffbilanz der österreichischen Landwirtschaft nach den Vorgaben der OECD. Aktualisierte und erweiterte Fassung. Berichte, Bd. BE-087a. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (1998b): Lahl, U.; Zeschmar-Lahl, B. & Scheidl, K. : Abluftemissionen aus der mechanisch-biologischen Abfallbehandlung in Österreich. Klagenfurt.

UMWELTBUNDESAMT (2000a): Ecker, A. & Winter, B.: Stand der Technik bei Raffinerien im Hinblick auf die IPPC-Richtlinie. Monographien, Bd. M-119. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2000b): Boin, U.; Linsmeyer, T. et al: Stand der Technik in der Sekundäraluminiumerzeugung im Hinblick auf die IPPC-Richtlinie. Monographien, Bd. M-120. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2000c): Lahl, U.; Zeschmar-Lahl, B. & Angerer, T.: Entwicklungspotentiale der mechanisch-biologischen Abfallbehandlung. Eine ökologische Analyse. Wien

UMWELTBUNDESAMT (2001a): Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoff-Inventur. Stand 1999. Interner Bericht, Bd. IB-614. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001b): Häusler, G.: Emissionen aus Abfalldeponien 1980–1998, Interner Bericht, Bd. IB-623. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001c): Wiesenberger, H.: State-of-the-art for the production of nitric acid with regard to the IPPC directive. Monographien, Bd. M-150. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2001d): Grech, H. & Rolland, C.: Stand der Abfallbehandlung in Österreich im Hinblick auf das Jahr 2004. Berichte, Bd. BE-182. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2003a): Böhmer, S.; Schindler, I. & Szednyj, I.: Stand der Technik bei Kalorischen Kraftwerken und Referenzanlagen in Österreich. Monographien, Bd. M-162. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2003b): Rolland, C. & Scheibengraf, M.: Biologisch abbaubarer Kohlenstoff im Restmüll. Berichte, Bd. BE-236. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004a): Wieser, M. & Kurzweil, A.: Emissionsfaktoren als Grundlage für die Österreichische Luftschadstoffinventur Stand 2003. Berichte, Bd. BE-254. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004b): Rolland, C. & Oliva, J.: Erfassung von Deponiegas – Statusbericht von österreichischen Deponien. Berichte, Bd. BE-238. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2004c): Schindler, I.; Kutschera, U. & Wiesenberger, H.: Medienübergreifende Umweltkontrolle in ausgewählten Gebieten. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2005a): Stubenvoll, J.; Holzerbauer, E.; Böhmer, S. et al.: Technische Maßnahmen zur Minderung der Staub- und NO_x-Emissionen bei Wirbelschichtkesseln und Laugenverbrennungskesseln. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2005b): Schachermayer, E.: Vergleich und Evaluierung verschiedener Modelle zur Berechnung der Methanemissionen aus Deponien. Umweltbundesamt, Wien 2005. (not published).

UMWELTBUNDESAMT (2006a): Gager, M.: Emissionen Österreichischer Großfeuerungsanlagen 1990–2004. Reports, Bd. REP-0006. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2006b): Krutzler, T.; Böhmer, S.; Szednyj, I.; Wiesenberger, H. & Poupa, S.: NO_x-Emissionen 2003–2020. Emissionsprognose und Minderungspotenziale für Energieumwandlung und ausgewählte industrielle Sektoren. Report, Bd. REP-0040. Umweltbundesamt, Wien. (unpublished).

UMWELTBUNDESAMT (2006c): Salchenegger, S.: Biokraftstoffe im Verkehrssektor in Österreich 2006, Zusammenfassung der Daten der Republik Österreich gemäß Art. 4, Abs. 1 der Richtlinie 2003/30/EG für das Berichtsjahr 2005. Reports, Bd. REP-0068. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2007): Böhmer, S.; Fröhlich, M.; Köther, T.; Krutzler, T.; Nagl, C.; Pölz, W.; Poupa, S.; Rigler, E.; Storch, A. & Thanner, G.: Aktualisierung von Emissionsfaktoren als Grundlage für den Anhang des Energieberichts. Reports, Bd. REP-0075. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2008): Schachermayer, E. & Lampert, C.: Deponiegaserfassung auf österreichischen Deponien. Reports, Bd. REP-0100. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2011): Data on sewage sludge application provided by the provincial governments. Vienna 2011.

UMWELTBUNDESAMT (2010, 2014 & 2018): External review of the Agricultural calculation model by Austrian Agricultural experts within the framework of stakeholder meetings held in 2010, 2014 & 2018. Discussion and validation of applied values, parameters and time series by the national experts. Vienna.

UMWELTBUNDESAMT (2012): National Action Plan pursuant to Article 5 of the Stockholm Convention on POPs and Article 6 of the EU-POP Regulation. First review, 2012. Report, REP-0395, Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2013): Data on sewage sludge application provided by the provincial governments. Vienna 2013.

UMWELTBUNDESAMT (2014a): Data on sewage sludge application provided by the provincial governments. Vienna 2014.

UMWELTBUNDESAMT (2014b): LAMPERT, C.: Stand der temporären Abdeckung von Deponien und Deponiegaserfassung. Bericht. REP-0484. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2014c): Haider, S.; Anderl, M.; Jobstmann, H.; Köther, T.; Lampert, C.; Moosmann, L.; Pazdernik, K.; Pinterits, M.; Poupa, S.; Stranner, G. & Zechmeister, A.: Austria's Informative Inventory Report 2014. Submission under the UNECE Convention on Long-range Transboundary Air Pollution. Reports, Bd. REP-0474 Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2015): Data on sewage sludge application provided by the provincial governments. Vienna 2015.

UMWELTBUNDESAMT (2016a): Data on sewage sludge application provided by the provincial governments. Vienna 2016.

UMWELTBUNDESAMT (2016b): Lampert, C.; Neubauer, M. & Bernhardt A.: Kommunale Grünabfälle (KoGa). Report. unpublished. Vienna.

UMWELTBUNDESAMT (2017a): Data on sewage sludge application provided by the provincial governments. Vienna 2017.

UMWELTBUNDESAMT (2017b): Böhmer, S.; Klösch, N.; Schieder, W.; Storch, A. & Thielen, P.: Emissionsfaktoren Raumwärme II. Endbericht zum AVH 03049-014. (unveröffentlicht).

UMWELTBUNDESAMT (2018): Data on sewage sludge application provided by the provincial governments. Vienna 2018.

UMWELTBUNDESAMT (2019a): Data on sewage sludge application provided by the provincial governments. Vienna 2019.

UMWELTBUNDESAMT (2019b) Lampert, C. & Thaler, P.: Deponiegaserfassung 2013–2017. Reports REP-0679. Wien 2019.

UMWELTBUNDESAMT (2019c): Stoiber, H.; Kellner, M. & Schindler, I.: Stand der Technik Österreichischer Abfallverbrennungsanlagen, Statusbericht 2016, Wien 2018.

UMWELTBUNDESAMT (2019d): Titz, M.; Anderl, M.; Haider, S.; Krutzler, T.; Lampert,,C.; Poupa, S.; Purzner, M.; Schieder, W.; Storch, A., Stranner & G. Zechmeister, A.: Austria's National Air Emission Projections 20121 for 2020, 2025 and 2030, Bd. REP-0689. Umweltbundesamt, Wien 2019.

UMWELTBUNDESAMT (2020a): Data on sewage sludge application provided by the provincial governments. Vienna 2020.

UMWELTBUNDESAMT (2020b): Preliminary data on connection rate 2018 based on information reported by Vienna and Tyrol.

UMWELTBUNDESAMT (2021a): Anderl, M.; Friedrich, A.; Gangl, M.; Haider, S.; Köther, T.; Kriech, M.; Kuschel, V.; Lampert, C.; Mandl, N.; Matthews, B.; Pazdernik, K.; Pinterits, M.; Poupa, S.; Purzner, M.; Schieder, W.; Schmid, C.; Schmidt, G.; Schodl, B.; Schwaiger, E.; Schwarzl, B.; Titz, M.; Weiss, P.; Wieser, M. & Zechmeister, A.: Austria's National Inventory Report 2021 – Submission under the United Nations Framework Convention of Climate Change and under the Kyoto Protocol. Reports. REP-0761. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2021b): Titz, M.; Anderl, M.; Haider, S.; Krutzler, T.; Lampert, C.; Poupa, S.; Purzner, M.; Schieder, W.; Schodl, B.; Wieser, M. & G. Zechmeister, A.: Austria's National Air Emission Projections 2021 for 2020, 2025 and 2030, Bd. REP-Draft. Umweltbundesamt, Wien 2021.

UMWELTBUNDESAMT BERLIN (UBA) (1998): Ermittlung von Emissionen und Minderungsmaßnahmen für POPs in Deutschland. UBA-Texte 74/98, Berlin.

UMWELTBUNDESAMT BERLIN (UBA) (1999): MBA Bericht: Ökologische Vertretbarkeit mechanisch-biologischer Vorbehandlung von Restabfällen. Berlin.

UNECE (2015): Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. United Nations Economic Commission for Europe, 2015. http://www.unece.org/environmental-policy/conventions/envlrtapwelcome/publications.html.

UNITED NATIONS (2010): Report for the Stage 3 in-depth review of emission inventories submitted under the UNECE LRTAP Convention and EU National Emissions Ceilings Directive for: AUSTRIA.

UNITED NATIONS (2017): Report for the Stage 3 in-depth review of emission inventories submitted under the UNECE LRTAP Convention and EU National Emissions Ceilings Directive for: AUSTRIA.

UNTERARBEITSGRUPPE N-ADHOC (2004): Überprüfung und Überarbeitung der N-Anfallswerte für einzelne Tierkategorien. Unterlagen ausgearbeitet vom Fachbeirat für Bodenfruchtbarkeit und Bodenschutz des BMLFUW.

WARTHA (2005) – Life Cycle Inventory Austria 2000 – Review, C. Wartha, Fachhochschulstudiengänge Burgenland GmbH, Pinkafeld 2005.

WIFO – Österreichisches Institut für Wirtschaftsforschung (1996): Volkswirtschaftliche Datenbank. Energiebilanzen 1986–1994. Österreichisches Institut für Wirtschaftsforschung, Wien.

WINDSPERGER, A. & HINTERMEIER, G. (2003): Entschwefelungstechnologien – Die Situation in Österreich. Studie im Auftrag der Umweltbundesamt GmbH. Institut für Industrielle Ökologie, St. Pölten.

WINDSPERGER, A.; MAYR, B.; SCHMIDT-STEJSKAL, H.; ORTHOFER, R. & WINIWARTER, W. (1999): Entwicklung der Schwermetallemissionen – Abschätzung der Emissionen von Blei, Cadmium und Quecksilber für die Jahre 1985, 1990 und 1995 gemäß der CORINAIR-Systematik. Institut für Industrielle Ökologie und Österreichisches Forschungszentrum Seibersdorf, Wien. (not published).

WINDSPERGER, A.; SCHMIDTH-STEJSKAL, H. & STEINLECHNER, S. (2003): Erhebung der IST-Situation und der Struktur der NO_x-Emissionen für bestimmte Sektoren der Industrie und Erstellung eines Maßnahmenplanes zur Reduktion der NO_x-Emissionen bis 2010. Institut für Industrielle Ökologie, St. Pölten.

WINDSPERGER, A. & TURI, K. (1997): Emissionserhebung der Industrie für 1993 und 1994. Technische Universität Wien. Forschungsinstitut für Chemie und Umwelt, Wien.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2002a): Gegenüberstellung und Abgleich der Daten von Top-down zu Bottom-up für Lösungsmittel im Jahr 2000. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung. Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit, Wien.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2002b): Verbesserung von Emissionsdaten (Inventur und Projektion bis 2010 für den Bereich Lösungsmittel in Österreich. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung. Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit, Wien.

WINDSPERGER, S.; STEINLECHNER, H.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G.; SCHÖNSTEIN, R. & SCHÖRNER, G. (2004): Studie zur Anpassung der Zeitreihe der Lösungsmittelemissionen der österreichischen Luftschadstoffinventur (OLI) 1980–2002. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung. Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Umweltbundesamt, Wien.

WINDSPERGER, S. & SCHMIDT-STEJSKAL, H. (2008): Austria's Emission Inventory from solvent use 2009. Institut für Industrielle Ökologie (IIÖ). Studie im Auftrag des Umweltbundesamt. Wien. Study has not been published, but can be made available upon request.

WINDSPERGER, A.; STEJSKAL, H.; PURZNER, M.; TITZ, M. & BURGSTALLER, J. (2018): Dokumentation der methodischen Arbeiten zur VOC-Inventur in Österreich. Internal Report. Vienna 2018.

WINDSPERGER, A. (2018): Aktualisierung der NOx- und Feinstaub-Emissionen der Holzindustrie in Österreich sowie Ableitung von Emissionsfaktoren, Institut für Industrielle Ökologie, St. Pölten, 2018.

WINDSPERGER, B. (2019): Aktualisierung der NOx- und Feinstaub-Emissionen der Papierindustrie in Österreich sowie Ableitung von Emissionsfaktoren, Institut für Industrielle Ökologie, St. Pölten, 2019.

WINDSPERGER et al. (2020): Bernhard Windsperger, Andreas Windsperger, Aktualisierung der NOx- und Feinstaub-Emissionen der Papierindustrie in Österreich sowie Ableitung von Emissionsfaktoren, Institut für Industrielle Ökologie, St. Pölten, 2020

WINIWARTER, W.; SCHMIDT-STEJSKAL, H. & WINDSPERGER, A. (2007): Aktualisierung und methodische Verbesserung der österreichischen Luftschadstoffinventur für Schwebstaub im Auftrag des Umweltbundesamt. ARC–sys–0149, Wien.

WINIWARTER, W. (2007): Quantifying Uncertainties of the Austrian Greenhouse Gas Inventory, ARC (Austrian Research Centers) Seibersdorf. Research Report ARC-sys-0154. Final report contracted by Umweltbundesamt.

WINIWARTER, W.; BAUER, H.; CASEIRO, A. & PUXBAUM, H. (2009): Quantifying emissions of Primary Biological Aerosol Particle mass in Europe. Atmos. Environ. 43, 1403–1409 (2009).

WINIWARTER, W. & RYPDAL, K. (2001): Assessing the Uncertainty Associated with National Greenhouse Gas Emission Inventories: A Case Study for Austria. Accepted for publication in Atmospheric Environment.

WINIWARTER, W. (1993): Abschätzung der Emissionen von ausgewählten Schwermetallen in die Atmosphäre für Österreich, 1992. Forschungszentrum Seibersdorf Bericht OEFZS-A--2784, Dezember 1993.

WINIWARTER, W. & SCHNEIDER, M. (1995): Abschätzung der Schwermetallemissionen in Österreich. Reports, Bd. UBA-95-108. Umweltbundesamt, Wien.

WINIWARTER, W.; TRENKER, C. & HÖFLINGER, W. (2001): Österreichische Emissionsinventur für Staub. Österreichisches Forschungszentrum Seibersdorf, Wien.

WURST, F. & HÜBNER, C. (1997): Erhebung des PCDD/F-Emissionspotentials für Österreich. Studie im Auftrag des BMWFA.

ZAR – Zentrale Arbeitsgemeinschaft österreichischer Rinderzüchter (2004): Cattle Breeding in Austria. 148pp.

ZESSNER, M. (1999): Bedeutung und Steuerung von Nährstoff- und Schwermetallflüssen des Abwassers. Wiener Mitteilung Band 157. Wien.

Energy demand model for space heating

AEA – AUSTRIAN ENERGY AGENCY (2015): Eine Typologie österreichischer Wohngebäude. Ein Nachschlagewerk mit charakteristischen, energierelevanten Merkmalen von 32 Modellgebäuden – im Bestand und für jeweils zwei Sanierungsvarianten. 2. Auflage. Wien, März 2015.

BMLRT -– Bundesministerium für Landwirtschaft, Regionen und Tourismus (2020b): Geodatenkatalog des BMLRT. Übersicht über Geodatensätze in der GDI GDS, Oktober 2020. Projektbezogene Nutzung des Gebäude- und Wohnungsregister (GWR), Stand, 01.01.2020. Wien.

BMWFW (2014): NEEAP 2014. Erster Nationaler Energieeffizienzaktionsplan der Republik Österreich 2014 gemäß Energieeffizienzrichtlinie 2012/27/EU. Anhang B: Gebäuderenovierungsstrategie Österreich. Österreichische Energieagentur – AEA / Monitoringstelle im Auftrag des Bundesministeriums für Wissenschaft, Forschung und Wirtschaft. Wien, April 2014.

E7 ENERGIE MARKT ANALYSE GMBH (2009): Jahresendenergieeinsatz nach Brennstoff, Technologie und Sektor. Analyse des Raumwärmeenergiebedarfs in Abhängigkeit der Heizungstechnologie (Bestandsdaten 2004). Endbericht. Wien, November 2009.

E7 ENERGIE MARKT ANALYSE GMBH (2017): Jahresendenergieeinsatz nach Brennstoff, Technologie und Sektor. Analyse des Raumwärmeenergiebedarfs in Abhängigkeit der Heizungstechnologie (Bestandsdaten 2015). Endbericht. Wien, Februar 2017.

IEA – International Energy Agency (2020): IEA/EUROSTAT Joint Questionnaire (IEA JQ 2020). Submitted years 1990-2019. Statistik Austria, Wien.

STATCUBE (2014a): Neue Gebäude mit Wohnungen 1970 - 1979; ohne An-, Auf-, Umbautätigkeit (Wohnbaustatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2014b): Neue Gebäude mit Wohnungen 1980 - 2002; ohne An-, Auf-, Umbautätigkeit (Wohnbaustatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2014c): Neue Wohnungen 1980 - 2002 (Wohnbaustatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2020a): Bevölkerung zu Jahresbeginn ab 1982 (Bevölkerungsstatistik). Statistische Datenbank von Statistik, Wien.

STATCUBE (2020b): Mikrozensus; Hauptwohnsitzwohnungen (HWS) ab 2004. Statistische Datenbank von Statistik, Wien.

STATISTIK AUSTRIA (1973): Häuser- und Wohnungszählung 1971. Österreichisches Statistisches Zentralamt, Wien.

STATISTIK AUSTRIA (1982): Häuser- und Wohnungszählung 1981. Österreichisches Statistisches Zentralamt, Wien.

STATISTIK AUSTRIA (1990): Mikrozensus Energieeinsatz der Haushalte 1990. Statistik Austria. Wien.

STATISTIK AUSTRIA (1992a): Häuser- und Wohnungszählung 1991. Österreichisches Statistisches Zentralamt, Wien.

STATISTIK AUSTRIA (1992b): Mikrozensus Energieeinsatz der Haushalte 1992. Statistik Austria. Wien.

STATISTIK AUSTRIA (2002): Mikrozensus Energieeinsatz der Haushalte 1999/2000. Statistik Austria. Wien.

STATISTIK AUSTRIA (2004): Gebäude- und Wohnungszählung 2001. Hauptergebnisse Österreich. Statistik Austria, Wien.

STATISTIK AUSTRIA (2013): Census 2011 Gebäude- und Wohnungszählung. Ergebnisse zu Gebäuden und Wohnungen aus der Registerzählung. Statistik Austria, Wien.

STATISTIK AUSTRIA (2018c): Gebäude- und Wohnungsregister, Datenabzüge vom 31.12.2017 und 15.09.2018. Erstellt am 27.11.2018. Vorläufiger Bestand an Wohnungen und Gebäuden zum 31.12.2017 nach Gebäudeeigenschaften und Bundesländern. Statistik Austria, Wien.

STATISTIK AUSTRIA (2019): Sonderauswertung des Mikrozensus 2004-2018 (MZ 2004-2018). Statistik Austria im Auftrag durch das Umweltbundesamt. Wien.

STATISTIK AUSTRIA (2020b): Paket Gebäude- und Wohnungsregister ab 2014 - Gemeinden, Politische Bezirke und Bundesländer. Statistik Austria, Wien.

STATISTIK AUSTRIA (2020c): Paket GWR-Baumaßnahmen. Statistik Austria, Wien.

UMWELTBUNDESAMT (2014d): Schieder, W.; Storch, A..; Thielen, P.; Wampl, S. & Zechmeister, A.: Entwicklung eines Raumwärme-Emissionsmodells. Endbericht *(unveröffentlicht).* Erstellung im Auftrag des BMLFUW, Umweltbundesamt, Wien, Dezember 2014.

VDLUFA (2017): Standortgerechte Landnutzung - umweltverträglich und wirtschaftlich, VDLUFA-Schriftenreihe Band 74/2017, VDLUFA-Verlag. Verband Deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten, Darmstadt 2017.

ZAMG – Zentralanstalt für Meteorologie und Geodynamik & Statistik Austria (2020): Auswertung der Heizgradtagsummen, Stand November 2020. Wien.

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 Luftschadstoff-inventur")

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)

BMLFUW .... Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (Federal Ministry for Agriculture, Forestry, Environment and Water Management), from 2018 on BMNT

BMNT.................... Bundesministerium für Nachhaltigkeit und Tourismus (Federal Ministry of Sustainability and Tourism), until 2017 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

GDP .... Gross Domestic Product

GLOBEMI .... Globale Modellbildung für Emissions- und Verbrauchsszenarien im Verkehrssektor ((Global Modelling for Emission- and Fuel consumption Scenarios of the Transport Sector) see (Hausberger 1998))

GPG...................... Good Practice Guidance (of the IPCC)

HBEFA.................. "Handbook of Emission Factors"

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)

PM .... Particulate Matter

POPs .... Persistent Organic Pollutants

PRTR .... Pollutant Release and Transfer Register

QA/QC .... Quality Assurance/Quality Control

QMS .... Quality Management System

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

Symbol................Name

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] 1990–2019 – 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	0.01	0.07	NO	**73.70**	0.25
1991	69.06	67.76	1.30	1.61	0.00	0.06	NO	**70.73**	0.28
1992	52.79	50.79	2.00	1.36	0.00	0.04	NO	**54.20**	0.30
1993	51.66	49.56	2.10	1.11	0.00	0.04	NO	**52.82**	0.32
1994	46.02	44.74	1.28	1.12	0.00	0.05	NO	**47.19**	0.34
1995	45.68	44.15	1.53	1.07	0.01	0.05	NO	**46.81**	0.38
1996	42.90	41.70	1.20	0.99	0.00	0.05	NO	**43.94**	0.42
1997	39.38	39.32	0.07	0.96	0.00	0.05	NO	**40.41**	0.43
1998	34.71	34.66	0.04	0.87	0.00	0.06	NO	**35.64**	0.45
1999	32.87	32.83	0.04	0.81	0.01	0.06	NO	**33.75**	0.44
2000	30.74	30.69	0.04	0.78	0.00	0.06	NO	**31.58**	0.48
2001	31.68	31.64	0.05	0.71	0.01	0.06	NO	**32.46**	0.47
2002	30.62	30.58	0.04	0.71	0.01	0.06	NO	**31.39**	0.43
2003	30.41	30.36	0.05	0.71	0.00	0.06	NO	**31.18**	0.40
2004	25.81	25.76	0.04	0.72	0.01	0.06	NO	**26.60**	0.47
2005	25.15	25.11	0.04	0.72	0.00	0.06	NO	**25.93**	0.55
2006	25.92	25.88	0.05	0.73	0.00	0.05	NO	**26.71**	0.58
2007	22.54	22.49	0.05	0.75	0.00	0.04	NO	**23.33**	0.61
2008	19.45	19.41	0.04	0.78	0.00	0.03	NO	**20.27**	0.61
2009	14.03	13.97	0.06	0.70	0.00	0.02	NO	**14.75**	0.53
2010	15.27	15.23	0.05	0.70	0.00	0.01	NO	**15.99**	0.57
2011	14.49	14.45	0.05	0.68	0.00	0.01	NO	**15.19**	0.60
2012	14.14	14.09	0.05	0.65	0.00	0.01	NO	**14.80**	0.57
2013	13.77	13.74	0.04	0.59	0.00	0.01	NO	**14.38**	0.54
2014	13.97	13.93	0.04	0.55	0.00	0.01	NO	**14.53**	0.54
2015	13.56	13.52	0.04	0.57	0.00	0.01	NO	**14.14**	0.58
2016	12.71	12.69	0.02	0.57	0.00	0.01	NO	**13.30**	0.54
2017	12.24	12.20	0.04	0.57	0.00	0.01	NO	**12.82**	0.52
2018	11.03	11.01	0.02	0.57	0.00	0.01	NO	**11.62**	0.59
2019	10.35	10.32	0.02	0.57	0.00	0.01	NO	**10.93**	0.68

Table A-2: Emission trends for NO_x [kt] 1990–2019 – 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 Bunkers
1990	200.93	200.93	IE	4.27	12.05	0.10	NO	**217.35**	2.48
1991	210.85	210.85	IE	3.93	11.99	0.09	NO	**226.86**	2.80
1992	199.66	199.66	IE	4.02	11.73	0.06	NO	**215.47**	3.06
1993	193.86	193.86	IE	1.46	11.57	0.05	NO	**206.93**	3.27
1994	185.95	185.95	IE	1.38	11.43	0.05	NO	**198.81**	3.43
1995	185.59	185.59	IE	0.90	11.61	0.05	NO	**198.14**	3.85
1996	203.56	203.56	IE	0.87	11.50	0.05	NO	**215.97**	4.24
1997	189.77	189.77	IE	0.86	11.57	0.05	NO	**202.25**	4.43
1998	201.57	201.57	IE	0.83	11.62	0.05	NO	**214.07**	4.59
1999	193.74	193.74	IE	0.82	11.27	0.05	NO	**205.88**	4.52
2000	199.72	199.72	IE	0.83	11.08	0.05	NO	**211.68**	6.44
2001	210.58	210.58	IE	0.78	11.05	0.05	NO	**222.46**	6.32
2002	218.47	218.47	IE	0.79	11.07	0.05	NO	**230.37**	5.67
2003	229.96	229.96	IE	0.81	10.59	0.05	NO	**241.42**	5.21
2004	230.46	230.46	IE	0.69	10.06	0.05	NO	**241.26**	6.09
2005	236.46	236.46	IE	0.70	10.12	0.05	NO	**247.33**	6.99
2006	227.11	227.11	IE	0.58	10.16	0.04	NO	**237.90**	7.54
2007	220.08	220.08	IE	0.48	10.31	0.04	NO	**230.90**	7.99
2008	206.37	206.37	IE	0.56	10.90	0.03	NO	**217.85**	7.90
2009	192.94	192.94	IE	0.41	10.69	0.02	NO	**204.07**	6.86
2010	194.11	194.11	IE	0.55	9.78	0.02	NO	**204.45**	7.60
2011	185.17	185.17	IE	0.52	10.28	0.02	NO	**195.98**	7.98
2012	179.54	179.54	IE	0.55	10.40	0.02	NO	**190.50**	7.68
2013	178.99	178.99	IE	0.45	10.29	0.02	NO	**189.75**	7.46
2014	170.90	170.90	IE	0.46	10.60	0.02	NO	**181.98**	7.49
2015	167.46	167.46	IE	0.52	10.99	0.02	NO	**178.98**	8.18
2016	159.80	159.80	IE	0.52	11.17	0.02	NO	**171.50**	10.28
2017	151.26	151.26	IE	0.47	10.99	0.02	NO	**162.74**	10.06
2018	140.21	140.21	IE	0.41	10.77	0.02	NO	**151.42**	11.54
2019	133.35	133.35	IE	0.50	10.33	0.02	NO	**144.20**	13.47

Table A-3: Emission trends for NMVOC [kt] 1990–2019 – 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	164.65	149.16	15.49	118.54	52.19	0.16	NO	**335.54**	0.18
1991	166.48	151.36	15.12	112.01	51.19	0.16	NO	**329.85**	0.20
1992	152.36	137.17	15.19	105.25	48.53	0.15	NO	**306.28**	0.21
1993	140.33	125.68	14.65	98.55	47.26	0.15	NO	**286.28**	0.23
1994	124.93	113.82	11.12	91.99	46.79	0.14	NO	**263.86**	0.24
1995	116.54	107.05	9.49	85.28	46.25	0.14	NO	**248.21**	0.26
1996	109.82	101.36	8.46	83.72	45.09	0.13	NO	**238.76**	0.31
1997	97.69	89.74	7.95	82.37	44.33	0.13	NO	**224.52**	0.35
1998	90.87	84.43	6.43	81.06	43.99	0.13	NO	**216.04**	0.39
1999	83.18	77.50	5.67	78.32	43.28	0.12	NO	**204.89**	0.38
2000	76.63	70.94	5.69	62.15	42.28	0.12	NO	**181.18**	0.42
2001	73.53	69.70	3.84	60.39	41.83	0.11	NO	**175.87**	0.41
2002	70.09	66.06	4.03	59.97	40.94	0.11	NO	**171.12**	0.37
2003	67.92	63.96	3.96	58.57	40.44	0.11	NO	**167.04**	0.34
2004	64.09	60.52	3.57	49.36	40.14	0.11	NO	**153.70**	0.40
2005	61.62	58.27	3.34	56.52	39.48	0.11	NO	**157.73**	0.47
2006	58.20	54.85	3.36	62.34	39.20	0.10	NO	**159.84**	0.50
2007	55.18	52.19	2.98	61.32	39.07	0.10	NO	**155.67**	0.53
2008	52.74	49.99	2.75	58.74	38.80	0.10	NO	**150.38**	0.52
2009	49.82	47.23	2.59	48.60	38.99	0.09	NO	**137.50**	0.45
2010	51.19	48.73	2.45	48.06	38.58	0.08	NO	**137.91**	0.49
2011	46.93	44.52	2.41	48.00	37.92	0.08	NO	**132.93**	0.51
2012	46.45	44.05	2.40	46.61	37.61	0.08	NO	**130.75**	0.49
2013	45.63	43.32	2.30	41.57	37.58	0.07	NO	**124.85**	0.46
2014	40.67	38.25	2.42	39.81	37.63	0.07	NO	**118.17**	0.46
2015	40.74	38.42	2.32	34.83	37.43	0.06	NO	**113.06**	0.50
2016	40.11	37.84	2.27	34.29	37.42	0.06	NO	**111.88**	0.23
2017	39.55	37.26	2.29	35.49	37.30	0.06	NO	**112.40**	0.20
2018	36.48	34.30	2.17	35.54	36.96	0.06	NO	**109.03**	0.22
2019	36.13	33.90	2.23	35.90	36.51	0.05	NO	**108.59**	0.24

Table A-4: Emission trends for NH_3 [kt] 1990–2019 – 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	1.959	1.959	IE	0.339	59.176	0.367	NO	**61.841**	0.002
1991	2.429	2.429	IE	0.577	59.307	0.382	NO	**62.695**	0.002
1992	2.612	2.612	IE	0.438	57.751	0.434	NO	**61.234**	0.002
1993	2.893	2.893	IE	0.287	58.584	0.515	NO	**62.278**	0.002
1994	3.032	3.032	IE	0.236	58.368	0.622	NO	**62.257**	0.002
1995	3.219	3.219	IE	0.165	59.334	0.642	NO	**63.360**	0.003
1996	3.395	3.395	IE	0.163	58.478	0.668	NO	**62.704**	0.003
1997	3.462	3.462	IE	0.162	58.686	0.666	NO	**62.976**	0.003
1998	3.764	3.764	IE	0.168	58.723	0.697	NO	**63.353**	0.003
1999	3.795	3.795	IE	0.186	57.397	0.767	NO	**62.144**	0.003
2000	3.745	3.745	IE	0.167	56.078	0.822	NO	**60.812**	0.003
2001	3.913	3.913	IE	0.146	55.906	0.922	NO	**60.886**	0.003
2002	4.044	4.044	IE	0.128	55.026	1.018	NO	**60.216**	0.003
2003	4.151	4.151	IE	0.141	54.902	1.099	NO	**60.293**	0.003
2004	4.040	4.040	IE	0.122	54.654	1.346	NO	**60.163**	0.003
2005	3.998	3.993	0.005	0.127	54.513	1.444	NO	**60.082**	0.004
2006	3.918	3.912	0.006	0.136	55.006	1.470	NO	**60.530**	0.004
2007	3.828	3.823	0.005	0.138	56.363	1.515	NO	**61.843**	0.004
2008	3.574	3.570	0.003	0.140	56.261	1.535	NO	**61.510**	0.004
2009	3.379	3.376	0.003	0.148	57.829	1.571	NO	**62.928**	0.004
2010	3.429	3.426	0.003	0.153	57.740	1.565	NO	**62.887**	0.004
2011	3.130	3.128	0.002	0.160	57.472	1.563	NO	**62.325**	0.004
2012	3.001	2.999	0.001	0.153	57.868	1.584	NO	**62.605**	0.004
2013	2.827	2.826	0.001	0.155	58.152	1.532	NO	**62.666**	0.004
2014	2.603	2.602	0.001	0.148	59.084	1.579	NO	**63.414**	0.004
2015	2.654	2.654	0.000	0.140	59.805	1.611	NO	**64.210**	0.004
2016	2.562	2.562	0.000	0.146	60.679	1.598	NO	**64.985**	0.004
2017	2.597	2.597	0.000	0.167	61.480	1.602	NO	**65.845**	0.004
2018	2.542	2.542	0.001	0.135	60.587	1.618	NO	**64.882**	0.005
2019	2.550	2.550	0.000	0.165	59.458	1.643	NO	**63.816**	0.006

Table A-5: Emission trends for CO [kt] 1990–2019 – 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	1 205.16	1 205.16	IE	37.19	1.23	10.31	NO	**1 253.89**	0.40
1991	1 217.21	1 217.21	IE	32.45	1.20	10.51	NO	**1 261.36**	0.43
1992	1 157.94	1 157.94	IE	35.31	1.21	10.36	NO	**1 204.82**	0.46
1993	1 094.53	1 094.53	IE	37.01	1.09	10.26	NO	**1 142.89**	0.49
1994	1 027.69	1 027.69	IE	38.14	1.18	9.95	NO	**1 076.97**	0.51
1995	927.61	927.61	IE	34.72	1.17	9.46	NO	**972.96**	0.56
1996	928.33	928.33	IE	29.08	1.12	8.93	NO	**967.45**	0.63
1997	855.12	855.12	IE	28.21	1.19	8.52	NO	**893.04**	0.68
1998	812.27	812.27	IE	25.85	1.16	8.19	NO	**847.47**	0.74
1999	700.12	700.12	IE	21.76	1.19	7.85	NO	**730.93**	0.72
2000	698.82	698.82	IE	18.69	1.05	7.52	NO	**726.08**	0.80
2001	676.30	676.30	IE	14.55	1.17	7.21	NO	**699.22**	0.78
2002	645.30	645.30	IE	14.42	1.10	7.19	NO	**668.01**	0.66
2003	647.73	647.73	IE	14.34	1.05	7.18	NO	**670.30**	0.65
2004	629.65	629.65	IE	14.55	1.63	7.30	NO	**653.13**	0.73
2005	605.47	605.47	IE	14.53	0.98	6.88	NO	**627.86**	0.91
2006	605.47	605.47	IE	14.71	0.91	6.53	NO	**627.62**	0.92
2007	582.36	582.36	IE	14.89	0.93	6.16	NO	**604.34**	0.96
2008	563.50	563.50	IE	14.82	0.90	5.85	NO	**585.08**	0.96
2009	544.20	544.20	IE	13.88	0.84	5.44	NO	**564.35**	0.82
2010	559.77	559.77	IE	14.28	0.80	5.08	NO	**579.92**	0.87
2011	542.74	542.74	IE	14.30	0.59	4.75	NO	**562.37**	0.86
2012	542.39	542.39	IE	14.14	0.43	4.45	NO	**561.41**	0.83
2013	545.25	545.25	IE	14.29	0.39	4.14	NO	**564.07**	0.74
2014	509.76	509.76	IE	14.19	0.44	3.83	NO	**528.22**	0.74
2015	521.09	521.09	IE	14.20	0.38	3.58	NO	**539.25**	0.78
2016	516.33	516.33	IE	14.12	0.38	3.33	NO	**534.16**	1.49
2017	507.44	507.44	IE	14.14	0.33	3.12	NO	**525.04**	1.46
2018	466.76	466.76	IE	14.22	0.31	2.93	NO	**484.21**	1.73
2019	481.29	481.29	IE	14.14	0.30	2.75	NO	**498.47**	1.89

Table A-6: Emission trends for Cd [kg] 1990–2019 – 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	1 052.7	1052.7	NA	634.1	8.0	60.3	NO	**1 755.1**	0.2
1991	1 059.2	1059.2	NA	544.5	7.8	49.6	NO	**1 661.1**	0.2
1992	968.6	968.6	NA	400.3	7.8	6.5	NO	**1 383.3**	0.3
1993	897.1	897.1	NA	339.1	6.9	5.8	NO	**1 249.0**	0.3
1994	827.9	827.9	NA	301.9	7.9	5.1	NO	**1 142.8**	0.3
1995	765.9	765.9	NA	278.1	8.2	3.2	NO	**1 055.4**	0.3
1996	782.9	782.9	NA	260.2	7.4	3.1	NO	**1 053.7**	0.4
1997	732.9	732.9	NA	264.2	8.0	3.1	NO	**1 008.1**	0.4
1998	675.6	675.6	NA	267.7	7.9	3.0	NO	**954.2**	0.4
1999	719.7	719.7	NA	277.2	8.4	3.0	NO	**1 008.2**	0.4
2000	685.7	685.7	NA	288.8	7.6	3.0	NO	**985.1**	0.4
2001	706.8	706.8	NA	283.3	8.6	2.9	NO	**1 001.6**	0.4
2002	671.6	671.6	NA	295.0	8.3	2.9	NO	**978.0**	0.4
2003	697.8	697.8	NA	292.6	7.5	2.9	NO	**1 000.9**	0.3
2004	692.5	692.5	NA	287.6	13.3	3.0	NO	**996.4**	0.4
2005	720.1	720.1	NA	302.9	7.2	2.7	NO	**1 032.9**	0.5
2006	757.8	757.8	NA	311.3	6.3	2.5	NO	**1 077.9**	0.5
2007	769.4	769.4	NA	323.2	6.8	2.7	NO	**1 102.1**	0.5
2008	790.8	790.8	NA	319.8	6.6	2.5	NO	**1 119.8**	0.5
2009	792.3	792.3	NA	259.1	6.2	2.4	NO	**1 060.0**	0.5
2010	863.5	863.5	NA	312.2	5.9	2.4	NO	**1 184.0**	0.5
2011	838.6	838.6	NA	315.4	3.9	2.3	NO	**1 160.2**	0.5
2012	862.5	862.5	NA	312.3	2.3	2.3	NO	**1 179.4**	0.5
2013	864.2	864.2	NA	329.2	2.0	2.1	NO	**1 197.4**	0.5
2014	806.0	806.0	NA	323.6	2.5	2.3	NO	**1 134.4**	0.5
2015	830.1	830.1	NA	314.3	1.8	2.3	NO	**1 148.5**	0.5
2016	822.1	822.1	NA	306.9	1.9	2.1	NO	**1 133.0**	0.6
2017	842.3	842.3	NA	329.8	1.3	2.1	NO	**1 175.5**	0.5
2018	847.1	847.1	NA	286.7	1.1	1.9	NO	**1 136.7**	0.6
2019	852.3	852.3	NA	307.0	1.0	1.8	NO	**1 162.2**	0.7

Table A-7: Emission trends for Hg [kg] 1990–2019 – 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	1 574.0	1 574.0	NA	534.1	1.6	54.8	NO	**2 164.5**	0.1
1991	1 509.6	1 509.6	NA	498.2	1.6	48.4	NO	**2 057.8**	0.1
1992	1 193.8	1 193.8	NA	440.9	1.6	27.8	NO	**1 664.1**	0.1
1993	966.9	966.9	NA	417.1	1.4	28.0	NO	**1 413.4**	0.1
1994	766.5	766.5	NA	403.8	1.6	27.8	NO	**1 199.7**	0.1
1995	719.9	719.9	NA	471.8	1.6	28.0	NO	**1 221.3**	0.1
1996	715.3	715.3	NA	436.4	1.5	26.7	NO	**1 179.9**	0.1
1997	686.4	686.4	NA	439.0	1.6	24.9	NO	**1 151.9**	0.1
1998	604.1	604.1	NA	338.9	1.6	22.8	NO	**967.3**	0.1
1999	646.9	646.9	NA	281.2	1.6	20.8	NO	**950.5**	0.1
2000	643.2	643.2	NA	246.7	1.5	18.1	NO	**909.5**	0.1
2001	701.5	701.5	NA	250.0	1.7	18.4	NO	**971.7**	0.1
2002	655.0	655.0	NA	266.1	1.6	19.5	NO	**942.2**	0.1
2003	694.3	694.3	NA	266.5	1.5	20.0	NO	**982.3**	0.1
2004	648.2	648.2	NA	276.8	2.5	20.6	NO	**948.0**	0.1
2005	656.7	655.7	1.0	310.0	1.4	21.7	NO	**989.8**	0.2
2006	682.3	681.0	1.3	316.1	1.2	22.3	NO	**1 022.0**	0.2
2007	667.8	666.8	1.1	334.7	1.3	23.7	NO	**1 027.6**	0.2
2008	681.8	681.1	0.7	334.3	1.3	24.7	NO	**1 042.1**	0.2
2009	644.9	644.2	0.7	251.2	1.2	26.4	NO	**923.6**	0.2
2010	676.6	676.0	0.6	323.5	1.1	27.6	NO	**1 028.8**	0.2
2011	661.2	660.8	0.5	333.3	0.8	28.4	NO	**1 023.7**	0.2
2012	678.0	677.7	0.3	329.1	0.5	30.6	NO	**1 038.2**	0.2
2013	704.0	703.9	0.1	349.3	0.4	31.6	NO	**1 085.3**	0.2
2014	658.9	658.7	0.2	341.6	0.5	32.4	NO	**1 033.4**	0.2
2015	645.3	645.2	0.0	331.8	0.4	35.5	NO	**1 013.0**	0.2
2016	592.0	592.0	0.0	322.9	0.4	35.6	NO	**950.9**	0.2
2017	631.4	631.4	0.0	361.2	0.3	37.9	NO	**1 030.9**	0.2
2018	619.3	619.2	0.1	302.0	0.3	39.2	NO	**960.8**	0.2
2019	617.1	617.1	0.1	328.9	0.2	40.1	NO	**986.4**	0.2

Table A-8: Emission trends for Pb [kg] 1990–2019 – 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	194 104.4	194 104.4	NA	37 414.8	3.8	1 016.3	NO	**232 539.3**	0.2
1991	163 536.9	163 536.9	NA	32 145.5	3.7	778.1	NO	**196 464.2**	0.2
1992	116 560.6	116 560.6	NA	22 903.9	3.7	488.8	NO	**139 957.1**	0.3
1993	79 450.1	79 450.1	NA	19 339.5	3.6	381.6	NO	**99 174.9**	0.3
1994	51 713.0	51 713.0	NA	16 696.5	3.7	266.3	NO	**68 679.5**	0.3
1995	11 417.8	11 417.8	NA	8 893.0	3.7	9.8	NO	**20 324.2**	0.3
1996	11 338.2	11 338.2	NA	8 540.5	3.5	9.7	NO	**19 892.0**	0.4
1997	10 340.4	10 340.4	NA	8 459.0	3.5	9.7	NO	**18 812.6**	0.4
1998	9 625.2	9 625.2	NA	8 009.1	3.4	9.6	NO	**17 647.3**	0.4
1999	9 445.8	9 445.8	NA	8 451.5	3.5	9.6	NO	**17 910.4**	0.4
2000	8 959.2	8 959.2	NA	8 179.6	3.4	9.5	NO	**17 151.7**	0.4
2001	9 303.2	9 303.2	NA	7 422.8	3.4	9.5	NO	**16 738.9**	0.4
2002	9 286.9	9 286.9	NA	8 314.9	3.4	9.5	NO	**17 614.7**	0.4
2003	9 676.3	9 676.3	NA	8 112.9	3.2	9.5	NO	**17 802.0**	0.3
2004	9 850.6	9 850.6	NA	7 913.3	4.0	9.5	NO	**17 777.4**	0.4
2005	9 647.0	9 647.0	NA	8 695.7	3.3	9.4	NO	**18 355.4**	0.5
2006	10 057.1	10 057.1	NA	9 078.0	3.2	7.8	NO	**19 146.0**	0.5
2007	10 381.3	10 381.3	NA	9 490.9	3.3	6.6	NO	**19 882.1**	0.5
2008	10 496.3	10 496.3	NA	9 419.9	3.1	5.3	NO	**19 924.6**	0.5
2009	10 305.0	10 305.0	NA	7 225.2	3.0	3.9	NO	**17 537.1**	0.5
2010	11 234.8	11 234.8	NA	8 852.3	2.9	2.7	NO	**20 092.7**	0.5
2011	11 133.2	11 133.2	NA	9 239.3	2.7	2.6	NO	**20 377.8**	0.5
2012	11 363.5	11 363.5	NA	8 963.7	2.5	2.6	NO	**20 332.4**	0.5
2013	11 463.1	11 463.1	NA	9 595.1	2.5	2.5	NO	**21 063.1**	0.5
2014	10 894.0	10 894.0	NA	9 247.4	2.6	2.5	NO	**20 146.5**	0.5
2015	11 183.8	11 183.8	NA	8 401.7	2.5	2.5	NO	**19 590.5**	0.5
2016	11 242.1	11 242.1	NA	8 618.1	2.5	2.4	NO	**19 865.2**	0.6
2017	11 438.1	11 438.1	NA	9 075.3	2.5	2.4	NO	**20 518.2**	0.5
2018	11 511.6	11 511.6	NA	7 772.2	2.4	2.2	NO	**19 288.5**	0.6
2019	11 608.3	11 608.3	NA	8 810.4	2.4	2.2	NO	**20 423.4**	0.7

Table A-9: Emission trends for PAH [kg] 1990–2019 – 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	11 908.4	11 908.4	NA	7 138.3	81.8	0.2	NO	**19 128.7**	NE
1991	12 849.6	12 849.6	NA	6 936.3	80.3	0.2	NO	**19 866.5**	NE
1992	11 509.6	11 509.6	NA	3 087.5	80.9	0.0	NO	**14 678.0**	NE
1993	11 243.3	11 243.3	NA	519.2	75.8	0.0	NO	**11 838.3**	NE
1994	10 144.5	10 144.5	NA	405.2	78.8	0.0	NO	**10 628.5**	NE
1995	10 489.1	10 489.1	NA	291.9	77.7	0.0	NO	**10 858.7**	NE
1996	11 027.8	11 027.8	NA	254.1	75.0	0.0	NO	**11 356.9**	NE
1997	9 874.7	9 874.7	NA	225.3	76.5	0.0	NO	**10 176.6**	NE
1998	9 246.0	9 246.0	NA	199.1	75.1	0.0	NO	**9 520.3**	NE
1999	8 966.6	8 966.6	NA	201.4	75.9	0.0	NO	**9 243.9**	NE
2000	8 263.6	8 263.6	NA	183.1	69.6	0.0	NO	**8 516.3**	NE
2001	8 350.6	8 350.6	NA	185.0	73.5	0.0	NO	**8 609.2**	NE
2002	7 473.9	7 473.9	NA	194.3	70.5	0.0	NO	**7 738.6**	NE
2003	7 075.4	7 075.4	NA	194.5	68.0	0.0	NO	**7 337.9**	NE
2004	6 724.4	6 724.4	NA	200.6	90.0	0.0	NO	**7 015.0**	NE
2005	6 824.9	6 824.9	NA	219.6	67.0	0.0	NO	**7 111.5**	NE
2006	7 040.9	7 040.9	NA	223.3	64.4	0.0	NO	**7 328.7**	NE
2007	6 988.4	6 988.4	NA	234.0	65.0	0.0	NO	**7 287.4**	NE
2008	6 979.4	6 979.4	NA	232.6	62.5	0.0	NO	**7 274.6**	NE
2009	6 896.9	6 896.9	NA	184.6	58.6	0.0	NO	**7 140.1**	NE
2010	7 583.5	7 583.5	NA	225.8	57.1	0.0	NO	**7 866.4**	NE
2011	6 907.0	6 907.0	NA	231.6	49.4	0.0	NO	**7 188.0**	NE
2012	7 151.0	7 151.0	NA	229.2	43.5	0.0	NO	**7 423.7**	NE
2013	7 290.0	7 290.0	NA	241.8	42.0	0.0	NO	**7 573.8**	NE
2014	6 446.0	6 446.0	NA	237.8	44.4	0.0	NO	**6 728.2**	NE
2015	6 523.3	6 523.3	NA	230.5	42.4	0.0	NO	**6 796.1**	NE
2016	6 751.7	6 751.7	NA	225.3	42.8	0.0	NO	**7 019.8**	NE
2017	6 738.4	6 738.4	NA	247.8	41.0	0.0	NO	**7 027.2**	NE
2018	6 170.9	6 170.9	NA	213.4	39.9	0.0	NO	**6 424.3**	NE
2019	6 209.0	6 209.0	NA	228.7	39.7	0.0	NO	**6 477.5**	NE

Table A-10: Emission trends for Benzo(a)pyrene [kg] 1990–2019 – 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	3 982.2	3 982.2	NA	2 297.0	18.7	0.0	NO	**6 298.0**	NE
1991	4 288.7	4 288.7	NA	2 232.0	18.4	0.0	NO	**6 539.2**	NE
1992	3 825.4	3 825.4	NA	995.5	18.5	0.0	NO	**4 839.4**	NE
1993	3 723.5	3 723.5	NA	170.0	17.6	0.0	NO	**3 911.1**	NE
1994	3 341.6	3 341.6	NA	131.3	18.1	0.0	NO	**3 491.0**	NE
1995	3 451.2	3 451.2	NA	92.5	17.8	0.0	NO	**3 561.5**	NE
1996	3 616.8	3 616.8	NA	77.5	17.2	0.0	NO	**3 711.6**	NE
1997	3 224.3	3 224.3	NA	66.8	17.4	0.0	NO	**3 308.5**	NE
1998	3 007.0	3 007.0	NA	57.1	17.1	0.0	NO	**3 081.2**	NE
1999	2 910.9	2 910.9	NA	57.8	17.2	0.0	NO	**2 985.8**	NE
2000	2 672.0	2 672.0	NA	52.8	15.9	0.0	NO	**2 740.7**	NE
2001	2 705.9	2 705.9	NA	53.3	16.6	0.0	NO	**2 775.8**	NE
2002	2 416.1	2 416.1	NA	55.8	16.0	0.0	NO	**2 487.9**	NE
2003	2 277.1	2 277.1	NA	55.9	15.5	0.0	NO	**2 348.5**	NE
2004	2 158.7	2 158.7	NA	57.5	19.5	0.0	NO	**2 235.7**	NE
2005	2 181.4	2 181.4	NA	62.5	15.4	0.0	NO	**2 259.4**	NE
2006	2 252.3	2 252.3	NA	63.6	15.0	0.0	NO	**2 330.9**	NE
2007	2 234.3	2 234.3	NA	66.4	15.1	0.0	NO	**2 315.8**	NE
2008	2 229.4	2 229.4	NA	66.0	14.5	0.0	NO	**2 309.9**	NE
2009	2 205.8	2 205.8	NA	53.1	13.6	0.0	NO	**2 272.6**	NE
2010	2 432.3	2 432.3	NA	64.2	13.3	0.0	NO	**2 509.9**	NE
2011	2 205.9	2 205.9	NA	65.7	12.0	0.0	NO	**2 283.7**	NE
2012	2 290.0	2 290.0	NA	65.1	10.9	0.0	NO	**2 366.0**	NE
2013	2 330.8	2 330.8	NA	68.5	10.6	0.0	NO	**2 409.9**	NE
2014	2 048.2	2 048.2	NA	67.4	11.1	0.0	NO	**2 126.7**	NE
2015	2 075.6	2 075.6	NA	65.5	10.8	0.0	NO	**2 151.8**	NE
2016	2 151.9	2 151.9	NA	64.0	10.9	0.0	NO	**2 226.8**	NE
2017	2 146.5	2 146.5	NA	70.1	10.6	0.0	NO	**2 227.1**	NE
2018	1 956.7	1 956.7	NA	60.8	10.4	0.0	NO	**2 027.9**	NE
2019	1 966.4	1 966.4	NA	64.9	10.3	0.0	NO	**2 041.7**	NE

Table A-11: Emission trends for Benzo(b)flouranthene [kg] 1990–2019 – Submission under UNECE/LRTAP.

Benzo (b)-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	4 089.1	4 089.1	NA	2 264.1	46.4	0.1	NO	**6 399.7**	NE
1991	4 428.5	4 428.5	NA	2 199.4	45.5	0.1	NO	**6 673.6**	NE
1992	3 975.0	3 975.0	NA	972.4	45.8	0.0	NO	**4 993.3**	NE
1993	3 900.5	3 900.5	NA	154.7	43.1	0.0	NO	**4 098.3**	NE
1994	3 534.3	3 534.3	NA	120.6	44.6	0.0	NO	**3 699.6**	NE
1995	3 664.6	3 664.6	NA	87.0	43.8	0.0	NO	**3 795.5**	NE
1996	3 865.5	3 865.5	NA	77.2	42.5	0.0	NO	**3 985.1**	NE
1997	3 470.5	3 470.5	NA	69.0	43.2	0.0	NO	**3 582.7**	NE
1998	3 248.1	3 248.1	NA	61.4	42.4	0.0	NO	**3 351.9**	NE
1999	3 162.9	3 162.9	NA	62.0	42.7	0.0	NO	**3 267.6**	NE
2000	2 916.8	2 916.8	NA	56.5	39.2	0.0	NO	**3 012.5**	NE
2001	2 932.5	2 932.5	NA	57.1	41.2	0.0	NO	**3 030.8**	NE
2002	2 608.7	2 608.7	NA	59.9	39.5	0.0	NO	**2 708.1**	NE
2003	2 467.9	2 467.9	NA	60.0	38.3	0.0	NO	**2 566.2**	NE
2004	2 346.0	2 346.0	NA	61.9	49.7	0.0	NO	**2 457.6**	NE
2005	2 394.3	2 394.3	NA	67.8	37.7	0.0	NO	**2 499.8**	NE
2006	2 472.2	2 472.2	NA	68.9	36.5	0.0	NO	**2 577.6**	NE
2007	2 456.4	2 456.4	NA	72.2	36.6	0.0	NO	**2 565.3**	NE
2008	2 458.2	2 458.2	NA	71.8	35.2	0.0	NO	**2 565.2**	NE
2009	2 431.6	2 431.6	NA	57.0	33.0	0.0	NO	**2 521.6**	NE
2010	2 681.4	2 681.4	NA	69.6	32.2	0.0	NO	**2 783.2**	NE
2011	2 443.6	2 443.6	NA	71.5	28.2	0.0	NO	**2 543.3**	NE
2012	2 530.1	2 530.1	NA	70.7	25.1	0.0	NO	**2 626.0**	NE
2013	2 584.7	2 584.7	NA	74.6	24.3	0.0	NO	**2 683.6**	NE
2014	2 288.8	2 288.8	NA	73.4	25.6	0.0	NO	**2 387.8**	NE
2015	2 317.2	2 317.2	NA	71.1	24.6	0.0	NO	**2 413.0**	NE
2016	2 395.5	2 395.5	NA	69.6	24.8	0.0	NO	**2 489.9**	NE
2017	2 393.7	2 393.7	NA	76.5	23.9	0.0	NO	**2 494.1**	NE
2018	2 190.2	2 190.2	NA	66.0	23.3	0.0	NO	**2 279.5**	NE
2019	2 202.0	2 202.0	NA	70.7	23.3	0.0	NO	**2 295.9**	NE

Table A-12: Emission trends for Benzo(k)flouranthene [kg] 1990–2019 – 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	1 592.1	1 592.1	NA	2 124.0	12.8	0.0	NO	**3 728.9**	NE
1991	1 720.2	1 720.2	NA	2 093.1	12.6	0.0	NO	**3 826.0**	NE
1992	1 548.9	1 548.9	NA	888.4	12.7	0.0	NO	**2 450.0**	NE
1993	1 520.1	1 520.1	NA	88.1	11.8	0.0	NO	**1 620.0**	NE
1994	1 385.4	1 385.4	NA	70.3	12.4	0.0	NO	**1 468.1**	NE
1995	1 432.8	1 432.8	NA	52.6	12.3	0.0	NO	**1 497.8**	NE
1996	1 514.2	1 514.2	NA	47.3	11.8	0.0	NO	**1 573.2**	NE
1997	1 362.2	1 362.2	NA	43.3	12.1	0.0	NO	**1 417.6**	NE
1998	1 286.8	1 286.8	NA	39.8	11.9	0.0	NO	**1 338.4**	NE
1999	1 248.2	1 248.2	NA	40.3	12.1	0.0	NO	**1 300.5**	NE
2000	1 159.8	1 159.8	NA	36.2	11.1	0.0	NO	**1 207.1**	NE
2001	1 169.2	1 169.2	NA	36.7	11.8	0.0	NO	**1 217.6**	NE
2002	1 054.4	1 054.4	NA	38.7	11.3	0.0	NO	**1 104.4**	NE
2003	1 005.8	1 005.8	NA	38.8	10.8	0.0	NO	**1 055.3**	NE
2004	959.8	959.8	NA	40.1	14.8	0.0	NO	**1 014.7**	NE
2005	978.6	978.6	NA	44.2	10.6	0.0	NO	**1 033.5**	NE
2006	1006.5	1006.5	NA	45.1	10.1	0.0	NO	**1 061.7**	NE
2007	998.7	998.7	NA	47.4	10.3	0.0	NO	**1 056.4**	NE
2008	998.8	998.8	NA	47.1	9.9	0.0	NO	**1 055.8**	NE
2009	980.5	980.5	NA	36.6	9.3	0.0	NO	**1 026.3**	NE
2010	1 068.9	1 068.9	NA	45.6	9.0	0.0	NO	**1 123.5**	NE
2011	979.7	979.7	NA	46.9	7.6	0.0	NO	**1 034.1**	NE
2012	1 008.6	1 008.6	NA	46.3	6.5	0.0	NO	**1 061.4**	NE
2013	1 031.1	1 031.1	NA	49.1	6.3	0.0	NO	**1 086.5**	NE
2014	924.3	924.3	NA	48.2	6.7	0.0	NO	**979.2**	NE
2015	932.1	932.1	NA	46.6	6.3	0.0	NO	**985.0**	NE
2016	961.2	961.2	NA	45.5	6.4	0.0	NO	**1 013.1**	NE
2017	960.5	960.5	NA	50.4	6.0	0.0	NO	**1 016.9**	NE
2018	890.0	890.0	NA	42.9	5.8	0.0	NO	**938.8**	NE
2019	898.1	898.1	NA	46.2	5.8	0.0	NO	**950.2**	NE

Table A-13: Emission trends for Indeno(1,2,3-c,d)pyrene [kg] 1990–2019 – 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	2 245.0	2 245.0	NA	453.1	3.9	0.1	NO	**2 702.1**	NE
1991	2 412.1	2 412.1	NA	411.8	3.8	0.1	NO	**2 827.7**	NE
1992	2 160.3	2 160.3	NA	231.2	3.8	0.0	NO	**2 395.3**	NE
1993	2 099.1	2 099.1	NA	106.4	3.3	0.0	NO	**2 208.9**	NE
1994	1 883.2	1 883.2	NA	83.0	3.8	0.0	NO	**1 969.9**	NE
1995	1 940.4	1 940.4	NA	59.8	3.8	0.0	NO	**2 004.0**	NE
1996	2 031.3	2 031.3	NA	52.1	3.6	0.0	NO	**2 087.0**	NE
1997	1 817.8	1 817.8	NA	46.2	3.9	0.0	NO	**1 867.9**	NE
1998	1 704.1	1 704.1	NA	40.8	3.8	0.0	NO	**1 748.8**	NE
1999	1 644.6	1 644.6	NA	41.3	4.0	0.0	NO	**1 689.9**	NE
2000	1 515.0	1 515.0	NA	37.5	3.5	0.0	NO	**1 556.0**	NE
2001	1 543.1	1 543.1	NA	37.9	4.0	0.0	NO	**1 585.0**	NE
2002	1 394.6	1 394.6	NA	39.8	3.8	0.0	NO	**1 438.2**	NE
2003	1 324.6	1 324.6	NA	39.9	3.5	0.0	NO	**1 367.9**	NE
2004	1 259.9	1 259.9	NA	41.1	6.0	0.0	NO	**1 307.1**	NE
2005	1 270.6	1 270.6	NA	45.0	3.2	0.0	NO	**1 318.8**	NE
2006	1 309.9	1 309.9	NA	45.8	2.9	0.0	NO	**1 358.6**	NE
2007	1 298.9	1 298.9	NA	48.0	3.0	0.0	NO	**1 349.9**	NE
2008	1 293.0	1 293.0	NA	47.7	2.9	0.0	NO	**1 343.7**	NE
2009	1 279.1	1 279.1	NA	37.8	2.7	0.0	NO	**1 319.6**	NE
2010	1 401.0	1 401.0	NA	46.3	2.5	0.0	NO	**1 449.8**	NE
2011	1 277.8	1 277.8	NA	47.5	1.6	0.0	NO	**1 326.9**	NE
2012	1 322.3	1 322.3	NA	47.0	0.9	0.0	NO	**1 370.3**	NE
2013	1 343.4	1 343.4	NA	49.6	0.8	0.0	NO	**1 393.8**	NE
2014	1 184.7	1 184.7	NA	48.8	1.0	0.0	NO	**1 234.4**	NE
2015	1 198.3	1 198.3	NA	47.3	0.7	0.0	NO	**1 246.3**	NE
2016	1 243.1	1 243.1	NA	46.2	0.7	0.0	NO	**1 290.0**	NE
2017	1 237.8	1 237.8	NA	50.8	0.5	0.0	NO	**1 289.1**	NE
2018	1 134.0	1 134.0	NA	43.7	0.4	0.0	NO	**1 178.1**	NE
2019	1 142.4	1 142.4	NA	46.9	0.3	0.0	NO	**1 189.7**	NE

Table A-14: Emission trends for Dioxin/Furan (PCDD/F) [g] 1990–2019 – 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	61.92	61.92	NA	42.85	0.18	20.29	NO	**125.24**	NE
1991	65.88	65.88	NA	38.96	0.18	19.88	NO	**124.91**	NE
1992	49.17	49.17	NA	24.63	0.18	2.68	NO	**76.66**	NE
1993	45.05	45.05	NA	19.14	0.18	2.38	NO	**66.76**	NE
1994	40.63	40.63	NA	13.41	0.18	2.26	NO	**56.48**	NE
1995	40.97	40.97	NA	14.37	0.18	2.27	NO	**57.79**	NE
1996	42.28	42.28	NA	13.31	0.18	2.26	NO	**58.03**	NE
1997	37.68	37.68	NA	18.19	0.18	2.27	NO	**58.31**	NE
1998	35.14	35.14	NA	17.49	0.18	2.28	NO	**55.08**	NE
1999	35.06	35.06	NA	14.26	0.18	2.29	NO	**51.79**	NE
2000	32.35	32.35	NA	15.71	0.18	2.31	NO	**50.55**	NE
2001	33.18	33.18	NA	15.13	0.18	2.31	NO	**50.80**	NE
2002	30.51	30.51	NA	4.73	0.18	2.34	NO	**37.77**	NE
2003	30.10	30.10	NA	4.40	0.17	2.36	NO	**37.02**	NE
2004	28.88	28.88	NA	4.64	0.22	2.37	NO	**36.12**	NE
2005	28.26	28.26	NA	5.29	0.15	2.04	NO	**35.75**	NE
2006	28.86	28.86	NA	5.97	0.15	2.03	NO	**37.00**	NE
2007	28.78	28.78	NA	5.24	0.15	2.54	NO	**36.72**	NE
2008	29.08	29.08	NA	4.72	0.13	2.48	NO	**36.40**	NE
2009	28.53	28.53	NA	5.11	0.13	2.47	NO	**36.25**	NE
2010	31.44	31.44	NA	6.47	0.13	2.89	NO	**40.93**	NE
2011	28.86	28.86	NA	6.34	0.09	2.80	NO	**38.09**	NE
2012	29.68	29.68	NA	6.30	0.07	2.87	NO	**38.92**	NE
2013	30.09	30.09	NA	6.66	0.06	2.52	NO	**39.34**	NE
2014	26.59	26.59	NA	6.82	0.07	2.90	NO	**36.38**	NE
2015	27.06	27.06	NA	6.82	0.06	2.92	NO	**36.86**	NE
2016	26.97	26.97	NA	6.83	0.06	2.75	NO	**36.61**	NE
2017	27.26	27.26	NA	7.05	0.06	2.78	NO	**37.15**	NE
2018	24.94	24.94	NA	6.18	0.05	2.37	NO	**33.55**	NE
2019	24.71	24.71	NA	6.49	0.05	2.41	NO	**33.66**	NE

Table A-15: Emission trends for HCB [kg] 1990–2019 – 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	52.33	52.33	NA	20.07	10.15	0.39	NO	**82.95**	NE
1991	54.36	54.36	NA	15.72	10.15	0.28	NO	**80.52**	NE
1992	46.45	46.45	NA	13.72	7.65	0.11	NO	**67.93**	NE
1993	40.97	40.97	NA	11.16	7.90	0.05	NO	**60.08**	NE
1994	34.88	34.88	NA	4.70	5.86	0.02	NO	**45.46**	NE
1995	33.20	33.20	NA	3.66	5.59	0.02	NO	**42.48**	NE
1996	31.79	31.79	NA	3.43	3.98	0.02	NO	**39.23**	NE
1997	25.52	25.52	NA	5.60	4.55	0.02	NO	**35.70**	NE
1998	21.65	21.65	NA	5.44	3.12	0.03	NO	**30.23**	NE
1999	19.20	19.20	NA	3.51	3.47	0.03	NO	**26.21**	NE
2000	15.80	15.80	NA	3.83	0.53	0.03	NO	**20.18**	NE
2001	16.04	16.04	NA	3.69	0.51	0.03	NO	**20.26**	NE
2002	14.23	14.23	NA	3.84	0.47	0.03	NO	**18.57**	NE
2003	13.72	13.72	NA	3.81	0.56	0.03	NO	**18.11**	NE
2004	13.03	13.03	NA	3.90	0.54	0.03	NO	**17.50**	NE
2005	12.23	12.23	NA	4.25	0.17	0.03	NO	**16.69**	NE
2006	12.20	12.20	NA	4.29	0.21	0.04	NO	**16.73**	NE
2007	11.70	11.70	NA	4.48	0.23	0.04	NO	**16.44**	NE
2008	11.81	11.81	NA	4.45	0.23	0.04	NO	**16.52**	NE
2009	11.21	11.21	NA	4.08	0.21	0.04	NO	**15.53**	NE
2010	12.40	12.40	NA	5.28	0.83	0.04	NO	**18.54**	NE
2011	10.99	10.99	NA	5.43	0.62	0.04	NO	**17.08**	NE
2012	35.45	35.45	NA	5.37	0.53	0.05	NO	**41.40**	NE
2013	113.67	113.67	NA	5.66	0.70	0.05	NO	**120.08**	NE
2014	117.68	117.68	NA	5.63	0.74	0.05	NO	**124.11**	NE
2015	9.99	9.99	NA	5.71	0.18	0.06	NO	**15.94**	NE
2016	9.97	9.97	NA	5.61	0.94	0.06	NO	**16.58**	NE
2017	10.09	10.09	NA	6.20	1.81	0.06	NO	**18.16**	NE
2018	9.17	9.17	NA	5.25	1.52	0.06	NO	**16.00**	NE
2019	9.14	9.14	NA	5.65	2.37	0.06	NO	**17.22**	NE

Table A-16: Emission trends for PCB [kg] 1990–2019 – 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	38.50	NA	0.00	NO	**47.23**	NE
1991	9.95	9.95	NA	25.93	NA	0.00	NO	**35.89**	NE
1992	8.63	8.63	NA	20.24	NA	0.00	NO	**28.87**	NE
1993	8.44	8.44	NA	20.72	NA	0.00	NO	**29.16**	NE
1994	7.61	7.61	NA	19.30	NA	0.01	NO	**26.91**	NE
1995	6.95	6.95	NA	22.20	NA	0.01	NO	**29.16**	NE
1996	6.72	6.72	NA	19.65	NA	0.01	NO	**26.37**	NE
1997	7.05	7.05	NA	22.89	NA	0.01	NO	**29.95**	NE
1998	6.86	6.86	NA	23.34	NA	0.01	NO	**30.20**	NE
1999	5.95	5.95	NA	22.80	NA	0.01	NO	**28.76**	NE
2000	5.07	5.07	NA	25.11	NA	0.01	NO	**30.18**	NE
2001	4.95	4.95	NA	25.68	NA	0.01	NO	**30.64**	NE
2002	4.32	4.32	NA	27.14	NA	0.01	NO	**31.46**	NE
2003	4.32	4.32	NA	27.38	NA	0.01	NO	**31.71**	NE
2004	4.10	4.10	NA	28.44	NA	0.01	NO	**32.54**	NE
2005	3.70	3.70	NA	31.22	NA	0.01	NO	**34.93**	NE
2006	3.50	3.50	NA	31.74	NA	0.01	NO	**35.24**	NE
2007	2.80	2.80	NA	33.67	NA	0.01	NO	**36.48**	NE
2008	2.79	2.79	NA	33.60	NA	0.01	NO	**36.40**	NE
2009	2.43	2.43	NA	25.10	NA	0.01	NO	**27.54**	NE
2010	2.41	2.41	NA	32.13	NA	0.01	NO	**34.55**	NE
2011	2.04	2.04	NA	33.24	NA	0.01	NO	**35.30**	NE
2012	1.89	1.89	NA	32.93	NA	0.01	NO	**34.83**	NE
2013	1.94	1.94	NA	35.25	NA	0.01	NO	**37.20**	NE
2014	1.95	1.95	NA	34.73	NA	0.01	NO	**36.69**	NE
2015	2.02	2.02	NA	33.70	NA	0.01	NO	**35.74**	NE
2016	2.07	2.07	NA	32.68	NA	0.01	NO	**34.77**	NE
2017	2.09	2.09	NA	36.15	NA	0.01	NO	**38.26**	NE
2018	1.68	1.68	NA	30.40	NA	0.02	NO	**32.09**	NE
2019	1.46	1.46	NA	33.33	NA	0.02	NO	**34.81**	NE

Table A-17: Emission trends for TSP [kt] 1990–2019 – 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	28.51	27.66	0.85	19.31	4.95	0.35	NO	**53.12**	0.27
1995	27.26	26.60	0.65	19.35	4.94	0.37	NO	**51.92**	0.41
2000	25.90	25.24	0.66	19.47	4.83	0.30	NO	**50.51**	0.52
2001	26.32	25.64	0.68	18.72	4.85	0.30	NO	**50.19**	0.51
2002	25.85	25.14	0.72	18.10	4.82	0.32	NO	**49.10**	0.46
2003	25.82	25.08	0.73	17.78	4.81	0.35	NO	**48.76**	0.43
2004	25.09	24.47	0.62	18.36	4.85	0.39	NO	**48.69**	0.51
2005	25.10	24.50	0.61	17.74	4.80	0.37	NO	**48.01**	0.59
2006	24.91	24.32	0.58	16.57	4.77	0.37	NO	**46.61**	0.63
2007	24.23	23.70	0.53	16.10	4.79	0.45	NO	**45.57**	0.66
2008	23.24	22.71	0.53	17.18	4.74	0.40	NO	**45.55**	0.66
2009	22.04	21.66	0.38	15.98	4.73	0.39	NO	**43.14**	0.57
2010	22.85	22.39	0.47	15.73	4.70	0.46	NO	**43.75**	0.62
2011	21.66	21.18	0.48	16.19	4.66	0.48	NO	**42.99**	0.65
2012	21.25	20.80	0.44	15.82	4.63	0.54	NO	**42.24**	0.62
2013	20.71	20.26	0.45	15.75	4.60	0.51	NO	**41.57**	0.59
2014	18.86	18.45	0.41	16.15	4.59	0.62	NO	**40.24**	0.59
2015	18.83	18.39	0.45	15.58	4.58	0.71	NO	**39.70**	0.63
2016	18.47	18.06	0.42	15.62	4.56	0.73	NO	**39.38**	0.70
2017	18.37	17.93	0.44	16.02	4.53	0.73	NO	**39.66**	0.67
2018	17.38	17.01	0.38	15.74	4.50	0.71	NO	**38.33**	0.76
2019	17.16	16.77	0.39	16.06	4.48	0.79	NO	**38.49**	0.88

Table A-18: Emission trends for PM_{10} [kt] 1990–2019 – 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	25.13	24.73	0.40	11.16	4.24	0.28	NO	**40.81**	0.27
1995	24.06	23.75	0.31	10.64	4.25	0.29	NO	**39.23**	0.41
2000	22.70	22.39	0.31	10.59	4.20	0.26	NO	**37.75**	0.52
2001	23.08	22.76	0.32	10.18	4.21	0.25	NO	**37.73**	0.51
2002	22.62	22.29	0.34	9.58	4.19	0.27	NO	**36.66**	0.46
2003	22.56	22.21	0.35	9.40	4.19	0.28	NO	**36.42**	0.43
2004	21.90	21.61	0.29	9.62	4.23	0.30	NO	**36.05**	0.51
2005	21.91	21.62	0.29	9.28	4.18	0.27	NO	**35.64**	0.59
2006	21.68	21.40	0.27	8.56	4.15	0.27	NO	**34.66**	0.63
2007	21.00	20.75	0.25	8.19	4.15	0.33	NO	**33.67**	0.66
2008	20.03	19.78	0.25	8.74	4.11	0.31	NO	**33.19**	0.66
2009	18.95	18.77	0.18	8.12	4.09	0.30	NO	**31.46**	0.57
2010	19.61	19.39	0.22	8.01	4.06	0.35	NO	**32.04**	0.62
2011	18.44	18.21	0.23	8.25	4.02	0.36	NO	**31.07**	0.65
2012	18.03	17.82	0.21	8.04	3.99	0.39	NO	**30.45**	0.62
2013	17.49	17.27	0.21	8.00	3.97	0.36	NO	**29.82**	0.59
2014	15.75	15.55	0.19	8.18	3.96	0.43	NO	**28.31**	0.59
2015	15.65	15.44	0.21	7.85	3.93	0.47	NO	**27.91**	0.63
2016	15.28	15.08	0.20	7.88	3.91	0.47	NO	**27.54**	0.70
2017	15.12	14.91	0.21	8.05	3.89	0.48	NO	**27.53**	0.67
2018	14.17	13.99	0.18	7.90	3.86	0.44	NO	**26.37**	0.76
2019	13.93	13.74	0.19	8.09	3.84	0.48	NO	**26.34**	0.88

Table A-19: Emission trends for $PM_{2.5}$ [kt] 1990–2019– 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	22.66	22.55	0.11	3.82	0.36	0.23	NO	**27.07**	0.27
1995	21.84	21.75	0.09	3.17	0.36	0.24	NO	**25.60**	0.41
2000	20.50	20.41	0.09	2.96	0.34	0.23	NO	**24.02**	0.52
2001	20.85	20.75	0.09	2.86	0.35	0.23	NO	**24.28**	0.51
2002	20.40	20.30	0.10	2.49	0.34	0.23	NO	**23.45**	0.46
2003	20.29	20.19	0.10	2.43	0.34	0.24	NO	**23.30**	0.43
2004	19.69	19.60	0.09	2.40	0.38	0.24	NO	**22.71**	0.51
2005	19.70	19.61	0.09	2.32	0.33	0.21	NO	**22.56**	0.59
2006	19.43	19.34	0.09	2.09	0.32	0.21	NO	**22.05**	0.63
2007	18.73	18.65	0.08	1.89	0.33	0.26	NO	**21.22**	0.66
2008	17.80	17.72	0.08	1.99	0.32	0.25	NO	**20.37**	0.66
2009	16.80	16.74	0.06	1.85	0.32	0.25	NO	**19.22**	0.57
2010	17.33	17.26	0.07	1.87	0.31	0.29	NO	**19.81**	0.62
2011	16.17	16.10	0.07	1.91	0.30	0.29	NO	**18.67**	0.65
2012	15.77	15.70	0.07	1.85	0.28	0.30	NO	**18.20**	0.62
2013	15.23	15.16	0.07	1.84	0.28	0.26	NO	**17.62**	0.59
2014	13.60	13.54	0.06	1.86	0.28	0.31	NO	**16.05**	0.59
2015	13.45	13.38	0.07	1.78	0.28	0.33	NO	**15.83**	0.63
2016	13.08	13.02	0.06	1.79	0.28	0.31	NO	**15.46**	0.70
2017	12.87	12.80	0.07	1.79	0.27	0.32	NO	**15.25**	0.67
2018	11.95	11.90	0.06	1.73	0.27	0.28	NO	**14.23**	0.76
2019	11.71	11.65	0.06	1.80	0.27	0.29	NO	**14.06**	0.88

12.2 National emission total for SO_2, NO_x, NMVOC and NH_3 calculated on the basis of fuels used

In the following tables Austria's emissions 1990–2019 are listed according to Directive (EU) 2016/2284 (NEC Directive). Austria uses the national emission totals calculated on the basis of *fuel used* (thus excluding emissions from fuel exports in the vehicle tank) for assessing compliance with the 2010 emission ceilings under the NEC Directive. Emissions are reported on the basis of fuel used (without 'fuel export'). The complete tables of the NFR Format are submitted separately in digital form only (excel files).

Table A-20: Emission trends 1990–2019 on the basis of fuel used.

	SO_2 [kt]	**NO_x [kt]**	**NMVOC [kt]**	**NH_3 [kt]**
1990	72.92	200.40	331.03	61.79
1991	69.68	202.02	319.45	62.52
1992	53.17	194.09	300.31	61.11
1993	51.66	185.58	282.24	62.17
1994	46.15	181.47	261.85	62.20
1995	45.86	180.68	246.75	63.32
1996	43.20	181.09	238.52	62.79
1997	39.98	181.45	225.32	63.11
1998	34.98	179.80	214.61	63.34
1999	33.28	179.98	204.97	62.28
2000	31.05	179.76	180.88	60.95
2001	31.82	182.85	174.38	60.87
2002	30.71	182.62	167.65	59.87
2003	30.44	186.95	162.58	59.75
2004	26.54	187.04	149.23	59.57
2005	25.88	190.30	153.26	59.46
2006	26.67	191.67	156.50	59.95
2007	23.30	187.86	152.60	61.25
2008	20.23	181.22	147.94	61.01
2009	14.72	168.67	135.24	62.42
2010	15.96	168.97	135.90	62.39
2011	15.15	167.70	131.38	61.92
2012	14.76	163.60	129.41	62.24
2013	14.34	160.25	123.61	62.34
2014	14.50	156.62	117.15	63.13
2015	14.10	154.99	112.07	63.91
2016	13.26	150.72	110.99	64.69
2017	12.78	143.99	111.60	65.56
2018	11.58	136.05	108.36	64.62
2019	10.89	130.66	108.01	63.57

Table A-21: Emission trends for SO_x [kt] 1990–2019 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 Bunkers
	kt								
1990	70.91	68.91	2.00	1.93	0.01	0.07	NO	**72.92**	0.25
1991	68.01	66.71	1.30	1.61	0.00	0.06	NO	**69.68**	0.28
1992	51.76	49.76	2.00	1.36	0.00	0.04	NO	**53.17**	0.30
1993	50.50	48.40	2.10	1.11	0.00	0.04	NO	**51.66**	0.32
1994	44.98	43.70	1.28	1.12	0.00	0.05	NO	**46.15**	0.34
1995	44.74	43.21	1.53	1.07	0.01	0.05	NO	**45.86**	0.38
1996	42.15	40.95	1.20	0.99	0.00	0.05	NO	**43.20**	0.42
1997	38.96	38.89	0.07	0.96	0.00	0.05	NO	**39.98**	0.43
1998	34.05	34.01	0.04	0.87	0.00	0.06	NO	**34.98**	0.45
1999	32.41	32.36	0.04	0.81	0.01	0.06	NO	**33.28**	0.44
2000	30.21	30.16	0.04	0.78	0.00	0.06	NO	**31.05**	0.48
2001	31.04	31.00	0.05	0.71	0.01	0.06	NO	**31.82**	0.47
2002	29.93	29.89	0.04	0.71	0.01	0.06	NO	**30.71**	0.43
2003	29.67	29.62	0.05	0.71	0.00	0.06	NO	**30.44**	0.40
2004	25.75	25.71	0.04	0.72	0.01	0.06	NO	**26.54**	0.47
2005	25.09	25.05	0.04	0.72	0.00	0.06	NO	**25.88**	0.55
2006	25.88	25.84	0.05	0.73	0.00	0.05	NO	**26.67**	0.58
2007	22.51	22.45	0.05	0.75	0.00	0.04	NO	**23.30**	0.61
2008	19.42	19.38	0.04	0.78	0.00	0.03	NO	**20.23**	0.61
2009	13.99	13.94	0.06	0.70	0.00	0.02	NO	**14.72**	0.53
2010	15.23	15.19	0.05	0.70	0.00	0.01	NO	**15.96**	0.57
2011	14.46	14.41	0.05	0.68	0.00	0.01	NO	**15.15**	0.60
2012	14.11	14.06	0.05	0.65	0.00	0.01	NO	**14.76**	0.57
2013	13.73	13.70	0.04	0.59	0.00	0.01	NO	**14.34**	0.54
2014	13.93	13.89	0.04	0.55	0.00	0.01	NO	**14.50**	0.54
2015	13.52	13.48	0.04	0.57	0.00	0.01	NO	**14.10**	0.58
2016	12.68	12.65	0.02	0.57	0.00	0.01	NO	**13.26**	0.54
2017	12.20	12.16	0.04	0.57	0.00	0.01	NO	**12.78**	0.52
2018	11.00	10.98	0.02	0.57	0.00	0.01	NO	**11.58**	0.59
2019	10.31	10.29	0.02	0.57	0.00	0.01	NO	**10.89**	0.68

Table A-22: Emission trends for NO_x [kt] 1990–2019 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	183.97	183.97	IE	4.27	12.05	0.10	NO	**200.40**	2.48
1991	186.01	186.01	IE	3.93	11.99	0.09	NO	**202.02**	2.80
1992	178.28	178.28	IE	4.02	11.73	0.06	NO	**194.09**	3.06
1993	172.50	172.50	IE	1.46	11.57	0.05	NO	**185.58**	3.27
1994	168.61	168.61	IE	1.38	11.43	0.05	NO	**181.47**	3.43
1995	168.12	168.12	IE	0.90	11.61	0.05	NO	**180.68**	3.85
1996	168.68	168.68	IE	0.87	11.50	0.05	NO	**181.09**	4.24
1997	168.98	168.98	IE	0.86	11.57	0.05	NO	**181.45**	4.43
1998	167.30	167.30	IE	0.83	11.62	0.05	NO	**179.80**	4.59
1999	167.84	167.84	IE	0.82	11.27	0.05	NO	**179.98**	4.52
2000	167.80	167.80	IE	0.83	11.08	0.05	NO	**179.76**	6.44
2001	170.97	170.97	IE	0.78	11.05	0.05	NO	**182.85**	6.32
2002	170.71	170.71	IE	0.79	11.07	0.05	NO	**182.62**	5.67
2003	175.50	175.50	IE	0.81	10.59	0.05	NO	**186.95**	5.21
2004	176.24	176.24	IE	0.69	10.06	0.05	NO	**187.04**	6.09
2005	179.43	179.43	IE	0.70	10.12	0.05	NO	**190.30**	6.99
2006	180.88	180.88	IE	0.58	10.16	0.04	NO	**191.67**	7.54
2007	177.04	177.04	IE	0.48	10.31	0.04	NO	**187.86**	7.99
2008	169.74	169.74	IE	0.56	10.90	0.03	NO	**181.22**	7.90
2009	157.55	157.55	IE	0.41	10.69	0.02	NO	**168.67**	6.86
2010	158.63	158.63	IE	0.55	9.78	0.02	NO	**168.97**	7.60
2011	156.88	156.88	IE	0.52	10.28	0.02	NO	**167.70**	7.98
2012	152.64	152.64	IE	0.55	10.40	0.02	NO	**163.60**	7.68
2013	149.49	149.49	IE	0.45	10.29	0.02	NO	**160.25**	7.46
2014	145.54	145.54	IE	0.46	10.60	0.02	NO	**156.62**	7.49
2015	143.46	143.46	IE	0.52	10.99	0.02	NO	**154.99**	8.18
2016	139.02	139.02	IE	0.52	11.17	0.02	NO	**150.72**	10.28
2017	132.52	132.52	IE	0.47	10.99	0.02	NO	**143.99**	10.06
2018	124.84	124.84	IE	0.41	10.77	0.02	NO	**136.05**	11.54
2019	119.81	119.81	IE	0.50	10.33	0.02	NO	**130.66**	13.47

Table A-23: Emission trends for NMVOC [kt] 1990–2019 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	160.15	144.66	15.49	118.54	52.19	0.16	NO	**331.03**	0.18
1991	156.08	140.97	15.12	112.01	51.19	0.16	NO	**319.45**	0.20
1992	146.39	131.20	15.19	105.25	48.53	0.15	NO	**300.31**	0.21
1993	136.29	121.64	14.65	98.55	47.26	0.15	NO	**282.24**	0.23
1994	122.93	111.81	11.12	91.99	46.79	0.14	NO	**261.85**	0.24
1995	115.09	105.60	9.49	85.28	46.25	0.14	NO	**246.75**	0.26
1996	109.58	101.11	8.46	83.72	45.09	0.13	NO	**238.52**	0.31
1997	98.49	90.53	7.95	82.37	44.33	0.13	NO	**225.32**	0.35
1998	89.43	83.00	6.43	81.06	43.99	0.13	NO	**214.61**	0.39
1999	83.26	77.58	5.67	78.32	43.28	0.12	NO	**204.97**	0.38
2000	76.33	70.64	5.69	62.15	42.28	0.12	NO	**180.88**	0.42
2001	72.04	68.20	3.84	60.39	41.83	0.11	NO	**174.38**	0.41
2002	66.63	62.60	4.03	59.97	40.94	0.11	NO	**167.65**	0.37
2003	63.46	59.50	3.96	58.57	40.44	0.11	NO	**162.58**	0.34
2004	59.62	56.05	3.57	49.36	40.14	0.11	NO	**149.23**	0.40
2005	57.15	53.81	3.34	56.52	39.48	0.11	NO	**153.26**	0.47
2006	54.86	51.51	3.36	62.34	39.20	0.10	NO	**156.50**	0.50
2007	52.10	49.12	2.98	61.32	39.07	0.10	NO	**152.60**	0.53
2008	50.31	47.56	2.75	58.74	38.80	0.10	NO	**147.94**	0.52
2009	47.56	44.97	2.59	48.60	38.99	0.09	NO	**135.24**	0.45
2010	49.18	46.73	2.45	48.06	38.58	0.08	NO	**135.90**	0.49
2011	45.39	42.98	2.41	48.00	37.92	0.08	NO	**131.38**	0.51
2012	45.11	42.71	2.40	46.61	37.61	0.08	NO	**129.41**	0.49
2013	44.39	42.09	2.30	41.57	37.58	0.07	NO	**123.61**	0.46
2014	39.64	37.23	2.42	39.81	37.63	0.07	NO	**117.15**	0.46
2015	39.75	37.43	2.32	34.83	37.43	0.06	NO	**112.07**	0.50
2016	39.21	36.94	2.27	34.29	37.42	0.06	NO	**110.99**	0.23
2017	38.75	36.46	2.29	35.49	37.30	0.06	NO	**111.60**	0.20
2018	35.80	33.63	2.17	35.54	36.96	0.06	NO	**108.36**	0.22
2019	35.54	33.31	2.23	35.90	36.51	0.05	NO	**108.01**	0.24

Table A-24: Emission trends for NH_3 [kt] 1990–2019 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	59.18	0.37	NO	**61.79**	0.00
1991	2.26	2.26	IE	0.58	59.31	0.38	NO	**62.52**	0.00
1992	2.48	2.48	IE	0.44	57.75	0.43	NO	**61.11**	0.00
1993	2.79	2.79	IE	0.29	58.58	0.52	NO	**62.17**	0.00
1994	2.98	2.98	IE	0.24	58.37	0.62	NO	**62.20**	0.00
1995	3.18	3.18	IE	0.17	59.33	0.64	NO	**63.32**	0.00
1996	3.48	3.48	IE	0.16	58.48	0.67	NO	**62.79**	0.00
1997	3.60	3.60	IE	0.16	58.69	0.67	NO	**63.11**	0.00
1998	3.75	3.75	IE	0.17	58.72	0.70	NO	**63.34**	0.00
1999	3.93	3.93	IE	0.19	57.40	0.77	NO	**62.28**	0.00
2000	3.88	3.88	IE	0.17	56.08	0.82	NO	**60.95**	0.00
2001	3.90	3.90	IE	0.15	55.91	0.92	NO	**60.87**	0.00
2002	3.70	3.70	IE	0.13	55.03	1.02	NO	**59.87**	0.00
2003	3.61	3.61	IE	0.14	54.90	1.10	NO	**59.75**	0.00
2004	3.45	3.45	IE	0.12	54.65	1.35	NO	**59.57**	0.00
2005	3.38	3.37	0.00	0.13	54.51	1.44	NO	**59.46**	0.00
2006	3.34	3.33	0.01	0.14	55.01	1.47	NO	**59.95**	0.00
2007	3.24	3.23	0.01	0.14	56.36	1.51	NO	**61.25**	0.00
2008	3.07	3.07	0.00	0.14	56.26	1.54	NO	**61.01**	0.00
2009	2.87	2.86	0.00	0.15	57.83	1.57	NO	**62.42**	0.00
2010	2.94	2.93	0.00	0.15	57.74	1.56	NO	**62.39**	0.00
2011	2.72	2.72	0.00	0.16	57.47	1.56	NO	**61.92**	0.00
2012	2.64	2.63	0.00	0.15	57.87	1.58	NO	**62.24**	0.00
2013	2.50	2.50	0.00	0.16	58.15	1.53	NO	**62.34**	0.00
2014	2.32	2.31	0.00	0.15	59.08	1.58	NO	**63.13**	0.00
2015	2.36	2.36	0.00	0.14	59.81	1.61	NO	**63.91**	0.00
2016	2.27	2.27	0.00	0.15	60.68	1.60	NO	**64.69**	0.00
2017	2.31	2.31	0.00	0.17	61.48	1.60	NO	**65.56**	0.00
2018	2.28	2.28	0.00	0.14	60.59	1.62	NO	**64.62**	0.00
2019	2.30	2.30	0.00	0.16	59.46	1.64	NO	**63.57**	0.01

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

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
1.A.3.c	Railways	No information in the EMEP/EEA GB 2019		EMEP/EEA GB 2019
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)	NO		
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 NFR 1.A.4. PM emission factors for the year 2017. (EMEP/EEA Guidebook 2016), (WINIWARTER et al. 2001), (WINIWARTER et al. 2007), (FOEN 2015), German Environment Agency (2008).
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 NFR 1.A.4. PM emission factors for the year 2017. (EMEP/EEA Guidebook 2019), (WINIWARTER et al. 2001), (WINIWARTER et al. 2007), (FOEN 2015), German Environment Agency (2008).
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 NFR 1.A.4. PM emission factors for the year 2017. (EMEP/EEA Guidebook 2019), (WINIWARTER et al. 2001), (WINIWARTER et al. 2007), (FOEN 2015), German Environment Agency (2008).
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	No information in the EMEP/EEA GB 2019		EMEP/EEA GB 2019
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	IE		
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	NE		
2.A.1	Cement production		X	MAUSCHITZ 2011
2.A.2	Lime production	X		(diffuse) WINIWARTER et al. 2007
2.A.3	Glass production	IE		
2.A.5.a	Quarrying and mining of minerals other than coal	NA		(diffuse) WINIWARTER et al. 2007
2.A.5.b	Construction and demolition	NA		(diffuse) WINIWARTER et al. 2007
2.A.5.c	Storage, handling and transport of mineral products	NO		
2.A.6	Other mineral products (please specify in the IIR)	NO		

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
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)	NA		(diffuse) 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	No information available		diffuse emissions + abatment technologies installed, directly reported by the operator
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	NA		
2.D.3.c	Asphalt roofing	NA		
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)	No information in the EMEP/EEA GB 2019		EMEP/EEA GB 2019
2.H.1	Pulp and paper industry	NA		
2.H.2	Food and beverages industry	NA		(diffuse) WINIWARTER et al. 2007
2.H.3	Other industrial processes (please specify in the IIR)	NO		
2.I	Wood processing	NA		(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		
2.L	Other production, consumption, storage, transportation or handling of bulk products (please specify in the IIR)	NO		

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
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 2019
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 2019		EMEP/EEA GB 2019
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		
5.B.2	Biological treatment of waste - Anaerobic digestion at biogas facilities	NA		
5.C.1.a	Municipal waste incineration	NO		

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
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		
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

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The Informative Inventory Report (IIR) 2021 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 2021, 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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