ENVIRONMENT AGENCY AUSTRIA umweltbundesamt

AUSTRIA'S INFORMATIVE INVENTORY REPORT (IIR) 2020

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

REPORT
DRAFT

Vienna 2020

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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PREFACE

The report "Austria's Informative Inventory Report (IIR) 2020" 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 2020 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 2020 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 2020 a).

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1 http://www.ceip.at/fileadmin/inhalte/emep/reporting_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 http://www.ceip.at/fileadmin/inhalte/emep/2014_Guidelines/ece.eb.air.125_ADVANCE_VERSION_reporting_guidelines_2013.pdf

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

5 Annex II: http://www.ceip.at/ms/ceip_home1/ceip_home/reporting_instructions/annexes_to_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 2020 are Michaela Titz and Daniela Perl.

Specific responsibilities for the IIR 2020 have been as follows:

- Executive Summary .... Michaela Titz, Daniela Perl, Marion Gangl
- Chapter 1 Introduction.................................... Michaela Titz, Günther Schmidt
- Chapter 2 Trends .... Michaela Titz, Daniela Perl, Marion Gangl
- 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
- Chapter 6 Waste .... Christoph Lampert, Katja Pazdernik
- Chapter 7 Recalculations & Improvements…. .... Michaela Titz, Daniela Perl
- Chapter 8 Projections.................................... Michaela Titz
- Chapter 9 Reporting of gridded emissions and LPS .... Simone Haider, Günther Schmidt
- Appendix .... Michaela Titz, Daniela Perl, 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 2018 for the main pollutants, for POPs and HMs and for the years 1990, 1995 and from 2000 onwards for PM.

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: http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2014_submissions/

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 compliance assessment 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 2018, emissions were reduced by 84.0% compared to 1990 and amounted to 12 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 reduced coal consumption 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 2017 to 2018 emissions decreased by 8.4%. This was mainly caused by reductions in emissions from iron and steel (*1.A.2.a*).

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 2018, NO_x emissions amounted to 151 kt and were about 31% lower than in 1990. From 2017 to 2018 emissions decreased by 6.8%. This was caused by the decline in road traffic, especially of heavy duty vehicles and passenger cars. In 2018 53% of the total nitrogen oxides emissions originate from road transport (including fuel exports). Austria is a landlocked country and fuel prices significantly vary between neighbouring countries. So Austria has experienced a considerable amount of 'fuel export' and the share of NO_x emissions caused by fuel sold in Austria but used abroad is notable. Emissions for 2018 based on fuel used amount to 136 kt and are about 15 kt lower than based on fuel sold; the decrease between 1990 and 2018 is slightly stronger (-32%).

In 1990, national total NMVOC emissions amounted to 334 kt. Emissions have decreased steadily since then and in the year 2018 emissions were reduced by 68% to 107 kt compared to 1990. The largest reductions were 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 several regulations (Solvent Ordinance, Cogeneration Act, VOC Emissions Ordinance). From 2017 to 2018 emissions decreased by 3.2%.

In 1990, national total NH_3 emissions amounted to 62 kt; emissions have increased over the period from 1990 to 2018. In 2018, emissions were 4.7% above 1990 levels and amounted to 65 kt. NH_3 in Austria is almost exclusively emitted in the agricultural sector. The higher NH_3

emissions (in spite of a decrease in the number of cattle) can be explained by an increase in loose housing systems (to ensure animal welfare and according to EU law) and an increase of high-capacity dairy cows. Additionally, there has been an increase in the use of urea as nitrogen fertiliser (a cost-efficient but otherwise less efficient fertiliser). Compared to the previous year, emissions in 2018 decreased by 1.6%. The main reason is the lower amount of mineral fertilizer, in particular urea, which was applied on agricultural soils. Furthermore, the livestock numbers of cattle (dairy cows and other cattle) and swine were falling. However, increased N excretion due to increased milk yields counterbalanced the decreasing dairy cow number.

In 1990, national total CO emissions amounted to 1 249 kt. Emissions considerably decreased from 1990 to 2018. In 2018, emissions were 61% below 1990 levels and amounted to 490 kt. This reduction was mainly due to decreasing emissions from road transport (catalytic converters). The emissions decreased between 2017 and 2018 by 7.4%, mainly due to sectors iron and steel and residential (stationary).

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 2018: 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 2017 and 2018 PM_{10}, $PM_{2.5}$ and TSP emissions decreased by 4.3% (PM_{10}), 6.8% ($PM_{2.5}$) and 3.4% (TSP). The decrease of TSP, PM_{10} and $PM_{2.5}$ was mainly because of reductions in the sector *1 A 4 b 1 residential: stationary*, due to the mild weather in 2018 and a decrease in the use of biomass for heating. To a small extent, the latest decline can also be explained by efficiency improvements through thermal renovation and by a switch to modern biomass boilers and stoves (improvements in fuel combustion technologies). TSP emissions also decreased slightly due to reduced emissions from *2.A.5.a Quarrying and mining of minerals other than coal*.

Heavy Metals

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

The overall Cd emissions reduction of 35% from 1990 to 2018 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 56% for the period 1990 to 2018 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. 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 2017 and 2018 emissions decreased by 7.0% mainly because of reduced emissions from NFR *2.C.1 Iron and Steel Production.*

The overall reduction trend of Pb emissions was minus 92% for the period 1990 to 2018, 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 a decrease of 6.2% as a result of reduced emissions from *Iron and Steel Production* (*2.C.1*).

Persistent Organic Pollutants (POPs)

Emissions of all POPs decreased remarkably from 1990 to 2018 (HCB -58%, PAH -64%, PCDD/F -73% and PCBs -32%), 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 2018 PCB emissions decreased by 16% compared to the previous year 2017, due to reduced emissions from *sector 2.C.1 Iron and Steel Production*.

PCDD/F emissions decreased by 7.5% compared to the previous year 2017, PAH emissions decreased by 8.1% and HCB emissions by 9.6% in the same time. These reductions are mainly due to the warm weather and thus reduced emissions from residential heating (decreased biomass consumption) as well as due to a decrease of iron and steel production (*2.C.1*) (relevant for HCB and PCDD/F). Dioxin/furan emissions from sector *Waste* (*5.E Other Waste)* also decreased remarkably from 2017 to 2018, although the share of this category in national total emissions is only 6%.

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. 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 43 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 2018.

Name of key category	No of occurrences as key category
1.A.4.b.1 – Residential: stationary	26 times (SO_2, NO_x, NMVOC, CO, Cd, Pb, Hg, PAH, DIOX, HCB, TSP, PM_{10}, $PM_{2.5}$)
1.A.1.a – Public Electricity and Heat Production	18 times (SO_2, NO_x, NMVOC, CO, Cd, Pb, Hg, DIOX, TSP, PM_{10}, $PM_{2.5}$)
2.C.1 – Iron and Steel Production	14 times (Cd, Pb, Hg, DIOX, HCB, PCB, PM_{10})
1.A.3.b – 1 R.T., Passenger cars	12 times (NO_x, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$)
1.A.2.d – Pulp, Paper and Print	8 times (SO_2, Cd, Pb, Hg)

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 2014 and 2015 has been revised downwards. However, natural gas consumption has been shifted to different sectors. For liquid fuels, gross inland consumption has been revised downwards for the years 2005 to 2011 (crude oil input into refineries) and for the year 2017, which does not have an effect on final consumption, because lower fuel imports have been counterbalanced by higher refinery fuel output. For the period 2013 to 2017, liquid fuels have been shifted from the industry sector (mostly from 1A2e food processing and 1A2g other manufacturing industries) to the residential (1A4b) and commercial (1A4a) sector. For solid fuels, mainly the residential sector has been revised for the years since 2005. For 'biomass', gross inland consumption has been revised upwards for the whole time series 2005 – 2017. For the years 2005 to 2016, transformation input to the power sector (1A1a) has been revised downwards while for 2017 it has been revised upwards, which explains most of the higher NOX (+7%) and PM2.5 (+6%) emissions in 2017 of category 1A1a. The largest revision to biomass consumption took place in the 1A4 stationary combustion sub-categories.

In NFR sector *1.A.3 Transport*, the domestic activity data (fuel consumption/mileage) has been updated fundamentally with new specific mileage per vehicle category: for the first time, data from periodic roadworthiness testing has been evaluated resulting in new age-related mileage data and improved data accuracy. This affects the categories passenger cars (PC), light-duty vehicles (LDV) and motorcycles (MC). Furthermore, the new HBEFA Version 4.1 was implemented, which resulted in increased emission factors for all vehicle categories.

In NFR sector *2 Industrial Processes and Product Use* recalculations have been carried out mainly in subcategory Solvent Use (2.D.3): Following in-depth QC activities, time series inconsistencies in the solvents model were removed and has led to a decrease in activity data (Solvents Used), leading to a decrease in emissions.
In the categories Iron and Steel Production (2.C.1) and Other processes (2.H.2) estimates for the PAH fractions BAP, BBF, BKF, IND has been included.

More detailed statistical data became available on cigarettes sold in Austria, as well as loose tobacco and cigars, and was used for a review of the timeline.

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

The main reason for revised emissions in NFR sector *3 Agriculture* is the implementation of the new EMEP/EEA Guidebook 2019 in category Manure Management (3.B). For mineral fertiliser application, rapid incorporation of urea into agricultural soils was considered for the first time. Inventory improvements resulted in lower NH_3 emissions over the whole time series.

In NFR sector *5 Waste,* the main revisions werde made in category Wastewater (5.D): For NMVOC from category *5.D.1 domestic wastewater* a recalculation for 2017 was carried out as new data on wastewater volumes became available. This new data was used to replace activity data that had been extrapolated based on population growth.

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 319. The next Stage 3 review is currently not scheduled, but will be 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 2018 for Austria are summarized and commented in Table 320.

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

ES.7 Condensable component of PM_{10} and $PM_{2.5}$

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

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

1 INTRODUCTION

1.1 National inventory background

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

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

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

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

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

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

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8 https://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

1.2 Institutional, legal and procedural arrangements

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

The accreditation comprises the emission inventory for all GHGs and air pollutants as reported under the UNFCCC 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 are made up of staff from various organisational units of the Umweltbundesamt, who in the course of their inspection activity are assigned to the IBE and therefore 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).

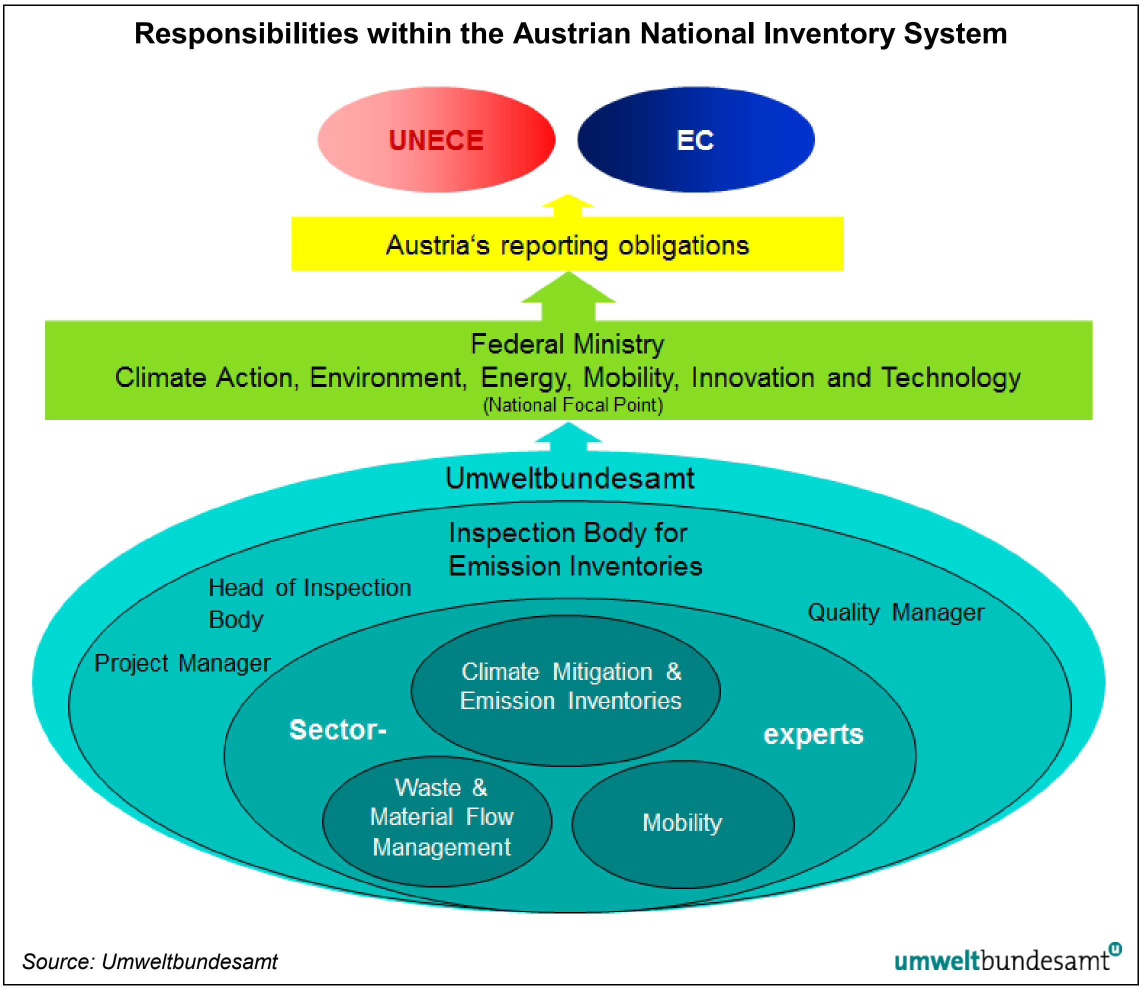

Figure 1: Responsibilities within the Austrian National Inventory System (Air Pollutants).

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

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. There are 8 sectors defined (Energy, Transport, Fugitive Emissions, Industrial Processes, Product Use, Agriculture, LULUCF[15] and Waste). Two experts form a sector team and one of them is nominated as 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. 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] 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 availaible 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 Federal Ministry 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' (BMK) and with the Federal Ministry for Digital and Economic Affairs (BMDW) 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.

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15 Only relevant for GHG emissions

16 *„Emissionszertifikate-Gesetz"*; Federal Law Gazette I No. 46/2004

17 *„Bundesstatistikgesetz 2000"*; Federal Law Gazette I No 163/1999, last amended by Federal Law Gazette I No 32/2018

- According to paragraph 38 (1) of the EG-K 2013[18] each licensee of an operating boiler with a thermal capacity of more than two megawatts (MW) is obliged to report the emissions to the competent authority. The Umweltbundesamt can request copies of these emission declarations. These data are 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. These data are 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.

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

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

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

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

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.
- 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 in 2005 and was renewed in 2011 and 2015.

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).

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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

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

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.

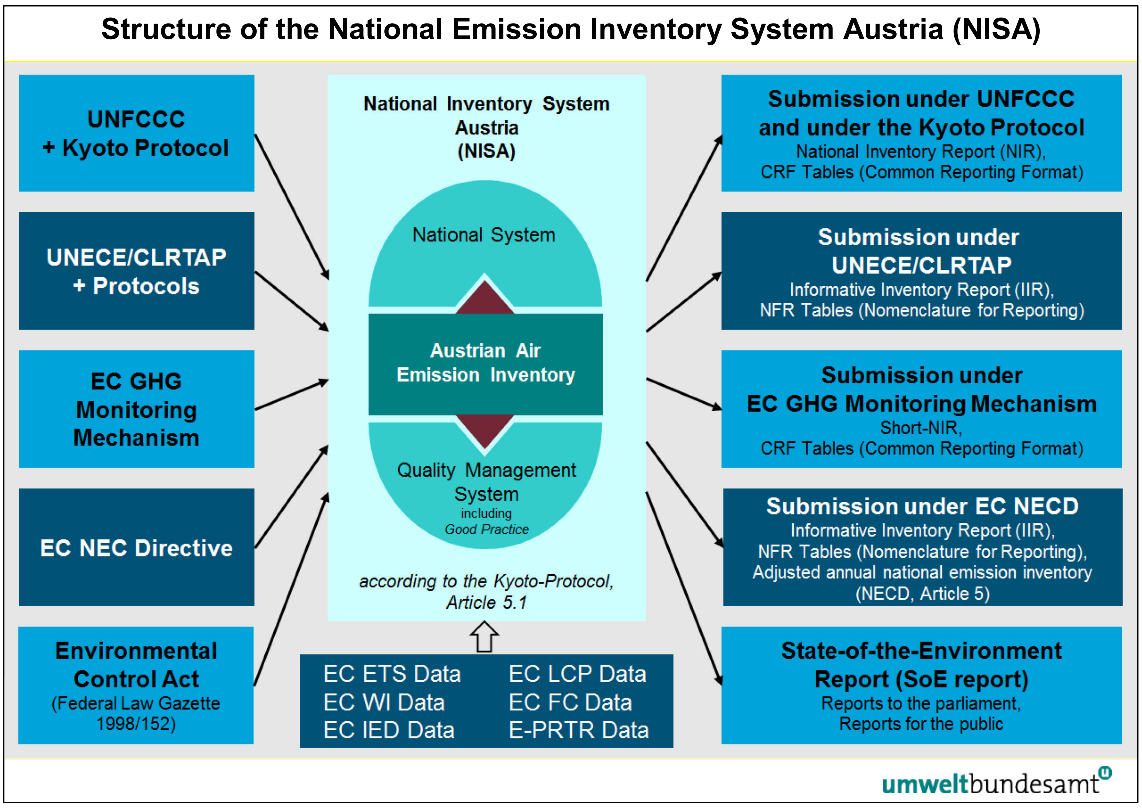

Figure 2: Structure of the National Emission Inventory System Austria (NISA).

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 emission ceilings law[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]
- 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.

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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=20002763

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

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

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	27	17.05.2005	01.12.1999 (s)

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

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

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

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

This report follows the regulations under the UNECE/LRTAP Convention and its Protocols that define standards for national emission inventories. In 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.

[38] http://www.ceip.at/fileadmin/inhalte/emep/reporting_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] http://www.ceip.at/fileadmin/inhalte/emep/2014_Guidelines/ece.eb.air.125_ADVANCE_VERSION_reporting_guidelines_2013.pdf

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 2017
2. Particulate matter	$PM_{2.5}$, PM_{10}, (*TSP, BC*)	for 1990, 1995, and for 2000 to 2017
3. Heavy metals	Pb, Cd, Hg, (*As, Cr, Cu, Ni, Se, Zn)*	from 1990 to 2017
4. POPs	PCDD/PCDF, PAHs [2], HCB, PCBs	from 1990 to 2017
B. Emissions by NFR source category		
1. Main pollutants	SO_x, NO_x, NH_3, NMVOC, CO	from 1990 to 2017
2. Particulate matter	$PM_{2.5}$, PM_{10}, (*TSP, BC*)	for 1990, 1995, and for 2000 to 2017
3. Heavy metals	Pb, Cd, Hg, *As, Cr, Cu, Ni, Se, Zn*	from 1990 to 2017
4. POPs	PCDD/PCDF, PAHs [2], HCB, PCBs	from 1990 to 2017
C. Activity data by source category		**from 1990 to 2016**
D. Gridded data in the EMEP 0.1x0.1 long/lat grid		
1. Sector emissions 2. National totals	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
E. Emissions from large point sources		
	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
ADDITIONAL REPORTING/FOR REVIEW AND ASSESSMENT PURPOSES		
VOC speciation/Height distribution/Temporal distribution		
Land-use data/Mercury breakdown		
% of toxic congeners of PCDD/F emissions		
Pre-1990 emissions of PAHs, HCB, PCDD/F and PCB		
Information on natural emissions		

[41] http://www.ceip.at/ms/ceip_home1/ceip_home/reporting_instructions/

Element(s)	Pollutant(s)	Years [1]
A. National total emissions		
Projected emissions and projected activity data		
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 2018 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.

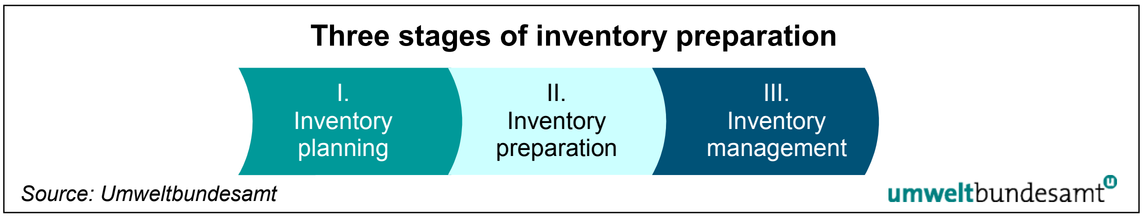

Figure 3: Three stages of inventory preparation.

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.

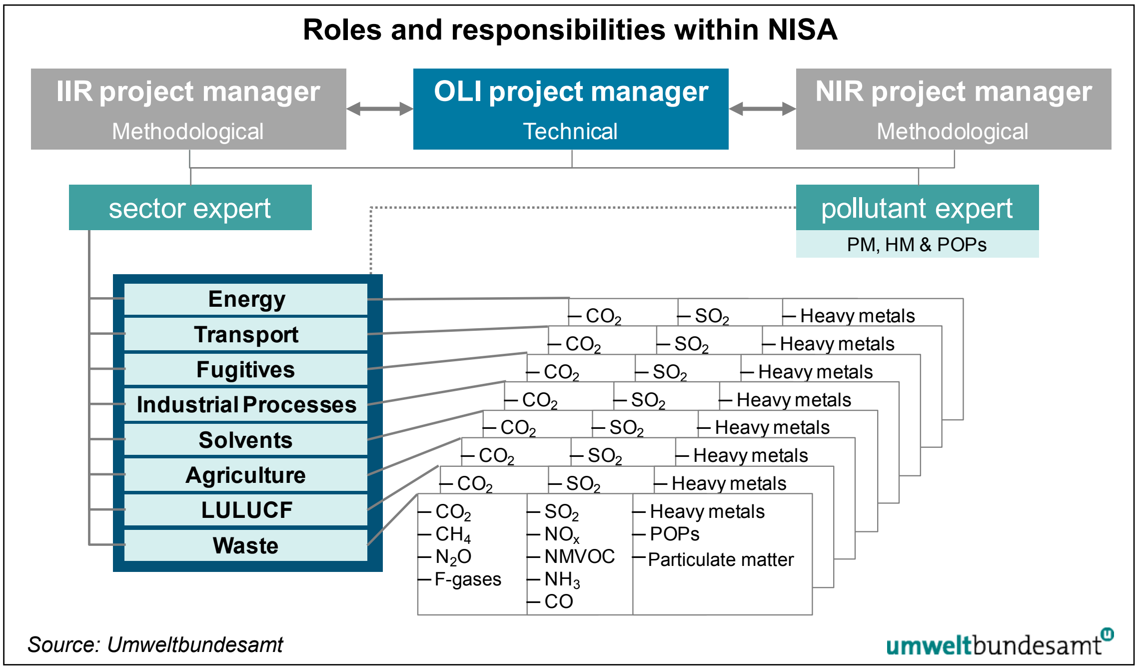

Figure 4: Roles and responsibilities within the National Emission Inventory System Austria (NISA).

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

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 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

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)

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
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
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 (BMNT) 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 Austrian Ministry for Transport, Technology and Innovation • ZBD: Zentrale Beguchtachtungsdatenbank (yearly 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 • Amount of taxed tobacco products
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 (~28,5 Mt CO_2 in 2018).

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 (CRF Sector 1) and 4 Industrial Processes and Product Use (CRF Sector 2).

An important feature of the emissions reported under the EU-ETS is that these emissions have to pass independent verification by an accredited verifier. The Austrian Federal Ministry for Sustainability and Tourism 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 Sustainability and Tourism (BMNT) 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.

[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

1.4.3 Other data (E-PRTR)

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

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

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

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

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

1.4.4 Literature

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

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).

[57] Data can be downloaded from: http://www.umweltbundesamt.at/prtr/

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

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.

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 2016" (EEA 2016)". It stipulates that a key category is one that is prioritised within the national inventory system because its 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 (EEA 2016).

Furthermore, it is good practice

- to identify the national key categories in a systematic and objective manner. This can be achieved by a quantitative analysis of the relationship between the magnitude of emission in any year (level) and the change in emission year to year (trend) of each category's emissions compared to the total national emissions;
- to focus the available resources for improvement in data and methods on categories identified as key. The identification of key categories in national inventories enables the limited resources available for preparing inventories to be prioritised; more detailed, higher tier methods can the be slected for key categories. Invetory compilers should use the category specific methods presented in sectoral decision tress Iin the sectoral volumes;
- that the analysis should be performed at the level of NFR categories or subcategoreis at which the guidebook methods and decision trees are provided in the sectoral volumes. Where possible, some categories should be disaggregated by main fuel types;
- that each air pollutant emitted from each category should be considered separately;
- that for each key category, the inventory compiler should determine if certain subcategoreis are particulary significant usually, for this purpose, the subcategories should be ranked according to their contribution to the aggregate key categories. Those subcategoreis that contribute together more than 60% to the key category should be treated as particularly significant. It may be appropriate to focus efforts towards methodological improvements of these most significant subcategories.

All notations, descriptions of identification and results for key categories included in this chapter are based on the latest Inventory Guidebook (EEA 2016).

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 2016 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 2019 to the UNECE/LRTAP and the European Commission. For all gases a level assessment for all years 1990 (base year) and 2017 (last year), as well as a trend assessment for 1990 to 2017 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.F	Field Burning of agricultural Residues
3.B.4.f	Mules and Asses	3.I	Agriculture Other
3.B.4.g	Poultry		
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 Handling
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 42 key sources were identified.

Table 7: Summary of Key Categories for the year 2018 – Contributions per pollutant for Level Assessment (LA) and Trend Assessment (TA) in %.

NFR Code	NFR Category	% Contributions to pollutant totals for key categories (cumulative 80%)																														Sum of KC % contributions	Rank
		SO_2		NO_X		NMVOC		NH_3		CO		Cd		Pb		Hg		PAH		DIOX		HCB		PCB		TSP		PM_{10}		$PM_{2.5}$			
		LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA		
1 A 1 a	Public Electricity and Heat Production	8	8	6	6							12	12	10	10	15	15			4	4					3	3	4	4	6	6	**134**	**3**
1 A 1 b	Petroleum refining											13	13																			**26**	**16**
1 A 2 a	Iron and Steel	36	36							27	27																					**127**	**4**
1 A 2 d	Pulp, Paper and Print	7	7									13	13	5	5	9	9															**67**	**10**
1 A 2 f	Non-metallic Minerals	8	8	4	4											17	17															**58**	**11**
1 A 2 g 7	Mobile Combustion in Manufacturing Industries and Construction			4	4																											**8**	**28**
1 A 2 g 8	Other Stationary Combustion in Manufacturing Industries and Construction	11	11																	5	5											**33**	**14**
1 A 3 b 1	R.T., Passenger cars			36	36	2	2			9	9															2	2	3	3	6	6	**118**	**6**
1 A 3 b 2	R.T., Light duty vehicles			7	7																											**13**	**24**
1 A 3 b 3	R.T., Heavy duty vehicles			11	11																									2	2	**25**	**17**
1 A 3 b 6	R.T., Automobile tyre and break wear													25	25											5	5	6	6	6	6	**82**	**9**

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 7	R.T., Automobile road abrasion																									4	4	3	3	3	3	**21**	**18**
1 A 3 c	Railways																									4	4	2	2			**13**	**25**
1 A 4 a 1	Commer-cial/Institutional: Stationary																													2	2	**4**	**33**
1 A 4 b 1	Residential: sta-tionary	11	11	7	7	21	21			43	43	20	20	9	9	15	15	72	72	50	50	69	69			18	18	24	24	42	42	**800**	**1**
1 A 4 b 2	Residential: Household and gardening (mobile)									4	4																					**7**	**29**
1 A 4 c 1	Agricultu-tu-re/Forestry/Fishing: Stationary																	13	13			6	6							3	3	**44**	**12**
1 A 4 c 2	Agricultu-tu-re/Forestry/Fishing: Off-road Vehicles and Other Machin-ery			4	4																							2	2	4	4	**20**	**19**
2 A 5	Mining, construc-tion/demolition and handling of prod-ucts																									34	34	23	23	5	5	**123**	**5**
2 C 1	Iron and Steel Production											18	18	32	32	31	31			7	7	10	10	95	95			2	2			**390**	**2**
2 C 3	Aluminium produc-tion																			10	10											**19**	**20**
2 D 3 a	Domestic solvent use including fun-					15	15																									**30**	**15**

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		
	gicides																																
2 D 3 d	Coating applica-tions					5	5																									**10**	**27**
2 D 3 h	Printing					3	3																									**7**	**30**
2 G	Other product manufacture and use											6	6																	3	3	**18**	**21**
2 H	Other Processes					3	3																									**5**	**32**
2 I	Wood processing																									3	3					**6**	**31**
3 B 1	Cattle					23	23	28	28																							**101**	**8**
3 B 3	Swine							9	9																							**18**	**22**
3 D a 1	Inorganic N-fertilizers							7	7																							**15**	**23**
3 D a 2	Organic fertilizers			4	4	8	8	40	40																							**102**	**7**
3 D c	On-farm storage, handling and transport of agri-cultural products																									9	9	13	13			**43**	**13**
5 E	Other waste han-dling																			6	6											**12**	**26**

Table 8: Key Categories for SO_2 emissions for the year 2018.

Level Assessment

NFR Code	NFR Category	Latest Year (2018) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 2 a	Iron and Steel	4.26	36.2%	36.2%
1 A 2 g 8	Other Stationary Combustion in Manufacturing Industries and Construction	1.35	11.5%	47.7%
1 A 4 b 1	Residential: stationary	1.25	10.6%	58.3%
1 A 1 a	Public Electricity and Heat Production	0.96	8.1%	66.4%
1 A 2 f	Non-metallic Minerals	0.91	7.7%	74.1%
1 A 2 d	Pulp, Paper and Print	0.81	6.9%	81.0%
	National Total	**11.77**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2018) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
1 A 2 a	Iron and Steel	1 A 2 a	6.73	4.26	4.256	36.2%
1 A 2 g 8	Other Stationary Combustion in Manufacturing Industries and Construction	1 A 2 g 8	1.88	1.35	1.353	11.5%
1 A 4 b 1	Residential: stationary	1 A 4 b 1	25.87	1.25	1.247	10.6%
1 A 1 a	Public Electricity and Heat Production	1 A 1 a	11.81	0.96	0.956	8.1%
1 A 2 f	Non-metallic Minerals	1 A 2 f	2.23	0.91	0.907	7.7%
1 A 2 d	Pulp, Paper and Print	1 A 2 d	4.30	0.81	0.810	6.9%
	National Total	**73.70**	**11.77**			

Table 9: Key Categories for NO_x emissions for the year 2018.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2018) 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	54.13	35.9%	35.9%
1 A 3 b 3	R.T., Heavy duty vehicles	16.30	10.8%	46.7%
1 A 4 b 1	Residential: stationary	10.29	6.8%	53.5%
1 A 3 b 2	R.T., Light duty vehicles	9.99	6.6%	60.1%
1 A 1 a	Public Electricity and Heat Production	8.92	5.9%	66.0%
1 A 4 c 2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	6.42	4.3%	70.3%
1 A 2 g 7	Mobile Combustion in Manufacturing Industries and Construction	6.16	4.1%	74.4%
1 A 2 f	Non-metallic Minerals	5.78	3.8%	78.2%
3 D a 2	Organic fertilizers	5.56	3.7%	81.9%
	National Total	**150.86**		

Trend Assessment							
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kt] $E_{x,0}$**	**Latest Year (2018) 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	60.20	54.13	54.129	35.9%	35.9%
1 A 3 b 3	R.T., Heavy duty vehicles	48.97	16.30	16.301	10.8%	46.7%
1 A 4 b 1	Residential: stationary	15.42	10.29	10.289	6.8%	53.5%
1 A 3 b 2	R.T., Light duty vehicles	7.30	9.99	9.989	6.6%	60.1%
1 A 1 a	Public Electricity and Heat Production	12.13	8.92	8.924	5.9%	66.0%
1 A 4 c 2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	9.42	6.42	6.415	4.3%	70.3%
1 A 2 g 7	Mobile Combustion in Manufacturing Industries and Construction	3.03	6.16	6.163	4.1%	74.4%
1 A 2 f	Non-metallic Minerals	9.99	5.78	5.778	3.8%	78.2%
3 D a 2	Organic fertilizers	5.80	5.56	5.561	3.7%	81.9%
	National Total	**217.22**	**150.86**			

Table 10: Key Categories for NMVOC emissions for the year 2018.

Level Assessment

NFR Code	NFR Category	Latest Year (2018) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
3 B 1	Cattle	24.35	22.7%	22.7%
1 A 4 b 1	Residential: stationary	22.91	21.4%	44.1%
2 D 3 a	Domestic solvent use including fungicides	16.10	15.0%	59.1%
3 D a 2	Organic fertilizers	8.40	7.8%	66.9%
2 D 3 d	Coating applications	5.31	5.0%	71.9%
2 D 3 h	Printing	3.74	3.5%	75.4%
2 H	Other Processes	2.71	2.5%	77.9%
1 A 3 b 1	R.T., Passenger cars	2.61	2.4%	80.3%
	National Total	**107.22**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2018) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
3 B 1	Cattle	32.77	24.35	24.346	22.7%	22.7%
1 A 4 b 1	Residential: stationary	36.28	22.91	22.909	21.4%	44.1%
2 D 3 a	Domestic solvent use including fungicides	16.30	16.10	16.096	15.0%	59.1%
3 D a 2	Organic fertilizers	14.82	8.40	8.402	7.8%	66.9%
2 D 3 d	Coating applications	45.79	5.31	5.309	5.0%	71.9%
2 D 3 h	Printing	12.65	3.74	3.744	3.5%	75.4%
2 H	Other Processes	1.89	2.71	2.706	2.5%	77.9%
1 A 3 b 1	R.T., Passenger cars	66.10	2.61	2.606	2.4%	80.3%
	National Total	**334.02**	**107.22**			

Table 11: Key Categories for NH_3 emissions for the year 2018.

Level Assessment

NFR Code	NFR Category	Latest Year (2018) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
3 D a 2	Organic fertilizers	25.58	39.6%	39.6%
3 B 1	Cattle	17.92	27.7%	67.3%
3 B 3	Swine	5.69	8.8%	76.1%
3 D a 1	Inorganic N-fertilizers	4.81	7.4%	83.6%
	National Total	**61.73**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2018) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
3 D a 2	Organic fertilizers	26.93	25.58	25.580	39.6%	39.6%
3 B 1	Cattle	13.89	17.92	17.919	27.7%	67.3%
3 B 3	Swine	8.47	5.69	5.693	8.8%	76.1%
3 D a 1	Inorganic N-fertilizers	5.00	4.81	4.813	7.4%	83.6%
	National Total	**61.73**	**64.63**			

Table 12: Key Categories for CO emissions for the year 2018.

Level Assessment

NFR Code	NFR Category	Latest Year (2018) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 4 b 1	Residential: stationary	211.84	43.2%	43.2%
1 A 2 a	Iron and Steel	133.30	27.2%	70.4%
1 A 3 b 1	R.T., Passenger cars	44.93	9.2%	79.6%
1 A 4 b 2	Residential: Household and gardening (mobile)	17.68	3.6%	83.2%
	National Total	**490.09**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2018) 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	358.27	211.84	211.843	43.2%	43.2%
1 A 2 a	Iron and Steel	210.72	133.30	133.305	27.2%	70.4%
1 A 3 b 1	R.T., Passenger cars	467.11	44.93	44.930	9.2%	79.6%
1 A 4 b 2	Residential: Household and gardening (mobile)	21.71	17.68	17.682	3.6%	83.2%
	National Total	**1 249.41**	**490.09**			

Table 13: Key Categories for Cd emissions for the year 2018.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2018) Estimate [t] $E_{x,t}$**	**Level Assessment $L_{x,t}$**	**Cumulative Total of $L_{x,t}$**
1 A 4 b 1	Residential: stationary	0.22	19.7%	19.7%
2 C 1	Iron and Steel Production	0.21	18.4%	38.1%
1 A 1 b	Petroleum refining	0.15	12.8%	50.9%
1 A 2 d	Pulp, Paper and Print	0.14	12.7%	63.6%
1 A 1 a	Public Electricity and Heat Production	0.13	11.8%	75.4%
2 G	Other product manufacture and use	0.07	6.4%	81.8%
	National Total	**1.13**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [t] $E_{x,0}$**	**Latest Year (2018) 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	0.31	0.22	0.223	19.7%	19.7%
2 C 1	Iron and Steel Production	0.46	0.21	0.209	18.4%	38.1%
1 A 1 b	Petroleum refining	0.15	0.15	0.145	12.8%	50.9%
1 A 2 d	Pulp, Paper and Print	0.15	0.14	0.144	12.7%	63.6%
1 A 1 a	Public Electricity and Heat Production	0.18	0.13	0.134	11.8%	75.4%
2 G	Other product manufacture and use	0.09	0.07	0.072	6.4%	81.8%
	National Total	**1.75**	**1.13**			

Table 14: Key Categories for Pb emissions for the year 2018.

Level Assessment

NFR Code	NFR Category	Latest Year (2018) Estimate [t] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
2 C 1	Iron and Steel Production	6.24	32.4%	32.4%
1 A 3 b 6	R.T., Automobile tyre and break wear	4.80	24.9%	57.3%
1 A 1 a	Public Electricity and Heat Production	1.91	9.9%	67.2%
1 A 4 b 1	Residential: stationary	1.75	9.1%	76.3%
1 A 2 d	Pulp, Paper and Print	0.98	5.1%	81.4%
	National Total	**19.26**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [t] $E_{x,0}$	Latest Year (2018) 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	32.09	6.24	6.239	32.4%	32.4%
1 A 3 b 6	R.T., Automobile tyre and break wear	2.67	4.80	4.798	24.9%	57.3%
1 A 1 a	Public Electricity and Heat Production	1.27	1.91	1.906	9.9%	67.2%
1 A 4 b 1	Residential: stationary	3.82	1.75	1.750	9.1%	76.3%
1 A 2 d	Pulp, Paper and Print	0.65	0.98	0.976	5.1%	81.4%
	National Total	**232.41**	**19.26**			

Table 15: Key Categories for Hg emissions for the year 2018.

Level Assessment

NFR Code	NFR Category	Latest Year (2018) Estimate [t] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
2 C 1	Iron and Steel Production	0.29	30.6%	30.6%
1 A 2 f	Non-metallic Minerals	0.17	17.3%	47.9%
1 A 4 b 1	Residential: stationary	0.14	15.0%	62.9%
1 A 1 a	Public Electricity and Heat Production	0.14	14.9%	77.8%
1 A 2 d	Pulp, Paper and Print	0.08	8.8%	86.6%
	National Total	**0.96**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [t] $E_{x,0}$	Latest Year (2018) 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	0.26	0.29	0.294	30.6%	30.6%
1 A 2 f	Non-metallic Minerals	0.70	0.17	0.166	17.3%	47.9%
1 A 4 b 1	Residential: stationary	0.39	0.14	0.144	15.0%	62.9%
1 A 1 a	Public Electricity and Heat Production	0.34	0.14	0.143	14.9%	77.8%
1 A 2 d	Pulp, Paper and Print	0.07	0.08	0.084	8.8%	86.6%
	National Total	**2.17**	**0.96**			

Table 16: Key Categories for PAH emissions for the year 2018.

Level Assessment

NFR Code	NFR Category	Latest Year (2018) Estimate [t] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 4 b 1	Residential: stationary	4.90	72.1%	72.1%
1 A 4 c 1	Agriculture/Forestry/Fishing: Stationary	0.88	13.0%	85.1%
	National Total	**6.80**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [t] $E_{x,0}$	Latest Year (2018) 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	10.60	4.90	4.902	72.1%	72.1%
1 A 4 c 1	Agriculture/Forestry/Fishing: Stationary	0.46	0.88	0.882	13.0%	85.1%
	National Total	**19.03**	**6.80**			

Table 17: Key Categories for PCDD/F/Furan emissions for the year 2018.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2018) Estimate [g] $E_{x,t}$**	**Level Assessment $L_{x,t}$**	**Cumulative Total of $L_{x,t}$**
1 A 4 b 1	Residential: stationary	17.13	49.8%	49.8%
2 C 3	Aluminium production	3.30	9.6%	59.4%
2 C 1	Iron and Steel Production	2.50	7.3%	66.6%
5 E	Other waste handling	2.06	6.0%	72.6%
1 A 2 g 8	Other Stationary Combustion in Manufacturing Industries and Construction	1.76	5.1%	77.7%
1 A 1 a	Public Electricity and Heat Production	1.32	3.8%	81.6%
	National Total	**34.41**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [g] $E_{x,0}$**	**Latest Year (2018) Estimate [g] $E_{x,t}$**	**Trend Assessment $L_{x,t}$**	**Contribution to the trend**	**Cumulative Total of $L_{x,t}$**
1 A 4 b 1	Residential: stationary	40.54	17.13	17.130	49.8%	49.8%
2 C 3	Aluminium production	2.40	3.30	3.296	9.6%	59.4%
2 C 1	Iron and Steel Production	37.21	2.50	2.496	7.3%	66.6%
5 E	Other waste handling	2.10	2.06	2.058	6.0%	72.6%
1 A 2 g 8	Other Stationary Combustion in Manufacturing Industries and Construction	0.35	1.76	1.759	5.1%	77.7%
1 A 1 a	Public Electricity and Heat Production	12.12	1.32	1.324	3.8%	81.6%
	National Total	**125.17**	**34.41**			

Table 18: Key Categories for HCB emissions for the year 2018.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2018) Estimate [kg] $E_{x,t}$**	**Level Assessment $L_{x,t}$**	**Cumulative Total of $L_{x,t}$**
1 A 4 b 1	Residential: stationary	24.51	68.8%	68.8%
2 C 1	Iron and Steel Production	3.54	9.9%	78.7%
1 A 4 c 1	Agriculture/Forestry/Fishing: Stationary	2.30	6.5%	85.2%
	National Total	**35.63**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kg] $E_{x.0}$**	**Latest Year (2018) 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	50.04	24.51	24.508	68.8%	68.8%
2 C 1	Iron and Steel Production	8.09	3.54	3.537	9.9%	78.7%
1 A 4 c 1	Agriculture/Forestry/Fishing: Stationary	1.88	2.30	2.301	6.5%	85.2%
	National Total	**85.50**	**35.63**			

Table 19: Key Categories for PCB emissions for the year 2018.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2018) Estimate [kg] $E_{x,t}$**	**Level Assessment $L_{x,t}$**	**Cumulative Total of $L_{x,t}$**
2 C 1	Iron and Steel Production	30.40	94.7%	94.7%
	National Total	**32.09**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kg] $E_{x.0}$**	**Latest Year (2018) Estimate [kg] $E_{x.t}$**	**Trend Assessment $L_{x.t}$**	**Contribution to the trend**	**Cumulative Total of $L_{x.t}$**
2 C 1	Iron and Steel Production	19.34	30.40	30.399	94.7%	94.7%
	National Total	**47.23**	**32.09**			

Table 20: Key Categories for TSP emissions for the year 2018.

Level Assessment

NFR Code	NFR Category	Latest Year (2018) 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	12.85	33.5%	33.5%
1 A 4 b 1	Residential: stationary	6.75	17.6%	51.1%
3 D c	On-farm storage, handling and transport of agricultural products	3.34	8.7%	59.9%
1 A 3 b 6	R.T., Automobile tyre and break wear	1.94	5.1%	64.9%
1 A 3 b 7	R.T., Automobile road abrasion	1.62	4.2%	69.1%
1 A 3 c	Railways	1.61	4.2%	73.3%
2 I	Wood processing	1.13	3.0%	76.3%
1 A 1 a	Public Electricity and Heat Production	1.09	2.9%	79.1%
1 A 3 b 1	R.T., Passenger cars	0.86	2.2%	81.4%
	National Total	**38.32**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2018) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	Contribution to the trend	Cumulative Total of $L_{x,t}$
2 A 5	Mining, construction/demolition and handling of products	9.97	12.85	12.849	33.5%	33.5%
1 A 4 b 1	Residential: stationary	11.49	6.75	6.752	17.6%	51.1%
3 D c	On-farm storage, handling and transport of agricultural products	3.56	3.34	3.340	8.7%	59.9%
1 A 3 b 6	R.T., Automobile tyre and break wear	1.05	1.94	1.935	5.1%	64.9%
1 A 3 b 7	R.T., Automobile road abrasion	0.89	1.62	1.617	4.2%	69.1%
1 A 3 c	Railways	2.00	1.61	1.607	4.2%	73.3%
2 I	Wood processing	0.92	1.13	1.131	3.0%	76.3%
1 A 1 a	Public Electricity and Heat Production	0.83	1.09	1.093	2.9%	79.1%
1 A 3 b 1	R.T., Passenger cars	1.61	0.86	0.859	2.2%	81.4%
	National Total	**53.21**	**38.32**			

Table 21: Key Categories for PM_{10} emissions for the year 2018.

Level Assessment				
NFR Code	**NFR Category**	**Latest Year (2018) Estimate [kt] $E_{x,t}$**	**Level Assessment $L_{x,t}$**	**Cumulative Total of $L_{x,t}$**
1 A 4 b 1	Residential: stationary	6.31	23.9%	23.9%
2 A 5	Mining, construction/demolition and handling of products	6.11	23.1%	47.0%
3 D c	On-farm storage, handling and transport of agricultural products	3.34	12.6%	59.7%
1 A 3 b 6	R.T., Automobile tyre and break wear	1.46	5.5%	65.2%
1 A 1 a	Public Electricity and Heat Production	0.99	3.7%	68.9%
1 A 3 b 1	R.T., Passenger cars	0.86	3.3%	72.2%
1 A 3 b 7	R.T., Automobile road abrasion	0.81	3.1%	75.3%
1 A 3 c	Railways	0.57	2.2%	77.4%
1 A 4 c 2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	0.51	1.9%	79.3%
2 C 1	Iron and Steel Production	0.49	1.8%	81.2%
	National Total	**26.40**		

Trend Assessment						
NFR Code	**NFR Category**	**'Base Year' (1990) Estimate [kt] $E_{x,0}$**	**Latest Year (2018) 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	10.66	6.31	6.313	23.9%	23.9%
2 A 5	Mining, construction/demolition and handling of products	4.73	6.11	6.106	23.1%	47.0%
3 D c	On-farm storage, handling and transport of agricultural products	3.56	3.34	3.340	12.6%	59.7%
1 A 3 b 6	R.T., Automobile tyre and break wear	0.79	1.46	1.456	5.5%	65.2%
1 A 1 a	Public Electricity and Heat Production	0.78	0.99	0.985	3.7%	68.9%
1 A 3 b 1	R.T., Passenger cars	1.61	0.86	0.859	3.3%	72.2%
1 A 3 b 7	R.T., Automobile road abrasion	0.44	0.81	0.808	3.1%	75.3%
1 A 3 c	Railways	0.96	0.57	0.570	2.2%	77.4%
1 A 4 c 2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	2.06	0.51	0.509	1.9%	79.3%
2 C 1	Iron and Steel Production	4.56	0.49	0.486	1.8%	81.2%
	National Total	**40.90**	**26.40**			

Table 22: Key Categories for $PM_{2.5}$ emissions for the year 2018.

Level Assessment

NFR Code	NFR Category	Latest Year (2018) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 4 b 1	Residential: stationary	5.98	41.9%	41.9%
1 A 3 b 1	R.T., Passenger cars	0.86	6.0%	48.0%
1 A 1 a	Public Electricity and Heat Production	0.82	5.8%	53.7%
1 A 3 b 6	R.T., Automobile tyre and break wear	0.79	5.5%	59.3%
2 A 5	Mining, construction/demolition and handling of products	0.68	4.8%	64.1%
1 A 4 c 2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	0.51	3.6%	67.6%
1 A 3 b 7	R.T., Automobile road abrasion	0.44	3.1%	70.7%
2 G	Other product manufacture and use	0.41	2.9%	73.6%
1 A 4 c 1	Agriculture/Forestry/Fishing: Stationary	0.37	2.6%	76.1%
1 A 4 a 1	Commercial/Institutional: Stationary	0.29	2.1%	78.2%
1 A 3 b 3	R.T., Heavy duty vehicles	0.27	1.9%	80.1%
	National Total	**14.26**		

Trend Assessment

NFR Code	NFR Category	'Base Year' (1990) Estimate [kt] $E_{x,0}$	Latest Year (2018) 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	9.97	5.98	5.980	41.9%	41.9%
1 A 3 b 1	R.T., Passenger cars	1.61	0.86	0.859	6.0%	48.0%
1 A 1 a	Public Electricity and Heat Production	0.66	0.82	0.822	5.8%	53.7%
1 A 3 b 6	R.T., Automobile tyre and break wear	0.43	0.79	0.790	5.5%	59.3%
2 A 5	Mining, construction/demolition and handling of products	0.53	0.68	0.684	4.8%	64.1%
1 A 4 c 2	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	2.06	0.51	0.509	3.6%	67.6%
1 A 3 b 7	R.T., Automobile road abrasion	0.24	0.44	0.437	3.1%	70.7%
2 G	Other product manufacture and use	0.54	0.41	0.408	2.9%	73.6%
1 A 4 c 1	Agriculture/Forestry/Fishing: Stationary	0.47	0.37	0.367	2.6%	76.1%
1 A 4 a 1	Commercial/Institutional: Stationary	0.78	0.29	0.294	2.1%	78.2%
1 A 3 b 3	R.T., Heavy duty vehicles	2.46	0.27	0.268	1.9%	80.1%
	National Total	**27.17**	**14.26**			

1.6 Quality Assurance, Quality Control and verification

For fulfilment of the reporting obligations the department *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 as Inspection Body for emission inventories, Type A (ID No. 0241), in accordance with EN ISO/IEC 17020 and the Austrian Accreditation Law (AkkG) [59], 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 every 20 months on average. 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 and 2016 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 2016

The implementation of QA/QC procedures as required by the IPCC 2006 GL and the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016 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 2016 Chapter 6 'Inventory management, improvement and QA/QC' (see Table below), and goes beyond. It also comprises supporting and management processes in addition to the QA/QC procedures in inventory compilation and thus ensures agreed standards not only within (i) the inventory compilation process and (ii) supporting processes (e.g. archiving), but also for (iii) management processes (e.g. annual management reviews, internal audits, regular training of personnel, definition of procedures for external communication).

[59] Federal Law Gazette I No 28/2012 (Akkreditierungsgesetz 2012), last amended by Federal Law Gazette I No 40/2014

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

EMEP/EEA GB 2016[60]	IPCC 2006 GL	ISO 9001[61]	ISO/IEC 17020[62]
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[63]	-	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.

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

61 Basic international standard for quality management and quality assurance

62 contains additional requirements compared to ISO 9001

63 According to the EMEP Guidebook 2016, 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.

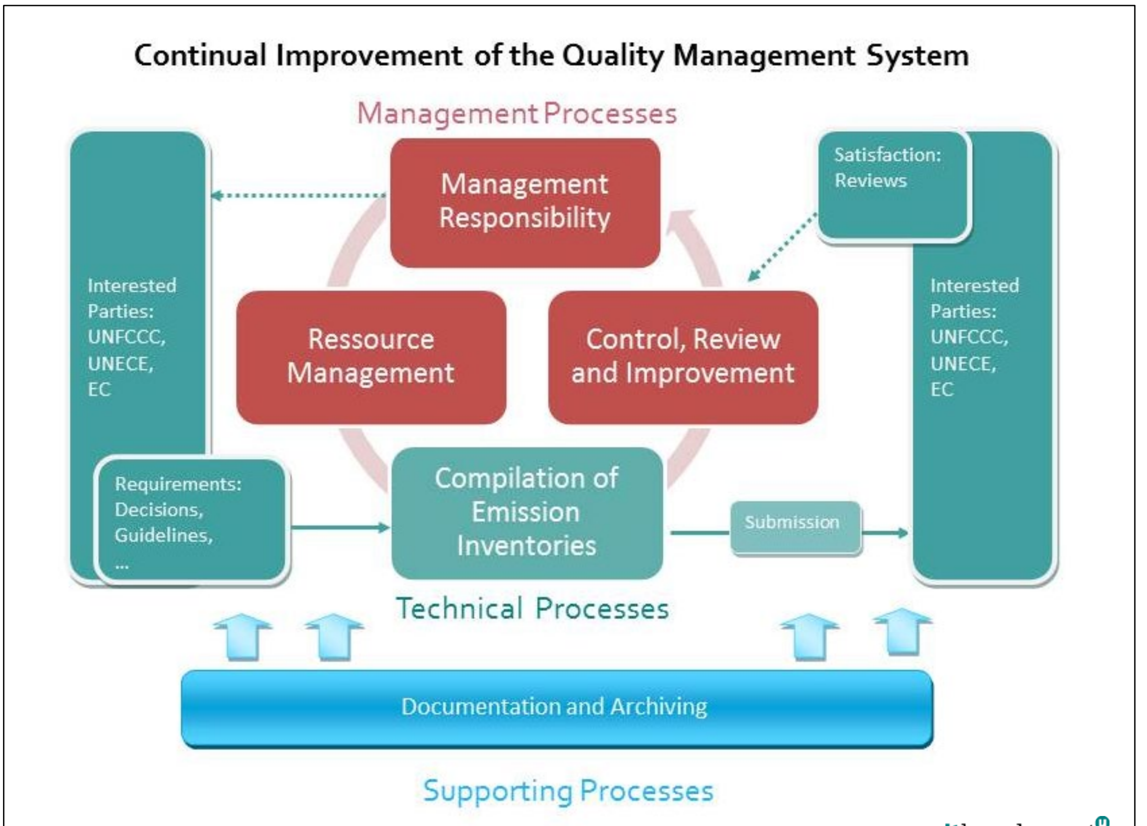
The quality objectives for emission inventories are above all the fulfilment of all relevant requirements in terms of content and format: 'TACCC': transparency, accuracy, completeness, comparability, consistency (as defined in the IPCC 2006 GL), and timeliness.

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 5).

The Quality Manual of the Inspection Body for Emission Inventories is published on:
http://www.umweltbundesamt.at/umweltsituation/luft/emissionsinventur/emi_akkreditierung/



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:

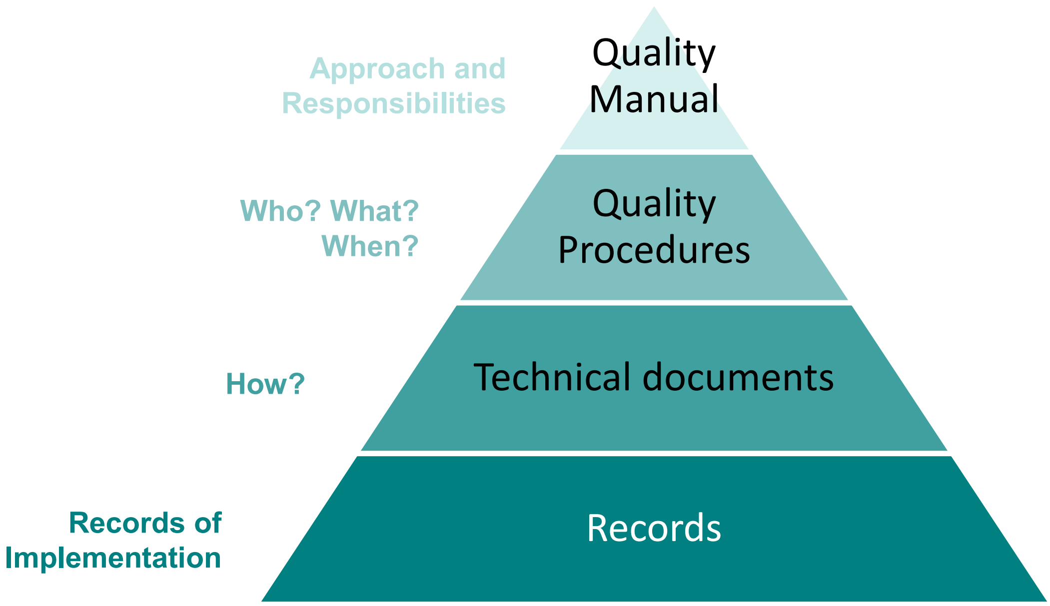
- QC activities
- Procedures for country specific methodologies
- Internal audits (QM specific)
- Procedures for sub-contracting
- Inventory improvement plan
- Documentation and archiving
- Treatment of confidential data
- Annual Management Review

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.): http://www.umweltbundesamt.at/umweltsituation/luft/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 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 7.4, 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 2019 are summarized in Chapter 7.4, 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 2016:

- 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[64].
- 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 2019

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

Three of these experts were able to gain experience by taking part in the international review process for greenhouse gases (centralized review under the European Effort Sharing Decision, centralized review under article 8 of the Kyoto Protocol and in-country review of the 7th National Communication and the 3rd Biennial Report respectively) and 6 experts took part in the reviews for air pollutants (NEC directive, CLRTAP).

Furthermore two experts passed exams of the 'Training programme for members of expert review teams participating in annual reviews under Article 8 of the Kyoto Protocol'.

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

Our senior expert for sector energy was part of an expert team that analyzed ways for improvement of the national energy balance provided by the Austrian Statistical Office.

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 2016 (EEA 2016)".

In the Austrian uncertainty analysis the Tier 1 method 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 Tier 2 method (Monte Carlo Simulation) was not included in this assessment as the less comprehensive Tier 1 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 2020 a).

Uncertainties of emission factors of the relevant pollutants are based on the qualitative ratings following the EMEP/EEA air pollutant emission inventory guidebook 2016 (EEA 2016). 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 of the EMEP/EEA air pollutant emission inventory guidebook 2016 (EEA 2016). 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 2016.

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 2016 (EEA 2016). 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**

NFR	Description	SO_2	NO_x	NMVOC	NH_3	CO	Cd	Hg	Pb	PAH	Diox	HCB	PCB	TSP	PM_{10}	$PM_{2.5}$
2.B	**CHEMICAL INDUSTRY**	B	**B**	A	A	D	A	**A**	B			D		A	A	A
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 handling**						C	C	C		C			D	D	D

Abbreviations: see Table 24
(dark shaded cells indicate that no such emissions arise from this source, light shaded cells (blue) indicate that source is a key source for this pollutant)
**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 Tier 1 methods according to (EEA 2016) 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 2018 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 2018	Level uncertainty 2018 [%]	Trend uncertainty 2018 [%]
SO2	[kt]	11.8	6.6	1.2
NO_x	[kt]	150.9	18.6	4.7
NMVOC	[kt]	107.2	37.6	10.1
NH_3	[kt]	64.6	21.5	6.0
CO	[kt]	490.1	68.5	11.3
Cd	[t]	1.1	41.0	10.2
Hg	[t]	1.0	30.7	5.5
Pb	[t]	19.3	46.9	7.6
PAH	[t]	6.8	148.3	16.6
DIOX	[g]	34.4	105.2	15.3
HCB	[kg]	35.6	139.5	12.0
PCB	[kg]	32.1	118.6	73.7
TSP	[kt]	38.3	73.6	22.8
PM_{10}	[kt]	26.4	61.8	17.2
$PM_{2.5}$	[kt]	14.3	31.5	8.8

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 2018.

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	1.0	8.0	20.0	21.54	3.06	-0.01	0.01	-0.25	0.15	0.08
1 A 1 b	SO2	2.3	0.7	1.0	10.0	10.05	0.32	0.00	0.01	0.04	0.01	0.00
1 A 1 c	SO2	0.0	0.0	2.0	125.0	125.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	SO2	6.7	4.3	5.0	10.0	11.18	16.36	0.04	0.06	0.43	0.41	0.35
1 A 2 b	SO2	0.2	0.1	5.0	20.0	20.62	0.02	0.00	0.00	0.02	0.01	0.00
1 A 2 c	SO2	0.7	0.3	5.0	20.0	20.62	0.23	0.00	0.00	0.05	0.03	0.00
1 A 2 d	SO2	4.3	0.8	10.0	20.0	22.36	2.37	0.00	0.01	0.03	0.16	0.03
1 A 2 e	SO2	1.6	0.1	5.0	20.0	20.62	0.04	0.00	0.00	-0.04	0.01	0.00
1 A 2 f	SO2	2.2	0.9	5.0	20.0	20.62	2.52	0.01	0.01	0.15	0.09	0.03
1 A 2 g 7	SO2	0.2	0.0	1.0	20.0	20.02	0.00	0.00	0.00	-0.01	0.00	0.00
1 A 2 g 8	SO2	1.9	1.4	10.0	20.0	22.36	6.61	0.01	0.02	0.29	0.26	0.15
1 A 3 a	SO2	0.0	0.1	3.0	20.0	20.22	0.03	0.00	0.00	0.02	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	-0.10	0.00	0.01
1 A 3 b 4	SO2	0.0	0.0	3.1	20.0	20.24	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 c	SO2	0.3	0.0	3.0	20.0	20.22	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 d	SO2	0.0	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	2.0	125.0	125.02	0.00	0.00	0.00	0.01	0.00	0.00
1 A 4 a	SO2	4.9	0.1	5.0	20.0	20.62	0.02	-0.01	0.00	-0.19	0.01	0.04
1 A 4 b	SO2	25.9	1.2	15.0	20.0	25.00	7.03	-0.04	0.02	-0.78	0.36	0.74
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	-0.08	0.00	0.01
2 B-10	SO2	1.6	0.4	2.0	40.0	40.05	1.55	0.00	0.00	0.06	0.01	0.00
2 C 1	SO2	0.3	0.1	0.5	125.0	125.00	0.29	0.00	0.00	0.02	0.00	0.00
2 C 7	SO2	0.1	0.1	5.0	125.0	125.10	2.52	0.00	0.00	0.22	0.01	0.05
2 G	SO2	0.0	0.0	100.0	125.0	160.08	0.00	0.00	0.00	0.00	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	0.05	0.00	0.00	0.01	0.00	0.00
Total		**73.7**	**11.8**				**43.10**					**1.50**
Total Uncertainties						Uncertainty in total inventory %:	**6.57**				Trend uncertainty %:	**1.23**

Table 28: Uncertainty estimation of NO_x emissions 1990 and 2018.

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	8.9	8.0	20.0	21.54	1.62	0.00	0.04	0.05	0.46	0.22
1 A 1 b	NOX	4.3	1.1	1.0	10.0	10.05	0.01	-0.01	0.00	-0.09	0.01	0.01
1 A 1 c	NOX	1.4	0.6	2.0	40.0	40.05	0.03	0.00	0.00	-0.06	0.01	0.00
1 A 2 a	NOX	5.4	3.6	5.0	10.0	11.18	0.07	0.00	0.02	-0.01	0.12	0.01
1 A 2 b	NOX	0.3	0.3	5.0	40.0	40.31	0.00	0.00	0.00	0.02	0.01	0.00
1 A 2 c	NOX	1.7	1.4	5.0	40.0	40.31	0.14	0.00	0.01	0.04	0.05	0.00
1 A 2 d	NOX	7.2	4.4	10.0	40.0	41.23	1.46	0.00	0.02	-0.10	0.29	0.09
1 A 2 e	NOX	1.7	0.7	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	5.8	5.0	40.0	40.31	2.38	-0.01	0.03	-0.21	0.19	0.08
1 A 2 g 7	NOX	3.0	6.2	1.0	40.0	40.01	2.67	0.02	0.03	0.75	0.04	0.56
1 A 2 g 8	NOX	3.7	4.1	10.0	40.0	41.23	1.23	0.01	0.02	0.27	0.26	0.14
1 A 3 a	NOX	0.4	1.6	3.0	40.0	40.11	0.19	0.01	0.01	0.25	0.03	0.06
1 A 3 b 1	NOX	60.2	54.1	3.1	40.0	40.12	207.21	0.06	0.25	2.26	1.09	6.31
1 A 3 b 2	NOX	7.3	10.0	3.1	40.0	40.12	7.06	0.02	0.05	0.91	0.20	0.86
1 A 3 b 3	NOX	49.0	16.3	3.1	40.0	40.12	18.79	-0.08	0.08	-3.25	0.33	10.70
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	-0.10	0.01	0.01
1 A 3 d	NOX	0.6	0.4	3.0	40.0	40.11	0.01	0.00	0.00	0.01	0.01	0.00
1 A 3 e	NOX	0.6	0.3	2.0	10.0	10.20	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	0.10	0.00	0.01	-0.18	0.04	0.03
1 A 4 b	NOX	16.2	10.7	15.0	40.0	42.72	9.14	0.00	0.05	-0.11	1.04	1.10
1 A 4 c	NOX	10.5	7.0	5.0	100.0	100.12	21.38	0.00	0.03	-0.15	0.23	0.08
1 A 5 b	NOX	0.1	0.1	1.0	125.0	125.00	0.00	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	-0.51	0.00	0.26
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	10.2	5.0	125.0	125.10	71.23	0.01	0.05	1.30	0.33	1.80
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		**217.2**	**150.9**				**344.89**					**22.35**
Total Uncertainties						Uncertainty in total inventory %:	**18.57**				Trend uncertainty %:	**4.73**

Table 29: Uncertainty estimation of NMVOC emissions 1990 and 2018.

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	0.34	0.00	0.00	0.13	0.01	0.02
1 A 1 c	NMVOC	0.0	0.0	2.0	200.0	200.01	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	NMVOC	0.1	0.2	5.0	200.0	200.06	0.08	0.00	0.00	0.08	0.00	0.01
1 A 2 b	NMVOC	0.0	0.0	5.0	200.0	200.06	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 c	NMVOC	0.0	0.0	5.0	200.0	200.06	0.01	0.00	0.00	0.02	0.00	0.00
1 A 2 d	NMVOC	0.7	0.3	10.0	200.0	200.25	0.23	0.00	0.00	0.01	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	0.19	0.00	0.00	0.09	0.01	0.01
1 A 2 g 7	NMVOC	0.5	0.2	1.0	40.0	40.01	0.01	0.00	0.00	0.00	0.00	0.00
1 A 2 g 8	NMVOC	0.0	0.1	10.0	40.0	41.23	0.00	0.00	0.00	0.01	0.01	0.00
1 A 3 a	NMVOC	0.2	0.2	3.0	40.0	40.11	0.01	0.00	0.00	0.02	0.00	0.00
1 A 3 b 1	NMVOC	66.1	2.6	3.1	125.0	125.04	9.24	-0.06	0.01	-6.95	0.03	48.33
1 A 3 b 2	NMVOC	2.8	0.1	3.1	125.0	125.04	0.01	0.00	0.00	-0.30	0.00	0.09
1 A 3 b 3	NMVOC	5.1	0.4	3.1	125.0	125.04	0.19	0.00	0.00	-0.47	0.00	0.22
1 A 3 b 4	NMVOC	2.9	1.6	3.1	125.0	125.04	3.61	0.00	0.00	0.26	0.02	0.07
1 A 3 b 5	NMVOC	19.7	0.4	3.1	125.0	125.04	0.22	-0.02	0.00	-2.21	0.01	4.90
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	0.6	0.2	3.0	40.0	40.11	0.01	0.00	0.00	0.00	0.00	0.00
1 A 3 e	NMVOC	0.0	0.0	2.0	200.0	200.01	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	NMVOC	1.3	0.6	5.0	70.0	70.18	0.15	0.00	0.00	0.03	0.01	0.00
1 A 4 b	NMVOC	40.8	24.2	15.0	70.0	71.59	261.29	0.03	0.07	2.32	1.54	7.76
1 A 4 c	NMVOC	5.7	2.6	5.0	100.0	100.12	5.88	0.00	0.01	0.23	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	0.06	0.00	0.00	0.05	0.00	0.00
2 D	NMVOC	114.4	30.1	20.0	30.0	36.06	102.64	-0.02	0.09	-0.59	2.55	6.86
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	1.08	0.01	0.01	0.25	0.11	0.08
3 B 1	NMVOC	32.8	24.3	1.0	125.0	125.00	805.65	0.04	0.07	5.17	0.10	26.73
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	1.45	0.00	0.00	0.20	0.02	0.04
3 B 4	NMVOC	1.0	1.4	10.0	125.0	125.40	2.81	0.00	0.00	0.41	0.06	0.17
3 D a	NMVOC	14.9	8.5	5.0	125.0	125.10	97.60	0.01	0.03	1.37	0.18	1.92
3 D e	NMVOC	1.8	1.6	5.0	750.0	750.02	117.96	0.00	0.00	2.21	0.03	4.90
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		**334.0**	**107.2**				**1.410.99**					**102.18**
Total						Uncertainty in total inventory %:	**37.56**				Trend uncertainty %:	**10.11**

Table 30: Uncertainty estimation of NH_3 emissions 1990 and 2018.

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	15.24	0.00	0.01	2.67	0.06	7.12
1 A 1 b	NH3	0.1	0.1	1.0	750.0	750.00	1.03	0.00	0.00	0.10	0.00	0.01
1 A 1 c	NH3	0.0	0.0	2.0	750.0	750.00	0.00	0.00	0.00	-0.07	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	0.08	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	0.05	0.00	0.00
1 A 2 c	NH3	0.0	0.0	5.0	750.0	750.02	0.16	0.00	0.00	0.08	0.00	0.01
1 A 2 d	NH3	0.1	0.1	10.0	750.0	750.07	0.47	0.00	0.00	-0.21	0.01	0.04
1 A 2 e	NH3	0.0	0.0	5.0	750.0	750.02	0.03	0.00	0.00	-0.08	0.00	0.01
1 A 2 f	NH3	0.1	0.1	5.0	750.0	750.02	2.43	0.00	0.00	-0.15	0.02	0.02
1 A 2 g 7	NH3	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 g 8	NH3	0.1	0.1	10.0	125.0	125.40	0.06	0.00	0.00	0.15	0.03	0.02
1 A 3 a	NH3	0.0	0.0	3.0	125.0	125.04	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b 1	NH3	0.8	1.0	3.1	200.0	200.02	8.86	0.00	0.02	0.52	0.07	0.27
1 A 3 b 2	NH3	0.0	0.0	3.1	200.0	200.02	0.01	0.00	0.00	0.00	0.00	0.00
1 A 3 b 3	NH3	0.0	0.1	3.1	200.0	200.02	0.13	0.00	0.00	0.36	0.01	0.13
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	2.0	750.0	750.00	0.02	0.00	0.00	0.08	0.00	0.01
1 A 4 a	NH3	0.1	0.0	5.0	125.0	125.10	0.01	0.00	0.00	-0.06	0.01	0.00
1 A 4 b	NH3	0.5	0.5	15.0	125.0	125.90	0.95	0.00	0.01	-0.09	0.17	0.04
1 A 4 c	NH3	0.0	0.0	5.0	125.0	125.10	0.01	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	0.00	0.00	0.00
2 B 2	NH3	0.0	0.0	2.0	20.0	20.10	0.00	0.00	0.00	0.00	0.00	0.00
2 B-10	NH3	0.3	0.1	2.0	20.0	20.10	0.00	0.00	0.00	-0.07	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	17.9	1.0	20.0	20.02	30.82	0.05	0.29	1.09	0.41	1.36
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	3.23	-0.05	0.09	-1.03	0.52	1.33
3 B 4	NH3	2.9	4.5	10.0	40.0	41.23	8.37	0.02	0.07	0.94	1.04	1.97
3 D a	NH3	33.0	31.2	5.0	40.0	40.31	379.24	-0.05	0.51	-2.13	3.58	17.33
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	9.82	0.02	0.03	2.47	0.73	6.65
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		**61.7**	**64.6**				**461.36**					**36.42**
Total Uncertainties						Uncertainty in total inventory %:	**21.48**				Trend uncertainty %:	**6.03**

Table 31: Uncertainty estimation of CO emissions 1990 and 2018.

NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty (1)	Emission factor uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
		t	t	%	%	%	%	%	%	%	%	%
	CO	Input data	Input data	input data Note A	input data Note A	$\sqrt{(E^2+F^2)}$	$\frac{(G\cdot D)^2}{\sum(D^2)}$	Note B	$\frac{D}{\sum C}$	I·F Note C	$J\cdot E\cdot\sqrt{2}$ Note D	K^2+L^2
1 A 1 a	CO	1.4	4.0	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	0.0	2.0	200.0	200.01	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	CO	210.7	133.3	5.0	125.0	125.10	1.157.84	0.04	0.11	5.06	0.75	26.16
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	0.5	5.0	125.0	125.10	0.02	0.00	0.00	0.03	0.00	0.00
1 A 2 d	CO	4.2	2.0	10.0	125.0	125.40	0.26	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	5.7	5.0	125.0	125.10	2.13	0.00	0.00	0.14	0.03	0.02
1 A 2 g 7	CO	3.8	4.1	1.0	40.0	40.01	0.11	0.00	0.00	0.08	0.00	0.01
1 A 2 g 8	CO	0.8	1.8	10.0	40.0	41.23	0.02	0.00	0.00	0.05	0.02	0.00
1 A 3 a	CO	2.5	4.0	3.0	40.0	40.11	0.11	0.00	0.00	0.10	0.01	0.01
1 A 3 b 1	CO	467.1	44.9	3.1	40.0	40.12	13.53	-0.11	0.04	-4.41	0.16	19.48
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	0.18
1 A 3 b 3	CO	12.4	7.6	3.1	40.0	40.12	0.39	0.00	0.01	0.09	0.03	0.01
1 A 3 b 4	CO	7.8	6.4	3.1	40.0	40.12	0.27	0.00	0.01	0.11	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	3.2	2.0	3.0	40.0	40.11	0.03	0.00	0.00	0.02	0.01	0.00
1 A 3 e	CO	0.0	0.1	2.0	125.0	125.02	0.00	0.00	0.00	0.01	0.00	0.00
1 A 4 a	CO	11.8	3.9	5.0	125.0	125.10	1.01	0.00	0.00	-0.07	0.02	0.01
1 A 4 b	CO	380.0	229.5	15.0	125.0	125.90	3.476.45	0.06	0.18	8.03	3.90	79.62
1 A 4 c	CO	34.3	18.2	5.0	125.0	125.10	21.56	0.00	0.01	0.47	0.10	0.24
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	0.1	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	20.40	0.00	0.01	0.98	0.03	0.97
2 C 1	CO	23.2	2.0	0.5	40.0	40.00	0.03	-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
2 H	CO	NA	NA	10.0	40.0	41.23						
3 F	CO	1.2	0.3	100.0	125.0	160.08	0.01	0.00	0.00	-0.01	0.04	0.00
5 A	CO	10.3	2.9	12.0	125.0	125.57	0.57	0.00	0.00	-0.11	0.04	0.01
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		**1249.4**	**490.1**				**4.694.94**					**126.80**
Total Uncertainties						Uncertainty in total inventory %:	**68.52**				Trend uncertainty %:	**11.26**

Table 32: Uncertainty estimation of Cd emissions 1990 and 2018.

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	217.64	0.01	0.08	1.25	0.86	2.29
1 A 1 b	Cd	0.1	0.1	1.0	125.0	125.00	255.73	0.03	0.08	3.53	0.12	12.47
1 A 1 c	Cd	0.0	0.0	2.0	125.0	125.02	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	0.13	0.00	0.00	-0.05	0.01	0.00
1 A 2 b	Cd	0.0	0.0	5.0	125.0	125.10	0.04	0.00	0.00	0.04	0.01	0.00
1 A 2 c	Cd	0.0	0.0	5.0	125.0	125.10	2.06	0.00	0.01	-0.37	0.05	0.14
1 A 2 d	Cd	0.2	0.1	10.0	125.0	125.40	254.91	0.03	0.08	3.34	1.16	12.51
1 A 2 e	Cd	0.0	0.0	5.0	125.0	125.10	0.01	0.00	0.00	-0.03	0.00	0.00
1 A 2 f	Cd	0.1	0.0	5.0	125.0	125.10	6.05	-0.02	0.01	-2.88	0.09	8.30
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	45.51	0.03	0.03	3.34	0.49	11.41
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	0.62	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	2.0	40.0	40.05	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	4.45	-0.01	0.01	-1.28	0.08	1.64
1 A 4 b	Cd	0.3	0.2	15.0	125.0	125.90	613.49	0.01	0.13	1.52	2.70	9.57
1 A 4 c	Cd	0.0	0.0	5.0	125.0	125.10	27.26	0.02	0.03	1.93	0.19	3.78
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	54.28	-0.05	0.12	-1.95	0.08	3.79
2 C 5	Cd	0.1	0.0	10.0	40.0	41.23	0.03	-0.02	0.00	-0.93	0.04	0.86
2 C 7	Cd	0.0	0.0	5.0	40.0	40.31	0.00	0.00	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	202.25	0.01	0.04	1.35	5.81	35.59
3 F	Cd	0.0	0.0	100.0	125.0	160.08	0.05	0.00	0.00	-0.26	0.12	0.08
5 A	Cd	0.0	0.0	12.0	40.0	41.76	0.00	0.00	0.00	-0.01	0.00	0.00
5 C	Cd	0.1	0.0	7.0	40.0	40.61	0.00	-0.02	0.00	-0.84	0.00	0.71
5 E	Cd	0.0	0.0	50.0	200.0	206.16	0.05	0.00	0.00	0.05	0.05	0.00
Total		**1.8**	**1.1**				**1.684.57**					**103.32**
Total Uncertainties						Uncertainty in total inventory %:	**41.04**				Trend uncertainty %:	**10.16**

Table 33: Uncertainty estimation of Hg emissions 1990 and 2018.

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	348.06	0.00	0.07	-0.57	0.75	0.88
1 A 1 b	Hg	0.0	0.0	1.0	125.0	125.00	5.27	0.01	0.01	0.83	0.01	0.69
1 A 1 c	Hg	0.0	0.0	2.0	125.0	125.02	0.00	0.00	0.00	0.00	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	0.14	0.00	0.00	0.07	0.03	0.01
1 A 2 d	Hg	0.1	0.1	10.0	40.0	41.23	13.12	0.02	0.04	1.00	0.55	1.29
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	48.50	-0.07	0.08	-2.67	0.54	7.41
1 A 2 g 7	Hg	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 g 8	Hg	0.0	0.0	10.0	125.0	125.40	14.21	0.01	0.01	1.43	0.19	2.09
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	2.0	40.0	40.05	0.00	0.00	0.00	0.02	0.00	0.00
1 A 4 a	Hg	0.0	0.0	5.0	125.0	125.10	0.90	0.00	0.00	-0.18	0.02	0.03
1 A 4 b	Hg	0.4	0.1	15.0	125.0	125.90	355.63	-0.01	0.07	-1.68	1.41	4.81
1 A 4 c	Hg	0.0	0.0	5.0	125.0	125.10	2.91	0.00	0.01	0.41	0.04	0.17
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	-1.10	0.00	1.22
2 C 1	Hg	0.3	0.3	0.5	40.0	40.00	150.29	0.08	0.14	3.32	0.10	11.02
2 C 7	Hg	0.0	0.0	5.0	40.0	40.31	0.11	0.00	0.00	0.10	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	0.00	0.00
3 F	Hg	0.0	0.0	100.0	125.0	160.08	0.00	0.00	0.00	-0.02	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	2.59	0.01	0.02	0.26	0.17	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**				**941.80**					**29.75**
Total Uncertainties						Uncertainty in total inventory %:	**30.69**				Trend uncertainty %:	**5.45**

Table 34: Uncertainty estimation of Pb emissions 1990 and 2018.

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	153.70	0.01	0.01	0.97	0.09	0.95
1 A 1 b	Pb	0.2	0.5	1.0	125.0	125.00	9.30	0.00	0.00	0.24	0.00	0.06
1 A 1 c	Pb	0.0	0.0	2.0	125.0	125.02	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 a	Pb	0.3	0.2	5.0	125.0	125.10	1.01	0.00	0.00	0.07	0.00	0.01
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	2.98	0.00	0.00	0.13	0.01	0.02
1 A 2 d	Pb	0.6	1.0	10.0	125.0	125.40	40.40	0.00	0.00	0.50	0.06	0.25
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	3.85	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	12.14	0.00	0.00	0.28	0.03	0.08
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	162.3	0.0	3.1	125.0	125.04	0.00	-0.06	0.00	-7.18	0.00	51.53
1 A 3 b 2	Pb	6.9	0.0	3.1	125.0	125.04	0.00	0.00	0.00	-0.31	0.00	0.09
1 A 3 b 3	Pb	4.1	0.0	3.1	125.0	125.04	0.00	0.00	0.00	-0.18	0.00	0.03
1 A 3 b 4	Pb	1.7	0.0	3.1	125.0	125.04	0.00	0.00	0.00	-0.07	0.00	0.01
1 A 3 b 6	Pb	2.7	4.8	3.1	40.0	40.12	99.91	0.02	0.02	0.79	0.09	0.63
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	2.0	40.0	40.05	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	Pb	0.4	0.1	5.0	125.0	125.10	0.79	0.00	0.00	0.06	0.00	0.00
1 A 4 b	Pb	6.0	1.8	15.0	125.0	125.90	130.94	0.01	0.01	0.67	0.16	0.48
1 A 4 c	Pb	1.0	0.2	5.0	125.0	125.10	1.02	0.00	0.00	0.04	0.00	0.00
1 A 5 b	Pb	0.0	0.0	1.0	125.0	125.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B-10	Pb	0.0	0.0	2.0	40.0	40.05	0.00	0.00	0.00	0.00	0.00	0.00
2 C 1	Pb	32.1	6.2	0.5	125.0	125.00	1.639.99	0.02	0.03	1.92	0.02	3.70
2 C 3	Pb	0.0	0.1	2.0	125.0	125.02	0.37	0.00	0.00	0.05	0.00	0.00
2 C 5	Pb	3.5	0.6	10.0	125.0	125.40	14.54	0.00	0.00	0.16	0.04	0.03
2 C 7	Pb	0.5	0.0	5.0	125.0	125.10	0.00	0.00	0.00	-0.02	0.00	0.00
2 D	Pb	0.0	0.0	20.0	40.0	44.72	0.00	0.00	0.00	0.00	0.00	0.00
2 G	Pb	1.2	0.8	100.0	200.0	223.61	93.26	0.00	0.00	0.63	0.51	0.65
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	-0.01	0.00	0.00
5 E	Pb	0.0	0.0	50.0	200.0	206.16	0.00	0.00	0.00	0.00	0.00	0.00
Total		**232.4**	**19.3**				**2.204.22**					**58.52**
Total Uncertainties						Uncertainty in total inventory %:	**46.95**				Trend uncertainty %:	**7.65**

Table 35: Uncertainty estimation of PAH emissions 1990 and 2018.

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	0.17	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	2.0	125.0	125.02	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	0.14	0.00	0.00	0.09	0.01	0.01
1 A 2 d	PAH	0.0	0.0	10.0	125.0	125.40	0.00	0.00	0.00	0.02	0.00	0.00
1 A 2 e	PAH	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	0.01	0.00	0.00
1 A 2 f	PAH	0.0	0.0	5.0	125.0	125.10	0.03	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	10.76	0.01	0.01	1.09	0.01	1.18
1 A 2 g 8	PAH	0.0	0.1	10.0	200.0	200.25	4.19	0.00	0.00	0.68	0.05	0.46
1 A 3 b 1	PAH	0.2	0.2	3.1	125.0	125.04	8.88	0.01	0.01	0.67	0.04	0.45
1 A 3 b 2	PAH	0.0	0.0	3.1	125.0	125.04	0.11	0.00	0.00	0.02	0.00	0.00
1 A 3 b 3	PAH	0.0	0.1	3.1	125.0	125.04	6.25	0.01	0.01	0.78	0.03	0.61
1 A 3 b 4	PAH	0.0	0.0	3.1	200.0	200.02	0.00	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	0.06	0.00	0.00	0.01	0.00	0.00
1 A 3 d	PAH	0.0	0.0	3.0	200.0	200.02	0.02	0.00	0.00	0.03	0.00	0.00
1 A 3 e	PAH	0.0	0.0	2.0	40.0	40.05	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	PAH	0.3	0.1	5.0	200.0	200.06	5.55	0.00	0.00	-0.28	0.03	0.08
1 A 4 b	PAH	10.6	4.9	15.0	200.0	200.56	21.132.07	0.06	0.26	11.83	5.49	170.06
1 A 4 c	PAH	0.5	1.0	5.0	200.0	200.06	787.84	0.04	0.05	8.05	0.35	64.87
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	10.15	0.00	0.01	0.32	0.01	0.10
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	16.67	-0.01	0.00	-6.21	0.03	38.58
3 F	PAH	0.1	0.0	100.0	125.0	160.08	0.96	0.00	0.00	0.08	0.31	0.10
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		**19.0**	**6.8**				**21.983.90**					**276.53**
Total Uncertainties						Uncertainty in total inventory %:	**148.27**				Trend uncertainty %:	**16.63**

Table 36: Uncertainty estimation of DIOX emissions 1990 and 2018.

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	23.22	-0.02	0.01	-2.00	0.12	4.02
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	2.0	200.0	200.01	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	0.31	0.00	0.00	0.10	0.00	0.01
1 A 2 b	DIOX	0.0	0.0	5.0	750.0	750.02	0.70	0.00	0.00	0.20	0.00	0.04
1 A 2 c	DIOX	0.4	0.5	5.0	750.0	750.02	127.25	0.00	0.00	2.38	0.03	5.68
1 A 2 d	DIOX	0.5	0.6	10.0	750.0	750.07	183.90	0.00	0.00	2.91	0.07	8.46
1 A 2 e	DIOX	0.0	0.0	5.0	750.0	750.02	0.95	0.00	0.00	0.22	0.00	0.05
1 A 2 f	DIOX	0.3	0.5	5.0	750.0	750.02	108.10	0.00	0.00	2.38	0.03	5.64
1 A 2 g 7	DIOX	0.0	0.1	1.0	200.0	200.00	0.62	0.00	0.00	0.21	0.00	0.04
1 A 2 g 8	DIOX	0.3	1.8	10.0	200.0	200.25	104.79	0.01	0.01	2.66	0.20	7.10
1 A 3 b 1	DIOX	3.6	0.6	3.1	200.0	200.02	14.01	0.00	0.01	-0.56	0.02	0.32
1 A 3 b 2	DIOX	0.2	0.1	3.1	200.0	200.02	0.31	0.00	0.00	0.08	0.00	0.01
1 A 3 b 3	DIOX	0.3	0.8	3.1	200.0	200.02	21.37	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	0.00	0.00	0.00	0.01	0.00	0.00
1 A 3 e	DIOX	0.0	0.0	2.0	200.0	200.01	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	DIOX	1.7	0.5	5.0	200.0	200.06	8.89	0.00	0.00	0.05	0.03	0.00
1 A 4 b	DIOX	40.6	17.2	15.0	200.0	200.56	10.025.30	0.05	0.14	9.59	2.91	100.39
1 A 4 c	DIOX	1.5	1.4	5.0	200.0	200.06	62.70	0.01	0.01	1.50	0.08	2.27
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	2.5	0.5	125.0	125.00	82.21	-0.06	0.02	-7.70	0.01	59.30
2 C 3	DIOX	2.4	3.3	2.0	125.0	125.02	143.42	0.02	0.03	2.63	0.07	6.93
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	2.12	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	8.15	0.00	0.00	-2.16	0.01	4.67
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	1.31	-0.04	0.00	-4.67	0.02	21.84
5 E	DIOX	2.1	2.1	50.0	200.0	206.16	152.05	0.01	0.02	2.37	1.16	6.96
Total		**125.2**	**34.4**				**11.071.84**					**235.11**
Total Uncertainties						Uncertainty in total inventory %:	**105.22**				Trend uncertainty %:	**15.33**

Table 37: Uncertainty estimation of HCB emissions 1990 and 2018.

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	$\sqrt{(E^2+F^2)}$	$\frac{(G \cdot D)^2}{\Sigma(D^2)}$	Note B	$\frac{D}{\Sigma C}$	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	2.94	0.00	0.01	0.55	0.06	0.30
1 A 1 b	HCB	0.0	0.0	1.0	200.0	200.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 1 c	HCB	0.0	0.0	2.0	200.0	200.01	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	0.00	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	0.19	0.00	0.00	0.12	0.01	0.01
1 A 2 d	HCB	0.1	0.1	10.0	200.0	200.25	0.49	0.00	0.00	0.19	0.02	0.04
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	0.21	0.00	0.00	0.13	0.01	0.02
1 A 2 g 7	HCB	0.0	0.0	1.0	200.0	200.00	0.02	0.00	0.00	0.06	0.00	0.00
1 A 2 g 8	HCB	0.1	0.3	10.0	200.0	200.25	2.39	0.00	0.00	0.59	0.05	0.35
1 A 3 b 1	HCB	0.7	0.1	3.1	200.0	200.02	0.52	0.00	0.00	-0.41	0.01	0.16
1 A 3 b 2	HCB	0.0	0.0	3.1	200.0	200.02	0.01	0.00	0.00	0.01	0.00	0.00
1 A 3 b 3	HCB	0.1	0.2	3.1	200.0	200.02	0.80	0.00	0.00	0.31	0.01	0.09
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	0.00	0.00	0.00
1 A 3 e	HCB	0.0	0.0	2.0	200.0	200.01	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 a	HCB	1.6	0.4	5.0	200.0	200.06	6.35	0.00	0.01	-0.46	0.04	0.21
1 A 4 b	HCB	50.0	24.5	15.0	200.0	200.56	19.051.74	0.04	0.29	8.52	6.08	109.63
1 A 4 c	HCB	1.9	2.3	5.0	200.0	200.06	169.81	0.02	0.03	3.58	0.19	12.89
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	3.5	0.5	125.0	125.00	153.98	0.00	0.04	0.24	0.03	0.06
2 C 3	HCB	1.2	1.6	2.0	125.0	125.02	33.45	0.01	0.02	1.68	0.05	2.82
2 C 7	HCB	0.1	0.1	5.0	125.0	125.10	0.26	0.00	0.00	0.15	0.01	0.02
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	0.30	0.00	0.00	-1.08	0.00	1.16
3 D f	HCB	10.1	1.5	0.0	125.0	125.00	27.97	-0.03	0.02	-3.95	0.00	15.64
3 F	HCB	0.0	0.0	100.0	125.0	160.08	0.00	0.00	0.00	-0.01	0.02	0.00
5 C	HCB	0.4	0.1	7.0	125.0	125.20	0.05	0.00	0.00	-0.15	0.01	0.02
Total		**85.5**	**35.6**				**19.451.49**					**143.44**
Total Uncertainties						Uncertainty in total inventory %:	**139.47**				Trend uncertainty %:	**11.98**

Table 38: Uncertainty estimation of PCB emissions 1990 and 2018.

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	0.1	8.0	125.0	125.26	0.04	-0.02	0.00	-1.96	0.01	3.83
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	2.0	200.0	200.01	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	0.02	0.00	0.00	-0.15	0.00	0.02
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	0.2	5.0	200.0	200.06	2.15	0.00	0.00	0.40	0.04	0.16
1 A 2 d	PCB	1.5	0.7	10.0	200.0	200.25	20.07	-0.01	0.02	-1.26	0.21	1.63
1 A 2 e	PCB	0.2	0.0	5.0	200.0	200.06	0.02	0.00	0.00	-0.33	0.00	0.11
1 A 2 f	PCB	0.5	0.4	5.0	200.0	200.06	7.71	0.00	0.01	0.51	0.07	0.27
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	0.01	0.00	0.00	-0.49	0.00	0.24
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	2.0	200.0	200.01	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	-3.26	0.00	10.62
1 A 4 b	PCB	4.5	0.1	15.0	750.0	750.15	11.44	-0.06	0.00	-46.50	0.06	2.162.64
1 A 4 c	PCB	0.1	0.0	5.0	750.0	750.02	0.01	0.00	0.00	-0.93	0.00	0.87
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	30.4	0.5	125.0	125.00	14.022.29	0.36	0.64	45.49	0.46	2.069.92
2 C 5	PCB	19.2	0.0	10.0	125.0	125.40	0.00	-0.27	0.00	-34.32	0.00	1.177.58
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**	**32.1**				**14.063.76**					**5.427.89**
Total Uncertainties						Uncertainty in total inventory %:	**118.59**				Trend uncertainty %:	**73.67**

Table 39: Uncertainty estimation of TSP emissions 1990 and 2018.

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	$\sqrt{(E^2+F^2)}$	$\frac{(G \cdot D)^2}{\Sigma(D^2)}$	Note B	$\frac{D}{\Sigma C}$	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	1.35	0.01	0.02	0.37	0.23	0.19
1 A 1 b	TSP	0.2	0.0	1.0	20.0	20.02	0.00	0.00	0.00	-0.02	0.00	0.00
1 A 1 c	TSP	0.1	0.1	2.0	40.0	40.05	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	-0.07	0.00	0.00
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	0.56	0.00	0.00	0.15	0.03	0.02
1 A 2 d	TSP	1.1	0.2	10.0	125.0	125.40	0.59	-0.01	0.00	-1.23	0.06	1.52
1 A 2 e	TSP	0.1	0.0	5.0	125.0	125.10	0.01	0.00	0.00	-0.12	0.00	0.02
1 A 2 f	TSP	0.1	0.1	5.0	125.0	125.10	0.09	0.00	0.00	0.08	0.01	0.01
1 A 2 g 7	TSP	0.5	0.1	1.0	40.0	40.01	0.02	0.00	0.00	-0.18	0.00	0.03
1 A 2 g 8	TSP	0.3	0.3	10.0	40.0	41.23	0.08	0.00	0.00	0.04	0.07	0.01
1 A 3 a	TSP	0.0	0.1	3.0	40.0	40.11	0.02	0.00	0.00	0.07	0.01	0.01
1 A 3 b 1	TSP	1.6	0.9	3.1	40.0	40.12	0.81	-0.01	0.02	-0.23	0.07	0.06
1 A 3 b 2	TSP	0.8	0.2	3.1	40.0	40.12	0.04	-0.01	0.00	-0.31	0.02	0.09
1 A 3 b 3	TSP	2.5	0.3	3.1	40.0	40.12	0.08	-0.03	0.01	-1.13	0.02	1.28
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	1.9	3.1	125.0	125.04	39.87	0.02	0.04	2.77	0.16	7.69
1 A 3 b 7	TSP	0.9	1.6	3.1	125.0	125.04	27.83	0.02	0.03	2.30	0.13	5.29
1 A 3 c	TSP	2.0	1.6	3.0	40.0	40.11	2.83	0.00	0.03	0.13	0.13	0.03
1 A 3 d	TSP	0.1	0.0	3.0	40.0	40.11	0.00	0.00	0.00	-0.05	0.00	0.00
1 A 3 e	TSP	0.0	0.0	2.0	125.0	125.02	0.00	0.00	0.00	0.01	0.00	0.00
1 A 4 a	TSP	0.9	0.3	5.0	125.0	125.10	1.13	-0.01	0.01	-0.80	0.04	0.64
1 A 4 b	TSP	11.6	6.8	15.0	125.0	125.90	494.21	-0.03	0.13	-3.76	2.70	21.45
1 A 4 c	TSP	2.6	1.0	5.0	125.0	125.10	9.99	-0.02	0.02	-2.14	0.13	4.58
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	3.81	0.00	0.01	-0.91	0.05	0.82
2 A 1	TSP	0.2	0.1	1.1	200.0	200.00	0.10	0.00	0.00	-0.25	0.00	0.06
2 A 2	TSP	0.1	0.1	1.6	200.0	200.01	0.22	0.00	0.00	0.17	0.00	0.03
2 A 5	TSP	10.0	12.8	5.0	200.0	200.06	4.499.68	0.11	0.24	21.26	1.71	454.70
2 B-10	TSP	1.0	0.3	2.0	20.0	20.10	0.03	-0.01	0.01	-0.13	0.02	0.02
2 C 1	TSP	6.4	0.7	0.5	40.0	40.00	0.51	-0.07	0.01	-2.96	0.01	8.79
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	3.84	0.00	0.01	0.04	1.25	1.56
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	1.39	0.01	0.02	0.35	0.03	0.13
3 B 1	TSP	0.6	0.4	1.0	200.0	200.00	5.50	0.00	0.01	0.05	0.01	0.00
3 B 2	TSP	0.1	0.1	10.0	200.0	200.25	0.25	0.00	0.00	0.16	0.03	0.03
3 B 3	TSP	0.3	0.3	4.0	200.0	200.04	1.86	0.00	0.00	0.06	0.03	0.00
3 B 4	TSP	0.2	0.3	10.0	200.0	200.25	2.60	0.00	0.01	0.54	0.08	0.29
3 D c	TSP	3.6	3.3	5.0	200.0	200.06	304.01	0.01	0.06	2.91	0.44	8.69
3 D d	TSP	0.0	0.1	5.0	200.0	200.06	0.09	0.00	0.00	0.13	0.01	0.02
3 F	TSP	0.1	0.0	100.0	125.0	160.08	0.01	0.00	0.00	-0.10	0.08	0.02
5 A	TSP	0.1	0.5	12.0	200.0	200.36	6.62	0.01	0.01	1.46	0.16	2.16
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		**53.2**	**38.3**				**5.411.26**					**520.35**
Total Uncertainties						Uncertainty in total inventory %:	**73.56**				Trend uncertainty %:	**22.81**

Table 40: Uncertainty estimation of PM_{10} emissions 1990 and 2018.

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	$\sqrt{(E^2+F^2)}$	$\frac{(G\cdot D)^2}{\Sigma(D^2)}$	Note B	$\frac{D}{\Sigma C}$	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	21.85	0.01	0.02	1.47	0.27	2.22
1 A 1 b	PM10	0.1	0.0	1.0	40.0	40.01	0.00	0.00	0.00	-0.04	0.00	0.00
1 A 1 c	PM10	0.1	0.1	2.0	40.0	40.05	0.02	0.00	0.00	0.04	0.01	0.00
1 A 2 a	PM10	0.1	0.0	5.0	125.0	125.10	0.00	0.00	0.00	-0.07	0.00	0.00
1 A 2 b	PM10	0.0	0.0	5.0	125.0	125.10	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 c	PM10	0.2	0.2	5.0	125.0	125.10	0.96	0.00	0.01	0.22	0.04	0.05
1 A 2 d	PM10	0.9	0.2	10.0	125.0	125.40	1.01	-0.01	0.01	-1.23	0.07	1.51
1 A 2 e	PM10	0.1	0.0	5.0	125.0	125.10	0.02	0.00	0.00	-0.12	0.01	0.01
1 A 2 f	PM10	0.1	0.1	5.0	125.0	125.10	0.15	0.00	0.00	0.11	0.01	0.01
1 A 2 g 7	PM10	0.5	0.1	1.0	40.0	40.01	0.04	0.00	0.00	-0.20	0.00	0.04
1 A 2 g 8	PM10	0.3	0.2	10.0	40.0	41.23	0.13	0.00	0.01	0.06	0.08	0.01
1 A 3 a	PM10	0.0	0.1	3.0	40.0	40.11	0.03	0.00	0.00	0.10	0.01	0.01
1 A 3 b 1	PM10	1.6	0.9	3.1	40.0	40.12	1.70	0.00	0.02	-0.18	0.09	0.04
1 A 3 b 2	PM10	0.8	0.2	3.1	40.0	40.12	0.09	-0.01	0.00	-0.34	0.02	0.11
1 A 3 b 3	PM10	2.5	0.3	3.1	40.0	40.12	0.17	-0.03	0.01	-1.29	0.03	1.67
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	47.56	0.02	0.04	2.88	0.16	8.33
1 A 3 b 7	PM10	0.4	0.8	3.1	125.0	125.04	14.66	0.01	0.02	1.60	0.09	2.55
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	0.0	3.0	40.0	40.11	0.00	0.00	0.00	-0.05	0.00	0.00
1 A 3 e	PM10	0.0	0.0	2.0	125.0	125.02	0.00	0.00	0.00	0.01	0.00	0.00
1 A 4 a	PM10	0.9	0.3	5.0	125.0	125.10	2.16	-0.01	0.01	-0.74	0.05	0.55
1 A 4 b	PM10	10.8	6.3	15.0	125.0	125.90	910.58	-0.02	0.15	-1.95	3.28	14.57
1 A 4 c	PM10	2.6	0.9	5.0	125.0	125.10	19.10	-0.02	0.02	-2.24	0.16	5.02
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	1.80	0.00	0.00	-0.41	0.03	0.17
2 A 1	PM10	0.2	0.1	1.1	200.0	200.00	0.17	0.00	0.00	-0.23	0.00	0.05
2 A 2	PM10	0.1	0.1	1.6	200.0	200.01	0.38	0.00	0.00	0.22	0.00	0.05
2 A 5	PM10	4.7	6.1	5.0	200.0	200.06	2.140.88	0.07	0.15	14.92	1.06	223.62
2 B-10	PM10	0.6	0.2	2.0	20.0	20.10	0.02	0.00	0.00	-0.08	0.01	0.01
2 C 1	PM10	4.6	0.5	0.5	40.0	40.00	0.54	-0.06	0.01	-2.40	0.01	5.76
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	7.73	0.00	0.01	0.20	1.59	2.55
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	0.47	0.01	0.01	0.21	0.02	0.04
3 B 1	PM10	0.3	0.2	1.0	200.0	200.00	2.35	0.00	0.00	0.13	0.01	0.02
3 B 2	PM10	0.0	0.0	10.0	200.0	200.25	0.11	0.00	0.00	0.11	0.01	0.01
3 B 3	PM10	0.2	0.1	4.0	200.0	200.04	0.79	0.00	0.00	0.09	0.02	0.01
3 B 4	PM10	0.1	0.1	10.0	200.0	200.25	1.11	0.00	0.00	0.35	0.05	0.13
3 D c	PM10	3.6	3.3	5.0	200.0	200.06	640.45	0.03	0.08	5.09	0.58	26.23
3 D d	PM10	0.0	0.0	5.0	200.0	200.06	0.04	0.00	0.00	0.08	0.00	0.01
3 F	PM10	0.1	0.0	100.0	125.0	160.08	0.03	0.00	0.00	-0.11	0.10	0.02
5 A	PM10	0.1	0.2	12.0	200.0	200.36	3.12	0.00	0.01	0.92	0.10	0.86
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	2.49	0.00	0.00	0.34	0.35	0.24
Total		**40.9**	**26.4**				**3.823.69**					**296.52**
Total Uncertainties						Uncertainty in total inventory %:	**61.84**				Trend uncertainty %:	**17.22**

Table 41: Uncertainty estimation of $PM_{2.5}$ emissions 1990 and 2018.

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	12.18	0.02	0.03	1.05	0.34	1.22
1 A 1 b	PM2.5	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	PM2.5	0.1	0.1	2.0	40.0	40.05	0.06	0.00	0.00	0.08	0.01	0.01
1 A 2 a	PM2.5	0.0	0.0	5.0	125.0	125.10	0.01	0.00	0.00	-0.06	0.00	0.00
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	2.29	0.00	0.01	0.37	0.04	0.14
1 A 2 d	PM2.5	0.8	0.2	10.0	125.0	125.40	2.34	-0.01	0.01	-1.08	0.09	1.18
1 A 2 e	PM2.5	0.1	0.0	5.0	125.0	125.10	0.05	0.00	0.00	-0.10	0.01	0.01
1 A 2 f	PM2.5	0.1	0.1	5.0	125.0	125.10	0.36	0.00	0.00	0.18	0.02	0.03
1 A 2 g 7	PM2.5	0.5	0.1	1.0	40.0	40.01	0.14	-0.01	0.00	-0.21	0.01	0.04
1 A 2 g 8	PM2.5	0.2	0.2	10.0	60.0	60.83	0.67	0.00	0.01	0.17	0.10	0.04
1 A 3 a	PM2.5	0.0	0.1	3.0	40.0	40.11	0.12	0.00	0.00	0.15	0.02	0.02
1 A 3 b 1	PM2.5	1.6	0.9	3.1	125.0	125.04	56.74	0.00	0.03	0.06	0.14	0.02
1 A 3 b 2	PM2.5	0.8	0.2	3.1	125.0	125.04	3.08	-0.01	0.01	-1.11	0.03	1.24
1 A 3 b 3	PM2.5	2.5	0.3	3.1	125.0	125.04	5.52	-0.04	0.01	-4.71	0.04	22.20
1 A 3 b 4	PM2.5	0.1	0.1	3.1	125.0	125.04	0.71	0.00	0.00	0.14	0.02	0.02
1 A 3 b 6	PM2.5	0.4	0.8	3.1	125.0	125.04	47.94	0.02	0.03	2.60	0.13	6.77
1 A 3 b 7	PM2.5	0.2	0.4	3.1	125.0	125.04	14.66	0.01	0.02	1.43	0.07	2.05
1 A 3 c	PM2.5	0.6	0.2	3.0	40.0	40.11	0.34	0.00	0.01	-0.16	0.03	0.03
1 A 3 d	PM2.5	0.1	0.0	3.0	40.0	40.11	0.01	0.00	0.00	-0.06	0.00	0.00
1 A 3 e	PM2.5	0.0	0.0	2.0	125.0	125.02	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	1.54	0.00	0.01	-0.25	0.08	0.07
1 A 4 b	PM2.5	10.1	6.0	15.0	60.0	61.85	676.24	0.03	0.22	1.52	4.68	24.23
1 A 4 c	PM2.5	2.5	0.9	5.0	100.0	100.12	37.89	-0.02	0.03	-1.65	0.23	2.77
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	0.61	0.00	0.00	-0.01	0.01	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	0.26	0.00	0.00	0.17	0.00	0.03
2 A 5	PM2.5	0.5	0.7	5.0	200.0	200.06	92.22	0.01	0.03	2.99	0.18	8.95
2 B-10	PM2.5	0.3	0.1	2.0	20.0	20.10	0.02	0.00	0.00	-0.04	0.01	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	0.40
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	20.96	0.00	0.02	0.58	2.12	4.84
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	0.26	0.00	0.01	0.15	0.01	0.02
3 B 1	PM2.5	0.1	0.0	1.0	200.0	200.00	0.40	0.00	0.00	0.10	0.00	0.01
3 B 2	PM2.5	0.0	0.0	10.0	200.0	200.25	0.02	0.00	0.00	0.04	0.00	0.00
3 B 3	PM2.5	0.0	0.0	4.0	200.0	200.04	0.13	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	3.25	0.00	0.00	0.42	0.03	0.17
3 D d	PM2.5	0.0	0.0	5.0	200.0	200.06	0.01	0.00	0.00	0.04	0.00	0.00
3 F	PM2.5	0.1	0.0	100.0	125.0	160.08	0.09	0.00	0.00	-0.11	0.14	0.03
5 A	PM2.5	0.0	0.1	12.0	200.0	200.36	1.06	0.00	0.00	0.46	0.05	0.21
5 C	PM2.5	0.0	0.0	7.0	200.0	200.12	0.00	0.00	0.00	0.00	0.00	0.00
5 E	PM2.5	0.2	0.2	50.0	200.0	206.16	8.52	0.00	0.01	0.69	0.53	0.75
Total		**27.2**	**14.3**				**991.06**					**77.56**
Total Uncertainties						Uncertainty in total inventory %:	**31.48**				Trend uncertainty %:	**8.81**

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 36^{th} 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 1990–2018 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[65].

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 2016.

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[65] Austria´s submission 2014 under the Convention on Long-range Transboundary Air Pollution covering the years 1980–2012: http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2014_submissions/

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

The transparency analysis for the reporting year 2018 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 2020.

Pollutants	Submission 2020			
	IE	NE	Transparency	Completeness
NO_x (as NO_2)	10	1	99%	92%
NMVOC	10	3	98%	92%
SO_x (as SO_2)	11	1	99%	91%
NH_3	9	0	100%	93%
$PM_{2.5}$	6	5	96%	95%
PM_{10}	6	5	96%	95%
TSP	6	5	96%	95%
CO	8	2	98%	94%
Pb	7	2	98%	94%
Cd	7	2	98%	94%
Hg	7	3	98%	94%
PCDD/PCDF	7	4	97%	94%
PAHs (total)	7	8	94%	94%
HCB	7	6	95%	94%
PCBs	7	3	98%	94%

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

2 EXPLANATIONS OF KEY TRENDS

This chapter describes the trends and the drivers of air pollutant emissions which Austria is obliged to report based on the following listed protocols. Additionally 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[67].

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 2017, Austria's SO_2 emissions were 83% 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[68] 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.

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.

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[67] Austria´s submission 2014 under the Convention on Long-range Transboundary Air Pollution covering the years 1980–2012: http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2014_submissions/

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

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

National total emissions and trends (1990–2018) 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 1990–2018 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	217.22	334.02	61.73	1 249.41
1991	70.72	226.75	328.31	62.57	1 256.55
1992	54.19	215.32	304.70	61.08	1 199.64
1993	52.82	206.77	284.67	62.07	1 137.53
1994	47.19	198.56	262.22	62.02	1 071.60
1995	46.81	197.88	246.57	63.11	967.74
1996	43.93	215.68	237.20	62.46	962.42
1997	40.40	201.89	223.01	62.73	888.02
1998	35.63	213.68	214.58	63.11	842.63
1999	33.74	205.43	203.49	61.91	726.15
2000	31.58	211.10	179.79	60.58	721.69
2001	32.46	221.81	174.09	60.66	695.04
2002	31.39	229.69	168.94	59.99	664.09
2003	31.17	240.90	165.74	60.07	666.46
2004	26.60	240.59	152.83	59.94	649.61
2005	25.95	246.14	157.11	59.87	624.59
2006	26.79	236.09	159.25	60.32	624.41
2007	23.44	228.56	154.80	61.64	601.23
2008	20.33	215.12	148.94	61.31	581.96
2009	14.80	201.09	135.51	62.73	561.34
2010	16.04	202.15	135.41	62.69	577.39
2011	15.23	194.02	129.93	62.13	560.10
2012	14.86	188.87	127.42	62.41	559.71
2013	14.44	188.07	121.56	62.48	564.19
2014	14.54	179.43	114.63	63.23	528.63
2015	13.98	176.36	111.44	64.01	541.56
2016	13.32	170.30	109.73	64.81	537.84
2017	12.84	161.95	110.73	65.67	529.08
2018	11.77	150.86	107.22	64.63	490.09
Trend 1990–2018	**-84.0%**	**-30.5%**	**-67.9%**	**4.7%**	**-60.8%**

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 2018, emissions were reduced by 84.0% compared to 1990 and amounted to 12 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 reduced coal consumption 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 2017 to 2018 emissions decreased by 8.4%. This was mainly caused by reductions in emissions from iron and steel (*1.A.2.a*).

Main sources and emission trends in Austria

As shown in Figure 7 the main source of SO_2 emissions in Austria in 2018 is NFR sector *1.A Fuel Combustion Activities* with 95% in national total SO_2 emissions. Sector *2 Industrial Processes and Product Use* contributes with 4.8%.

NFR sectors *1.B Fugitive Emissions*, *3 Agriculture* and *5 Waste* are only minor contributors to national total SO_2 emissions in 2018 with 0.2%, 0.01% and 0.1%, respectively.

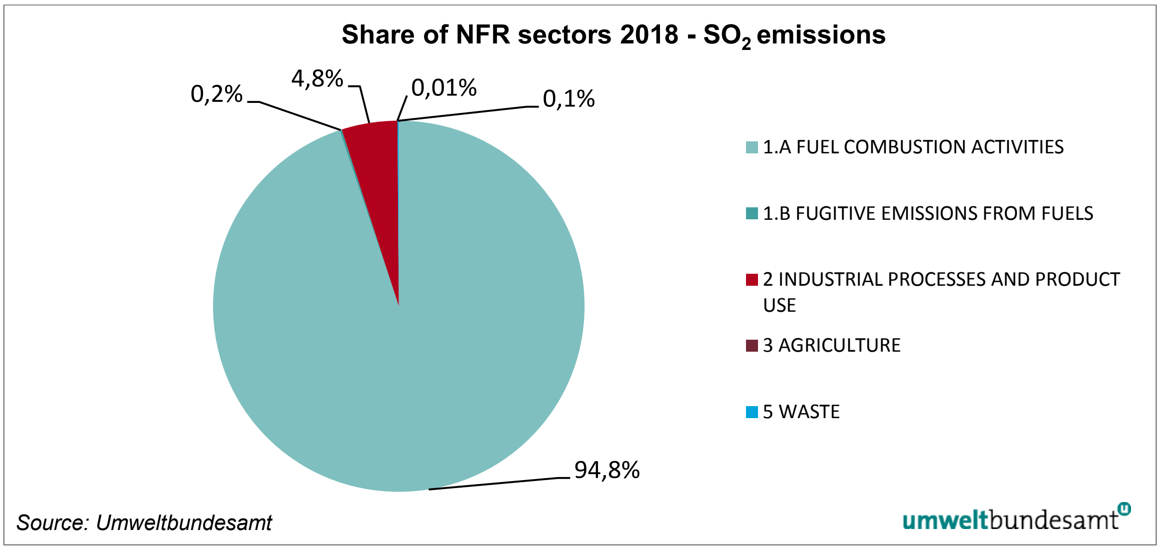

Figure 7: Share of NFR sectors 2018 in SO_2 emissions.

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 both years, 1990 and 2018, 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 66% (more than half of the emissions stem from iron and steel industry), *1.A.4 Other Sectors* (residential heating) with 12% and *1.A.1 Energy Industries* with 14%.

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[69]),
- 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[70] 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 2018 is 4.8%. 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.

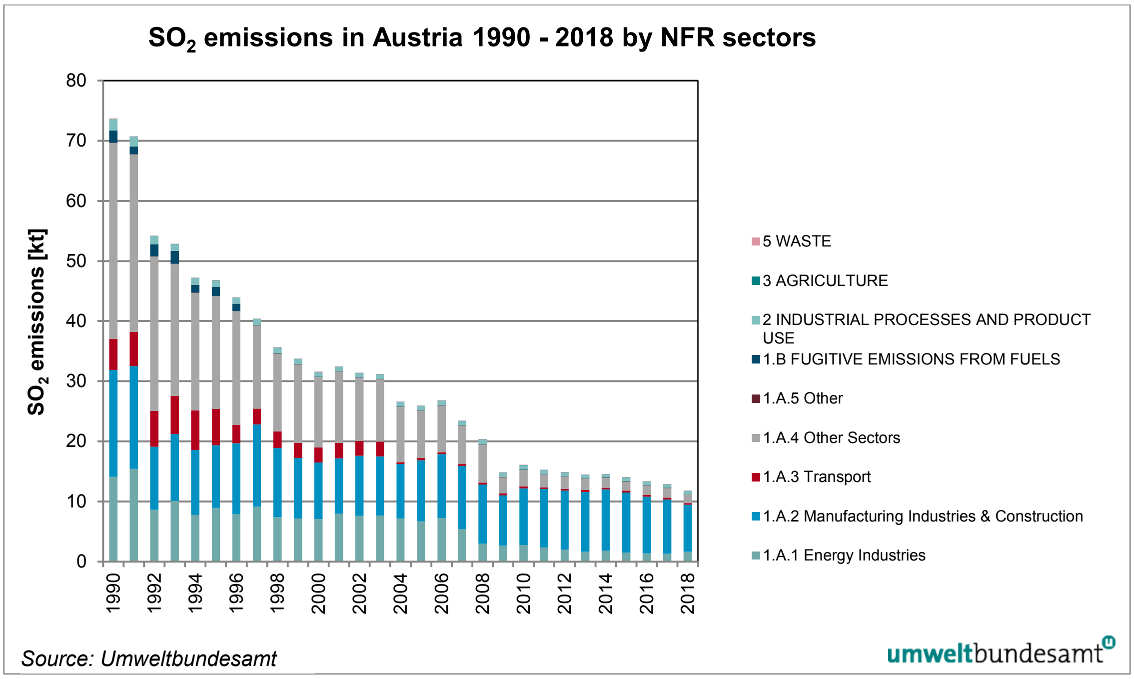

Figure 8: SO_2 emissions in Austria 1990–2018 by sectors in absolute terms.

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69 BGBl_II_417-04_Kraftstoffverordnung; idF. BGBl. II Nr. 398/2012

70 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)

Table 45: SO_2 emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		SO_2 Emission in [kt]		Trend		Share in National Total	
		1990	2018	1990–2018	2017–2018	1990	2018
1	ENERGY	71.69	11.18	-84%	-9%	97%	95%
1.A	FUEL COMBUSTION ACTIVITIES	69.69	11.16	-84%	-9%	95%	95%
1.A.1	Energy Industries	14.07	1.62	-88%	22%	19%	14%
1.A.1.a	Public Electricity and Heat Production	11.81	0.96	-92%	-2%	16%	8%
1.A.1.b	Petroleum refining	2.25	0.66	-71%	86%	3%	6%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-58%	-8%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	17.83	7.81	-56%	-13%	24%	66%
1.A.2.a	Iron and Steel	6.73	4.26	-37%	-13%	9%	36%
1.A.2.b	Non-ferrous Metals	0.18	0.09	-50%	-16%	<1%	1%
1.A.2.c	Chemicals	0.66	0.28	-58%	-23%	1%	2%
1.A.2.d	Pulp, Paper and Print	4.30	0.81	-81%	-16%	6%	7%
1.A.2.e	Food Processing, Beverages and Tobacco	1.65	0.12	-93%	-22%	2%	1%
1.A.2.f	Non-metallic Minerals	2.23	0.91	-59%	2%	3%	8%
1.A.2.g	Manufacturing Industries and Constr. - other	2.08	1.36	-35%	-17%	3%	12%
1.A.3	Transport	5.13	0.29	-94%	-2%	7%	2%
1.A.3.a	Civil Aviation	0.03	0.10	194%	9%	<1%	1%
1.A.3.b	Road Transportation	4.78	0.14	-97%	<1%	6%	1%
1.A.3.c	Railways	0.26	0.04	-85%	-18%	<1%	<1%
1.A.3.d	Navigation	0.05	0.01	-68%	-26%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	162%	-7%	<1%	<1%
1.A.4	Other Sectors	32.66	1.42	-96%	-11%	44%	12%
1.A.4.a	Commercial/Institutional	4.95	0.08	-98%	-30%	7%	1%
1.A.4.b	Residential	25.93	1.25	-95%	-10%	35%	11%
1.A.4.c	Agriculture/Forestry/Fisheries	1.78	0.09	-95%	-16%	2%	1%
1.A.5	Other	0.01	0.02	28%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	2.00	0.02	-99%	-36%	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	-32%	-10%	<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	-73%	-1%	<1%	<1%
5	WASTE	0.07	0.01	-81%	1%	<1%	<1%
	Total without sinks	**73.70**	**11.77**	**-84%**	**-8%**		

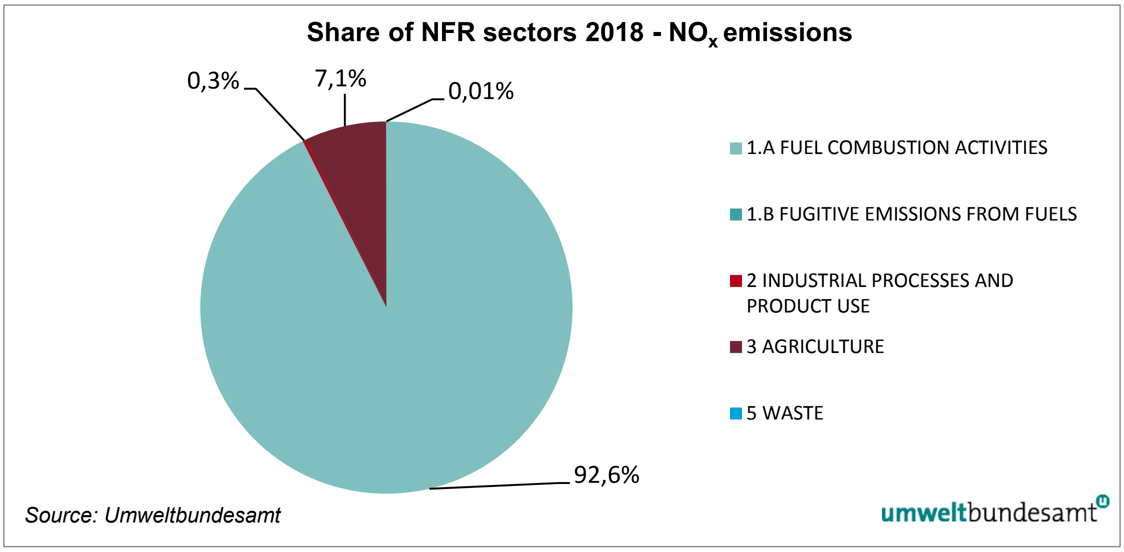
2.1.2 NO_x Emissions

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 2018, NO_x emissions amounted to 151 kt and were about 31% lower than in 1990. From 2017 to 2018 emissions decreased by 6.8%. This was caused by the decline in road traffic, especially of heavy duty vehicles and passenger cars. In 2018 53% 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 93% in 2018 are *1.A Fuel Combustion Activities.* Sector *3 Agriculture* contributes with 7.1%.

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 2018.



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

Figure 9: Share of NFR sectors 2018 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 53% of national total emissions in 2018, 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 2018 based on fuel used amount to 136 kt and are about 15 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.

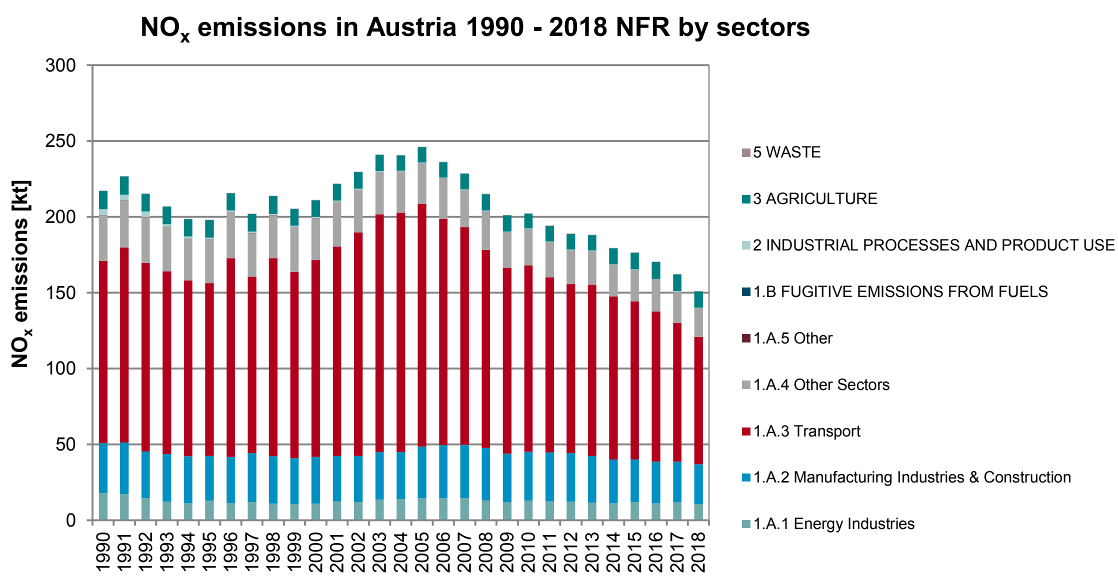
Also mileage has increased in passenger and freight transport. While NMVOC and CO emissions from road transport have been reduced significantly since 1990 due to well-functioning after-treatment devices, NO_x emissions increased up to 2005. Since then NO_x emissions have shown a decreasing trend, which 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.

- *NFR 1.A.2 Manufacturing Industries and Construction-* NO_x emissions have decreased compared to 1990 (-20%) 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. This is counterbalanced by a significant increase in energy consumption (also the use of biomass).
- *NFR 1.A.4 Other Sectors* (mainly residential heating): NO_x emissions decreased steadily between 1990 and 2018 (-37%) mainly due to increased efficiency and modern fuel technology. From 2017 to 2018 NO_x emissions of this source category decreased by 7.1% because of lower emissions from residential heating, due to warmer weather.

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 7.1% of national total NO_x emissions in Austria in 2018. Within the Agriculture sector, source category 3*.D Agricultural Soils* is the biggest contributor with 95% in 2018. 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 11%, mainly influenced by livestock numbers and N-fertilizer consumption. Compared to the previous year 2017 emissions slightly decreased by 2.1%, which was due to reduced mineral fertilizer consumption.



Source: Umweltbundesamt

Figure 10: NO_x emissions in Austria 1990–2018 by sectors in absolute terms.

Table 46: NO_x emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		NO_x Emission in [kt]		Trend		Share in National Total	
		1990	2018	1990–2018	2017–2018	1990	2018
1	ENERGY	200.79	139.68	-30%	-7%	92%	93%
1.A	FUEL COMBUSTION ACTIVITIES	200.79	139.68	-30%	-7%	92%	93%
1.A.1	Energy Industries	17.82	10.66	-40%	-9%	8%	7%
1.A.1.a	Public Electricity and Heat Production	12.13	8.92	-26%	-11%	6%	6%
1.A.1.b	Petroleum refining	4.32	1.08	-75%	9%	2%	1%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	1.37	0.65	-53%	-8%	1%	<1%
1.A.2	Manufacturing Industries and Construction	33.03	26.32	-20%	-2%	15%	17%
1.A.2.a	Iron and Steel	5.41	3.57	-34%	-4%	2%	2%
1.A.2.b	Non-ferrous Metals	0.25	0.26	4%	11%	<1%	<1%
1.A.2.c	Chemicals	1.69	1.39	-18%	-13%	1%	1%
1.A.2.d	Pulp, Paper and Print	7.17	4.41	-38%	3%	3%	3%
1.A.2.e	Food Processing, Beverages & Tobacco	1.74	0.68	-61%	-4%	1%	<1%
1.A.2.f	Non-metallic Minerals	9.99	5.78	-42%	4%	5%	4%
1.A.2.g	Manufacturing Industries and Constr. - other	6.77	10.22	51%	-4%	3%	7%
1.A.3	Transport	120.02	83.80	-30%	-8%	55%	56%
1.A.3.a	Civil Aviation	0.41	1.62	297%	10%	<1%	1%
1.A.3.b	Road Transportation	116.60	80.65	-31%	-8%	54%	53%
1.A.3.c	Railways	1.82	0.74	-59%	-22%	1%	<1%
1.A.3.d	Navigation	0.58	0.44	-24%	-26%	<1%	<1%
1.A.3.e	Other transportation	0.61	0.35	-42%	-20%	<1%	<1%
1.A.4	Other Sectors	29.85	18.82	-37%	-7%	14%	12%
1.A.4.a	Commercial/Institutional	3.11	1.18	-62%	-8%	1%	1%
1.A.4.b	Residential	16.22	10.68	-34%	-9%	7%	7%
1.A.4.c	Agriculture/Forestry/Fisheries	10.51	6.97	-34%	-4%	5%	5%
1.A.5	Other	0.07	0.08	11%	<1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	IE	IE	IE	IE	IE	IE
2	INDUSTRIAL PROCESSES /PRODUCT USE	4.27	0.41	-90%	-13%	2%	<1%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	4.07	0.28	-93%	-18%	2%	<1%
2.C	METAL PRODUCTION	0.17	0.11	-34%	1%	<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%	-4%	<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	10.75	-11%	-2%	6%	7%
3.B	MANURE MANAGEMENT	0.60	0.55	-8%	<1%	<1%	<1%
3.D	AGRICULTURAL SOILS	11.40	10.18	-11%	-2%	5%	7%
3.F	FIELD BURNING OF AGRICULTURAL RESIDUE	0.05	0.02	-58%	-1%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.10	0.02	-82%	2%	<1%	<1%
	Total without sinks	**217.22**	**150.86**	**-31%**	**-6.8%**		

2.1.3 NMVOC Emissions

In 1990, national total NMVOC emissions amounted to 334 kt. Emissions have decreased steadily since then and in the year 2018 emissions were reduced by 68% to 107 kt compared to 1990. The largest reductions were 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 several regulations (Solvent Ordinance, Cogeneration Act, VOC Emissions Ordinance). From 2017 to 2018 emissions decreased by 3.2%.

Main sources and emission trends in Austria

As can be seen in Figure 11 and Table 47, the main sources of NMVOC emissions in 2018 in Austria are NFR sectors *3 Agriculture* with a contribution of 34%, *1.A Fuel Combustion Activities* with a contribution of 32% and *2 Industrial Processes and Product Use* with a share of 31% in national total emissions.

NMVOC emissions resulting from NFR sectors *1.B Fugitive Emissions* and *5 Waste* are minor sources contributing to national total NMVOC emissions with 2.0% and 0.1%, respectively.

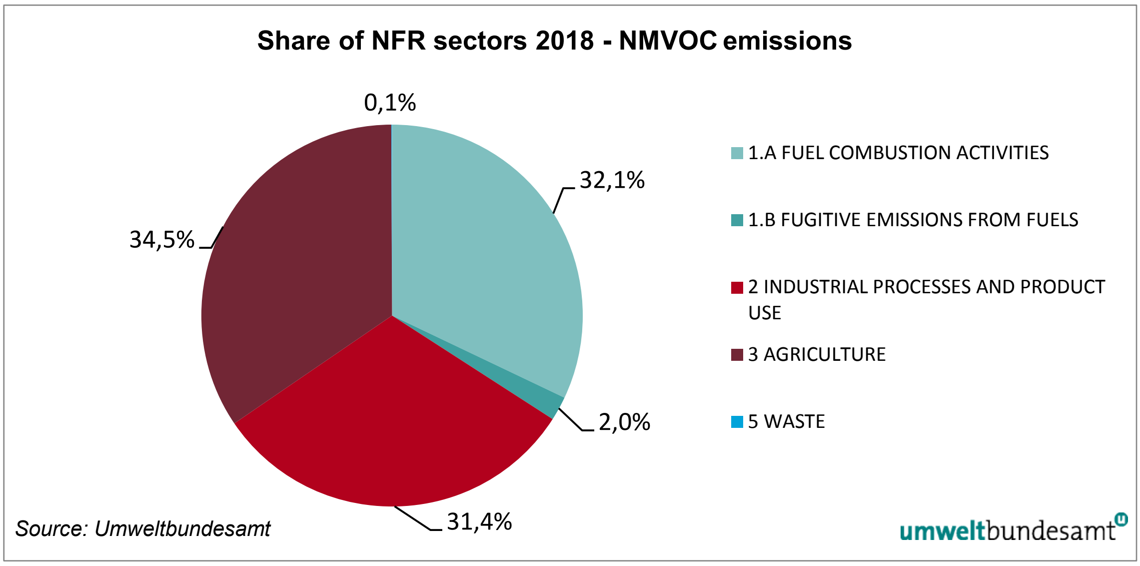


Figure 11: Share of NFR sectors 2018 in NMVOC emissions.

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 24% between 1990 and 2018. Compared to the previous year 2017 emissions decreased by 1.0%. 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 40% is mainly driven by the reduced livestock numbers resulting in smaller amounts of NMVOC that is applied to agricultural soils.

1.A Fuel Combustion Activities

NMVOC emissions from *1.A Fuel Combustion Activities* contribute with 32% to the national total. Within sector *1.A Fuel Combustion Activities* the main emitters in 2018 are *1.A.4 Other Sectors* (26% 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 residential heating decreased by 43% 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 2017 emissions from this source category decreased by 7.7% in 2018 mainly due to the warm weather.
- *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* (28% 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 2000 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 81% between 1990 and 2018 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 (-70% between 1990 and 2018) is a result of legal/abatement measures.
- *NFR 2.D.3.i Other solvent use*: The significant long term emission reduction of 91% could be achieved due to technical abatement measures such as closed loop processes, waste gas purification and recycling.

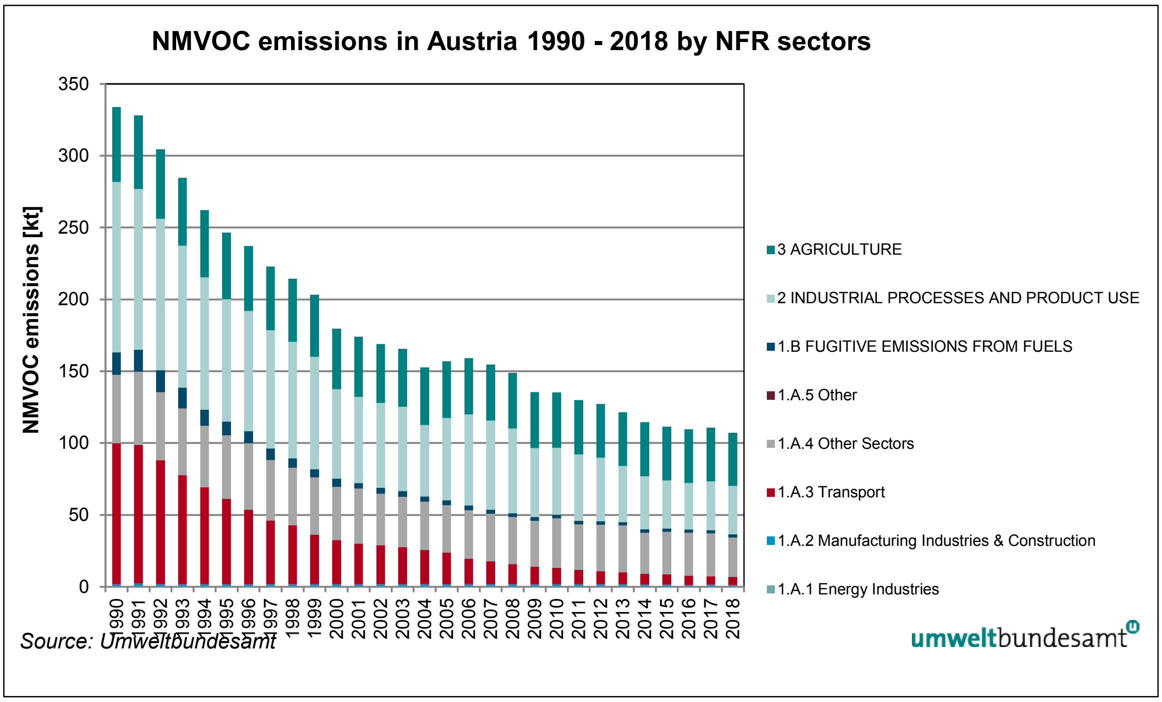


Figure 12: NMVOC emissions in Austria 1990–2018 by sectors in absolute terms.

Table 47: NMVOC emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		**NMVOC Emission in [kt]**		**Trend**		**Share in National Total**	
		1990	**2018**	**1990–2018**	**2017–2018**	**1990**	**2018**
1	ENERGY	163.13	36.56	-78%	-7%	49%	34%
1.A	FUEL COMBUSTION ACTIVITIES	147.64	34.39	-77%	-7%	44%	32%
1.A.1	Energy Industries	0.32	0.31	<1%	-6%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	1.68	1.03	-38%	-9%	1%	1%
1.A.3	Transport	97.78	5.62	-94%	-6%	29%	5%
1.A.3.a	Civil Aviation	0.20	0.21	1%	11%	<1%	<1%
1.A.3.b	Road Transportation	96.62	5.11	-95%	-6%	29%	5%
1.A.3.c	Railways	0.37	0.07	-80%	-22%	<1%	<1%
1.A.3.d	Navigation	0.59	0.23	-61%	-12%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.01	162%	-7%	<1%	<1%
1.A.4	Other Sectors	47.85	27.40	-43%	-8%	14%	26%
1.A.4.a	Commercial/Institutional	1.34	0.59	-56%	<1%	<1%	1%
1.A.4.b	Residential	40.84	24.21	-41%	-8%	12%	23%
1.A.4.c	Agriculture/Forestry/Fisheries	5.67	2.60	-54%	-5%	2%	2%
1.A.5	Other	0.01	0.02	24%	6%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	15.49	2.17	-86%	-5%	5%	2%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	118.54	33.63	-72%	-1%	35%	31%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	1.62	0.27	-83%	-15%	<1%	<1%
2.C	METAL PRODUCTION	0.51	0.47	-9%	2%	<1%	<1%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	114.44	30.13	-74%	-1%	34%	28%
2.D.3	Solvent use	114.44	30.13	-74%	-1%	34%	28%
2.D.3.a	Domestic solvent use including fungicides	16.30	16.10	-1%	-1%	5%	15%
2.D.3.b	Road paving with asphalt	0.01	0.02	273%	11%	<1%	<1%
2.D.3.c	Asphalt roofing	NE	NE	NE	NE	NE	NE
2.D.3.d	Coating applications	45.79	5.31	-88%	-1%	14%	5%
2.D.3.e	Degreasing	13.26	1.33	-90%	-1%	4%	1%
2.D.3.f	Dry cleaning	0.44	0.05	-89%	-1%	<1%	<1%
2.D.3.g	Chemical products	12.79	2.38	-81%	-1%	4%	2%
2.D.3.h	Printing	12.65	3.74	-70%	-1%	4%	3%
2.D.3.i	Other solvent use	13.20	1.20	-91%	-1%	4%	1%
2.G	Other product manufacture and use	0.08	0.06	-22%	-4%	<1%	<1%
2.H	Other Processes	1.89	2.71	43%	2%	1%	3%
2.I	Wood processing	NA	NA	NA	NA	NA	NA
2.J	Production of POPs	NO	NO	NO	NO	NO	NO
2.K	"Consumption of POPs and heavy metals	NO	NO	NO	NO	NO	NO
2.L	Other production, consumption, storage, …	NO	NO	NO	NO	NO	NO
3	AGRICULTURE	52.19	36.97	-29%	-1%	16%	34%
3.B	MANURE MANAGEMENT	35.42	26.94	-24%	-1%	11%	25%
3.D	AGRICULTURAL SOILS	16.71	10.02	-40%	-1%	5%	9%
3.F	FIELD BURNING OF AGRICULTURAL RES.	0.06	0.01	-86%	-6%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.16	0.06	-64%	-5%	<1%	<1%
	Total without sinks	**334.02**	**107.22**	**-68%**	**-3%**		

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 2018. In 2018, emissions were 4.7% above 1990 levels and amounted to 65 kt. NH_3 in Austria is almost exclusively emitted in the agricultural sector. The higher NH_3 emissions (in spite of a decrease in the number of cattle) can be explained by an increase in loose housing systems (to ensure animal welfare and according to EU law) and an increase of high-capacity dairy cows. Additionally, there has been an increase in the use of urea as nitrogen fertiliser (a cost-efficient but otherwise less efficient fertiliser). Compared to the previous year, emissions in 2018 decreased by 1.6%. The main reason is the lower amount of mineral fertilizer, in particular urea, which was applied on agricultural soils. Furthermore, the livestock numbers of cattle (dairy cows and other cattle) and swine were falling. However, increased N excretion due to increased milk yields counterbalanced the decreasing dairy cow number.

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 2018. Sector *1.A Fuel Combustion Activities* contributes with 3.9% 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 2018 with 0.2% and 2.5%, respectively.

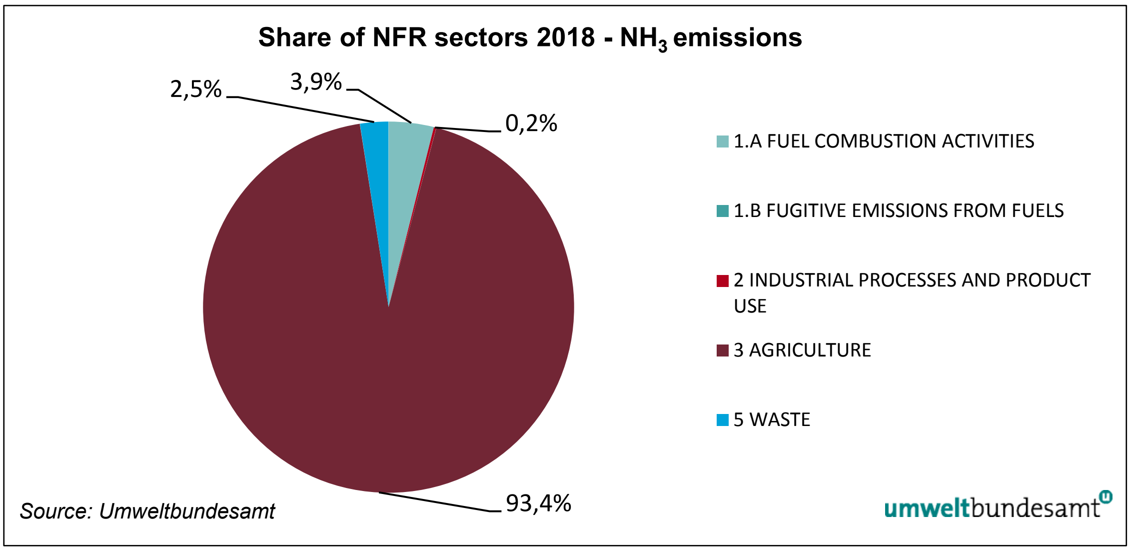


Figure 13: Share of NFR sectors 2018 in NH_3 emissions.

3 Agriculture

In 1990 national NH_3 emissions from the sector *Agriculture* amounted to 59 kt; emissions have increased by 2.2% since then and by the year 2018 they amounted to 60 kt. The reason for this increase is, as already explained above, due to an increase in loose-housing systems and high-capacity dairy cows. Furthermore, there was a higher consumption of urea as nitrogen fertilizer. Compared to the previous year, emissions decreased in 2018 (-1.5%), because of the lower amount of mineral fertilizer, in particular urea, which was applied on agricultural soils. Furthermore, the livestock numbers of cattle (dairy cows and other cattle) and swine were falling. However, the decrease of dairy cows was compensated with the rising milk yield.

- *NFR 3.B Manure Management* has a share of 45% in national total NH_3 emissions in 2018. The emissions result from animal husbandry and the storage of manure. Within this source category manure management of cattle has the highest contribution with 62%. 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 12%, 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 2018. 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 3.9% in 2018. NH_3 emissions from NFR sector *1.A* are increasing: in 1990, emissions amounted to about 2.0 kt. In the year 2018, they were about 29% 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* – 4 stroke engines and an increase of biomass use in category *1.A.1.a Public Electricity and Heat.*

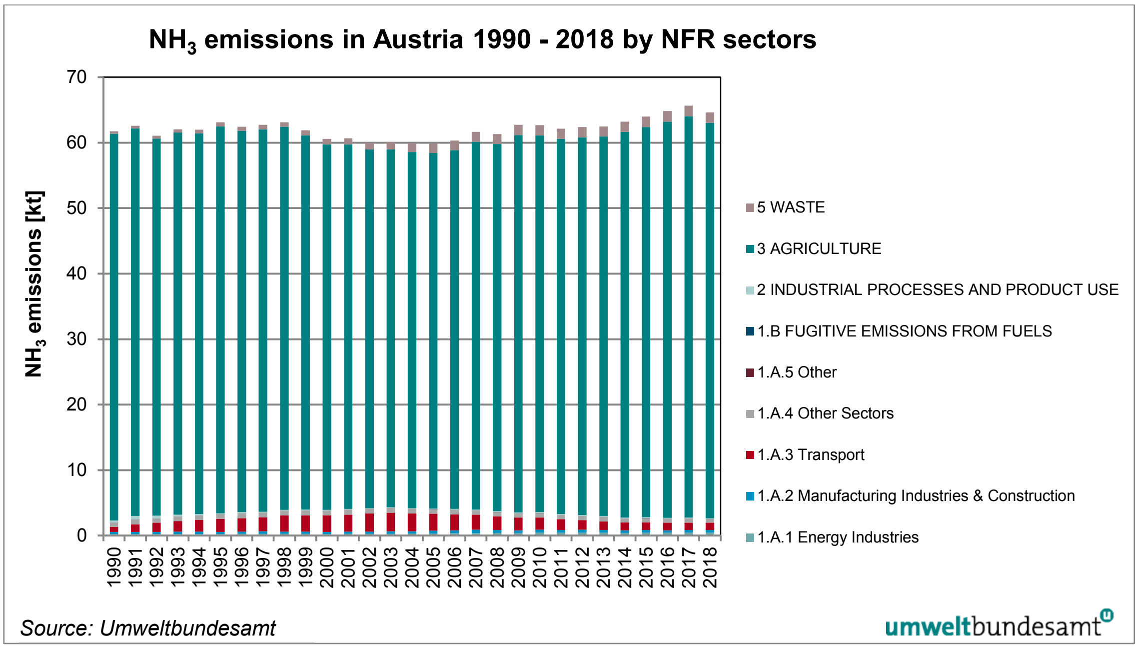


Figure 14: NH_3 emissions in Austria 1990–2018 by sectors in absolute terms.

Table 48: NH_3 emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		**NH_3 Emission in [kt]**		**Trend**		**Share in National Total**	
		1990	**2018**	**1990–2018**	**2017–2018**	**1990**	**2018**
1	ENERGY	1.96	2.54	29%	-2%	3%	4%
1.A	FUEL COMBUSTION ACTIVITIES	1.96	2.54	29%	-2%	3%	4%
1.A.1	Energy Industries	0.20	0.43	118%	-6%	<1%	1%
1.A.2	Manufacturing Industries and Construction	0.33	0.41	22%	7%	1%	1%
1.A.3	Transport	0.80	1.12	39%	<1%	1%	2%
1.A.4	Other Sectors	0.63	0.58	-7%	-9%	1%	1%
1.A.5	Other	0.00	0.00	38%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	IE	0.00		164%		<1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	0.34	0.14	-60%	-19%	1%	<1%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.27	0.08	-70%	-27%	<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%	-4%	<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	59.06	60.36	2%	-2%	96%	93%
3.B	MANURE MANAGEMENT	26.05	29.12	12%	-1%	42%	45%
3.B.1	Cattle	13.89	17.92	29%	-1%	23%	28%
3.B.2	Sheep	0.74	0.98	31%	1%	1%	2%
3.B.3	Swine	8.47	5.69	-33%	-2%	14%	9%
3.B.4	Other livestock	2.94	4.54	54%	0%	5%	7%
3.B.4.a	Buffalo	NO	NO	NO	NO	NO	NO
3.B.4.d	Goats	0.11	0.28	145%	<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	2.50	17%	<1%	3%	4%
3.B.4.h	Other animals	0.03	0.03	11%	<1%	<1%	<1%
3.D	AGRICULTURAL SOILS	32.98	31.22	-5%	-2%	53%	48%
3.D.a	Direct Soil Emissions	32.98	31.22	-5%	-2%	53%	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	-71%	-1%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.37	1.60	336%	<1%	1%	2%
	Total without sinks	**61.73**	**64.63**	**5%**	**-2%**		

2.1.5 Carbon monoxide (CO) Emissions

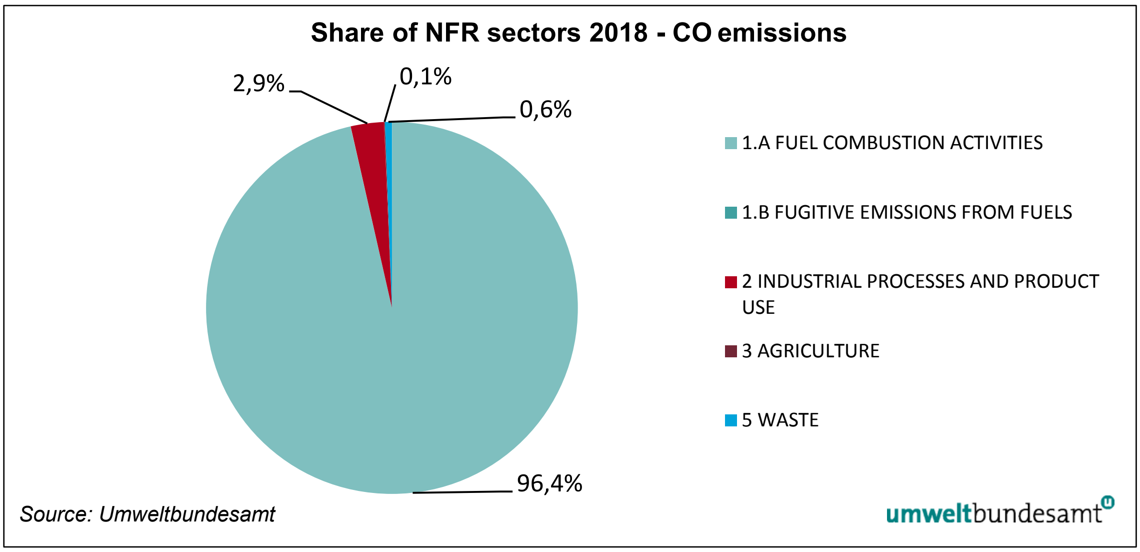
CO is a colourless and odourless gas, formed when carbon in fuel is not burned completely. It is a component of motor vehicle exhaust; other sources of CO emissions include industrial processes, non-transportation fuel combustion, and natural sources such as wildfires.

In 1990, national total CO emissions amounted to 1 249 kt. Emissions considerably decreased from 1990 to 2018. In 2018, emissions were 61% below 1990 levels and amounted to 490 kt. This reduction was mainly due to decreasing emissions from road transport (catalytic converters). The emissions decreased between 2017 and 2018 by 7.4%, mainly due to sectors iron and steel and residential (stationary).

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 96% for 1990 and for 2018.

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 2.9%, 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 2018 in CO emissions.

1.A Fuel Combustion Activities

As described above, in the period 1990–2018, the share of CO emissions from *1.A Fuel Combustion Activities* in national total emissions has been quite stable in spite of growing activities because of considerable efforts regarding abatement techniques and improved combustion efficiency in all sub-sectors.

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

- NFR *1.A.4 Other Sectors:* CO emissions decreased since 1990 by 41% due to the switch-over to improved technologies and decreased use of coke. Between 2017 and 2018 emissions decreased by 7.8% mainly due to the warm weather.

- NFR *1.A.2 Manufacturing Industries and Construction:* Compared to 1990 emissions decreased by 36%. The trend is dominated by fuel combustion from iron and steel industry. The emissions decrease of 8.8% compared to the previous year 2017 is also mainly due to lower emissions from the sector iron and steel.
- NFR *1.A.3 Transport:* The significant emission reduction of 87% 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.

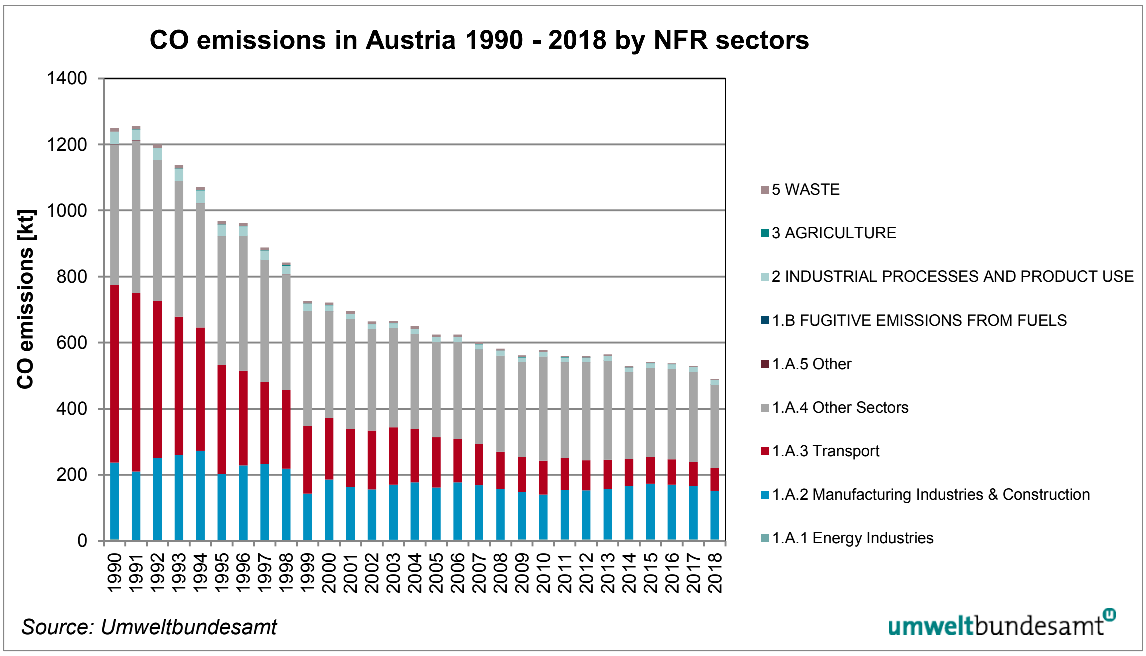


Figure 16: CO emissions in Austria 1990–2018 by sectors in absolute terms.

Table 49: CO emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		**CO Emission in [kt]**		**Trend**		**Share in National Total**	
		1990	**2018**	**1990–2018**	**2017–2018**	**1990**	**2018**
1	ENERGY	1200.68	472.56	-61%	-8%	96%	96%
1.A	FUEL COMBUSTION ACTIVITIES	1200.68	472.56	-61%	-8%	96%	96%
1.A.1	Energy Industries	6.10	4.27	-30%	-7%	<1%	1%
1.A.2	Manufacturing Industries and Construction	231.22	147.59	-36%	-9%	19%	30%
1.A.2.a	Iron and Steel	210.72	133.30	-37%	-8%	17%	27%
1.A.2.b	Non-ferrous Metals	0.05	0.05	2%	1%	<1%	<1%
1.A.2.c	Chemicals	0.46	0.49	6%	-23%	<1%	<1%
1.A.2.d	Pulp, Paper and Print	4.15	2.01	-52%	5%	<1%	<1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.20	0.12	-41%	-1%	<1%	<1%
1.A.2.f	Non-metallic Minerals	11.03	5.71	-48%	-29%	1%	1%
1.A.2.g	Manufacturing Industries and Constr. - other	4.61	5.91	28%	-2%	<1%	1%
1.A.3	Transport	537.13	68.77	-87%	-4%	43%	14%
1.A.3.a	Civil Aviation	2.47	3.96	60%	1%	<1%	1%
1.A.3.b	Road Transportation	529.40	62.20	-88%	-4%	42%	13%
1.A.3.c	Railways	2.04	0.50	-75%	-21%	<1%	<1%
1.A.3.d	Navigation	3.19	2.00	-37%	-5%	<1%	<1%
1.A.3.e	Other transportation	0.04	0.11	162%	-7%	<1%	<1%
1.A.4	Other Sectors	426.00	251.64	-41%	-8%	34%	51%
1.A.4.a	Commercial/Institutional	11.76	3.93	-67%	-4%	1%	1%
1.A.4.b	Residential	379.98	229.53	-40%	-8%	30%	47%
1.A.4.c	Agriculture/Forestry/Fisheries	34.27	18.19	-47%	-6%	3%	4%
1.A.5	Other	0.22	0.30	37%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	IE	IE	IE	IE	IE	IE
2	INDUSTRIAL PROCESSES AND PRODUCT USE	37.19	14.22	-62%	1%	3%	3%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	12.67	11.13	-12%	<1%	1%	2%
2.C	METAL PRODUCTION	23.32	2.09	-91%	4%	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%	-4%	<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	0.35	-72%	-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	0.35	-72%	-2%	<1%	<1%
3.I	AGRICULTURE OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	10.31	2.96	-71%	-6%	1%	1%
5.A	SOLID WASTE DISPOSAL ON LAND	10.26	2.94	-71%	-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	-67%	4%	<1%	<1%
5.D	WASTEWATER TREATMENT	NA	NA	NA	NA	NA	NA
5.E	OTHER WASTE HANDLING	NE	NE	NE	NE	NE	NE
	Total without sinks	**1249.41**	**490.09**	**-61%**	**-7%**		

2.2 Emission Trends for Particulate matter (PM)

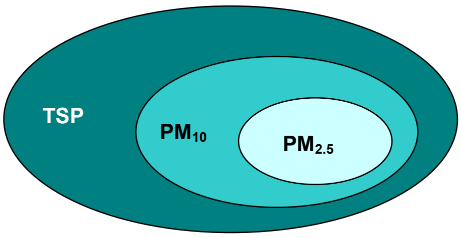
Particulate matter (PM) is a complex mixture consisting of both directly emitted and secondarily formed components of both natural and anthropogenic origin (e.g. geological material, combustion by-products and biological material). It has an inhomogeneous composition of sulphate, nitrate, ammonium, organic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

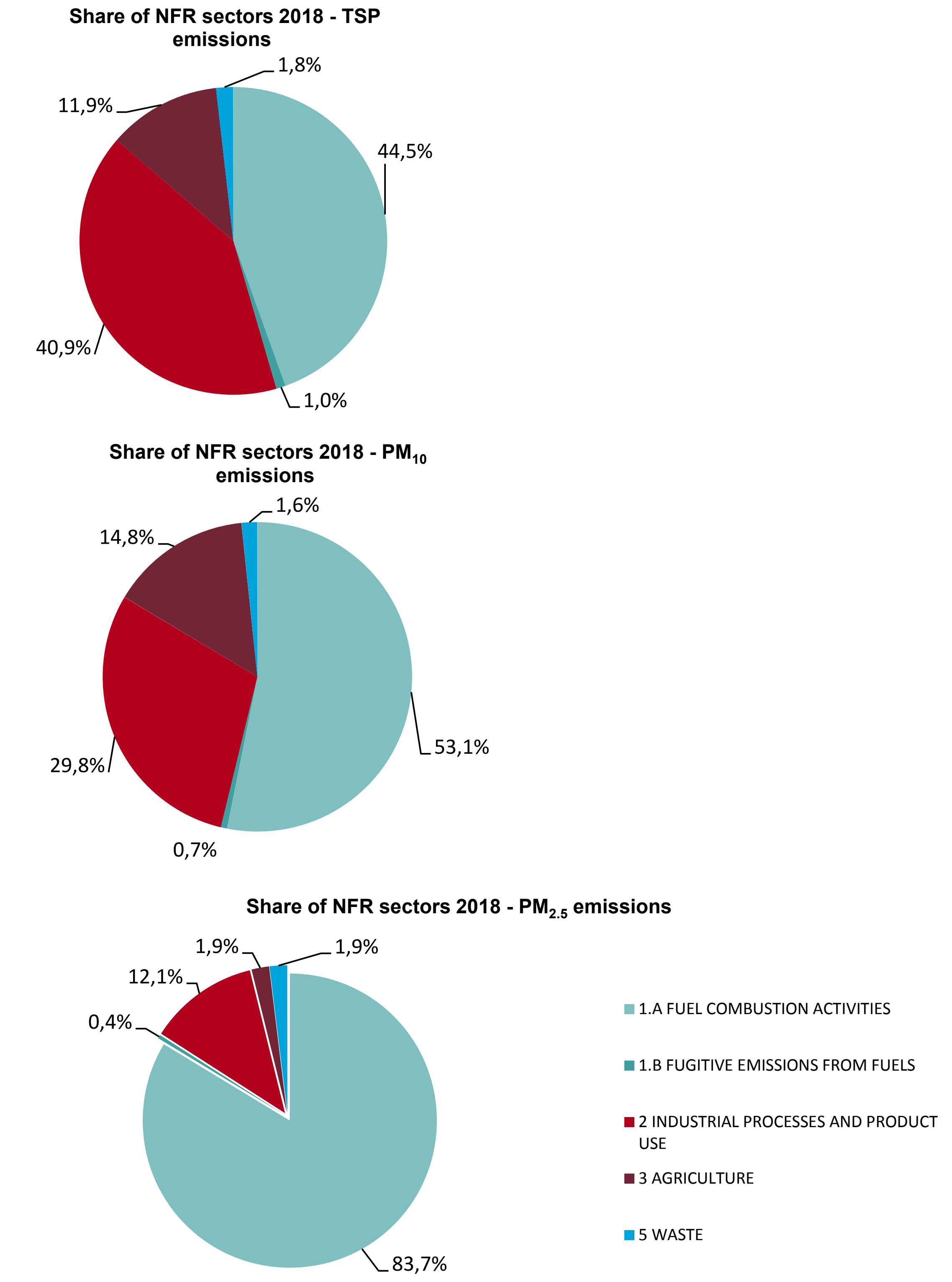
Figure 17: Distribution of TSP, PM_{10} and $PM_{2.5}$ (schematic).

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, con-*

struction/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 (less than 2%).



Source: Umweltbundesamt

umweltbundesamt

Figure 18: Share of NFR sectors 2018 in PM emissions (TSP, PM_{10} and $PM_{2.5}$).

Table 50: National total emissions and emission trends for particulate matter (PM) 1990–2018.

Year	Emissions [kt]		
	TSP	**PM_{10}**	**$PM_{2.5}$**
1990	53.21	40.90	27.17
:	NR	NR	NR
1995	52.06	39.37	25.69
:	NR	NR	NR
2000	50.58	37.82	24.12
2001	50.26	37.80	24.38
2002	49.17	36.74	23.56
2003	48.81	36.48	23.39
2004	48.81	36.18	22.83
2005	48.14	35.77	22.67
2006	46.74	34.78	22.17
2007	45.67	33.78	21.35
2008	45.57	33.23	20.44
2009	43.14	31.48	19.27
2010	43.77	32.08	19.87
2011	43.01	31.12	18.73
2012	42.26	30.51	18.27
2013	41.62	29.89	17.69
2014	40.25	28.35	16.11
2015	39.81	28.02	15.94
2016	39.43	27.62	15.56
2017	39.69	27.58	15.30
2018	38.32	26.40	14.26
Trend 1990–2018	**-28.0%**	**-35.5%**	**-47.5%**

Particulate matter (PM) emissions show a decreasing trend over the period 1990 to 2018: 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 2017 and 2018 PM_{10}, $PM_{2.5}$ and TSP emissions decreased by 4.3% (PM_{10}), 6.8% ($PM_{2.5}$) and 3.4% (TSP). The decrease of TSP, PM_{10} and $PM_{2.5}$ was mainly because of reductions in the sector *1 A 4 b 1 residential: stationary*, due to the mild weather in 2018 and a decrease in the use of biomass for heating. To a small extent, the latest decline can also be explained by efficiency improvements through thermal renovation and by a switch to modern biomass boilers and stoves (improvements in fuel combustion technologies). TSP emissions also decreased slightly due to reduced emissions from *2.A.5.a Quarrying and mining of minerals other than coal*.

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 18% TSP, 17% PM_{10} and 21% $PM_{2.5}$ emissions of the respective national totals. The reduction of PM emissions since 2005 is due to improvements in the drive and exhaust gas after treatment technologies and the integration of particulate filter systems in the fuel consumption based taxation for passenger cars in Austria (NOVA). PM emissions from automobile tyre and break wear (NFR sector *1.A.3.b.6*) and road abrasion (NFR *1.A.3.b.7*) are increasing as a function of travelled vehicles kilometres which have shown an increasing trend since 1990.
- *NFR 1.A.1 Energy Industries* and *NFR 1.A.2 Manufacturing Industries and Construction*: NFR *1.A.2 Manufacturing Industries and Construction* is responsible for 2.6% of the national total TSP emissions, 3.5% of PM_{10} emissions and 5.5% of $PM_{2.5}$ emissions. *1.A.1 Energy Industries* contributes in 2018 with 3.2% of TSP, 4.2% of PM_{10} and 6.7% 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 2017 and 2018 a decrease can be observed.

- *NFR 2.C Metal Production*, a decreasing trend of about 89% of all PM fractions can be noted for the period 1990 to 2018 because considerable efforts were made by introducing low-PM technologies, abatement techniques, flue gas collection and flue gas cleaning systems etc. In 2018 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 3.5% of the agricultural $PM_{2.5}$ emissions from this source category. TSP and PM_{10} emissions from *3.D Agricultural Soils* decreased by 5.5% and 5.8% over the period 1990 to 2018.
- *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 2018 emissions decreased by 11% for all PM fractions due to falling livestock numbers. Compared to the previous year emissions decreased by 0.9%.

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 2018 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 2018 in Austria are combustion processes in the NFR category 1.A *Fuel Combustion Activities* (53% 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* (30% in national total emissions). Sector *3 Agriculture* contributes with a share of 15% in national total PM_{10} emissions.

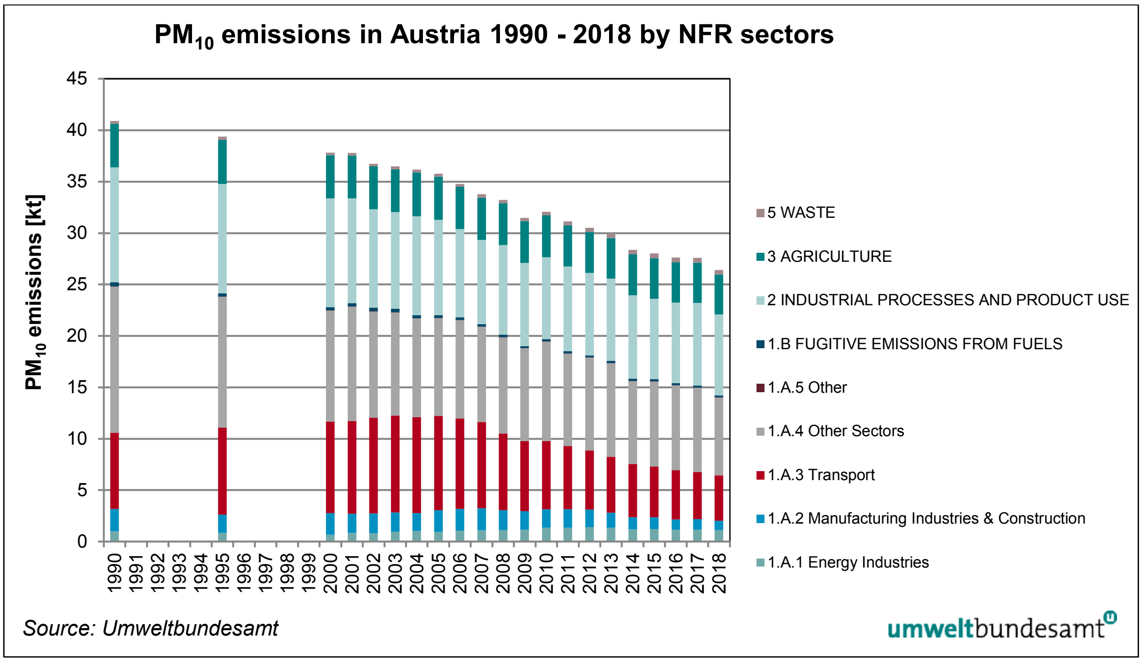


Figure 19: PM_{10} emissions in Austria 1990–2018 by sectors in absolute terms.

Table 51: PM_{10} emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		PM_{10} Emission in [kt]		Trend		Share in National Total	
		1990	2018	1990–2018	2017–2018	1990	2018
1	ENERGY	25.22	14.21	-44%	-6%	62%	54%
1.A	FUEL COMBUSTION ACTIVITIES	24.82	14.03	-43%	-6%	61%	53%
1.A.1	Energy Industries	1.00	1.12	12%	-4%	2%	4%
1.A.2	Manufacturing Industries and Construction	2.18	0.92	-58%	-10%	5%	3%
1.A.2.a	Iron and Steel	0.05	0.01	-78%	-7%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.01	0.01	-21%	2%	<1%	<1%
1.A.2.c	Chemicals	0.21	0.21	-1%	-18%	1%	1%
1.A.2.d	Pulp, Paper and Print	0.95	0.21	-78%	2%	2%	1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.11	0.03	-72%	8%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.07	0.08	19%	3%	<1%	<1%
1.A.2.g	Manufacturing Ind. and Constr. - other	0.78	0.36	-54%	-14%	2%	1%
1.A.3	Transport	7.41	4.42	-40%	-4%	18%	17%
1.A.3.a	Civil Aviation	0.03	0.12	250%	9%	<1%	<1%
1.A.3.b	Road Transportation	6.28	3.69	-41%	-4%	15%	14%
1.A.3.c	Railways	0.96	0.57	-41%	-3%	2%	2%
1.A.3.d	Navigation	0.13	0.03	-76%	-27%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	162%	-7%	<1%	<1%
1.A.4	Other Sectors	14.21	7.56	-47%	-8%	35%	29%
1.A.4.a	Commercial/Institutional	0.85	0.31	-64%	-5%	2%	1%
1.A.4.b	Residential	10.80	6.33	-41%	-8%	26%	24%
1.A.4.c	Agriculture/Forestry/Fisheries	2.56	0.92	-64%	-8%	6%	3%
1.A.5	Other	0.02	0.02	10%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	0.40	0.18	-56%	-14%	1%	1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	11.16	7.86	-30%	-2%	27%	30%
2.A	MINERAL PRODUCTS	4.94	6.24	26%	-1%	12%	24%
2.A.1	Cement Production	0.16	0.05	-66%	5%	<1%	<1%
2.A.2	Lime Production	0.06	0.08	43%	-5%	<1%	<1%
2.A.3	Glass production	IE	IE	IE	IE	IE	IE
2.A.5	Mining, construction, handling of products	4.73	6.11	29%	-1%	12%	23%
2.A.6	Other Mineral products	NO	NO	NO	NO	NO	NO
2.B	CHEMICAL INDUSTRY	0.57	0.20	-64%	-16%	1%	1%
2.C	METAL PRODUCTION	4.68	0.51	-89%	-2%	11%	2%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	0.61	0.46	-25%	-5%	1%	2%
2.H	Other Processes	0.00	0.00	-26%	-8%	<1%	<1%
2.I	Wood processing	0.37	0.45	23%	-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	3.90	-8%	<1%	10%	15%
3.B	MANURE MANAGEMENT	0.56	0.50	-11%	-1%	1%	2%
3.D	AGRICULTURAL SOILS	3.58	3.37	-6%	<1%	9%	13%
3.F	FIELD BURNING OF AGRICUL. RESIDUES	0.10	0.03	-72%	-1.7%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.28	0.44	58%	-8.4%	1%	2%
	Total without sinks	**40.90**	**26.40**	**-35%**	**-4%**		

$PM_{2.5}$ 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 2018 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 84% in the total emissions in 2018. A further emission source is NFR sector *2 Industrial Processes and Product Use,* which had a share of 12% 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.

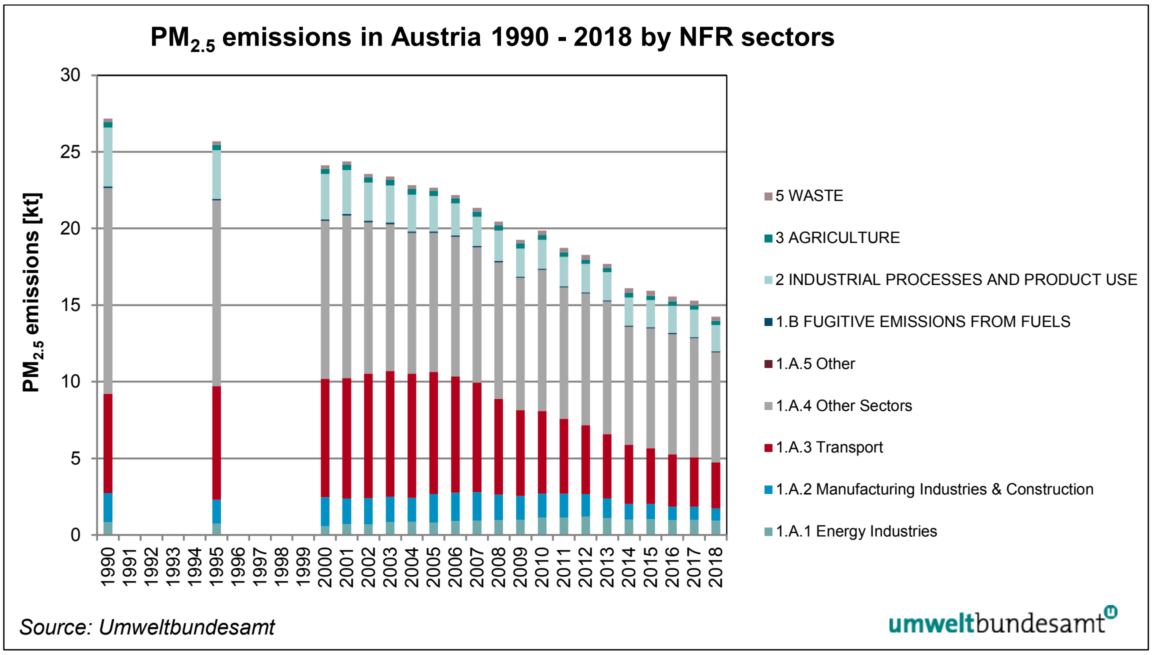


Figure 20: $PM_{2.5}$ emissions in Austria 1990–2018 by sectors in absolute terms.

Table 52: $PM_{2.5}$ emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		$PM_{2.5}$ Emission in [kt]		Trend		Share in National Total	
		1990	2018	1990–2018	2017–2018	1990	2018
1	ENERGY	22.76	11.99	-47%	-7%	84%	84%
1.A	FUEL COMBUSTION ACTIVITIES	22.65	11.93	-47%	-7%	83%	84%
1.A.1	Energy Industries	0.85	0.95	11%	-4%	3%	7%
1.A.2	Manufacturing Industries and Construction	1.90	0.78	-59%	-10%	7%	5%
1.A.2.a	Iron and Steel	0.04	0.01	-78%	-7%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.01	0.01	-21%	2%	<1%	<1%
1.A.2.c	Chemicals	0.17	0.17	-1%	-18%	1%	1%
1.A.2.d	Pulp, Paper and Print	0.78	0.17	-78%	2%	3%	1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.09	0.03	-72%	8%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.06	0.07	19%	3%	<1%	<1%
1 A 2 g	Manufacturing Industries and Constr. – other	0.74	0.33	-56%	-14%	3%	2%
1.A.3	Transport	6.48	3.01	-53%	-6%	24%	21%
1.A.3.a	Civil Aviation	0.03	0.12	250%	9%	<1%	1%
1.A.3.b	Road Transportation	5.71	2.65	-54%	-7%	21%	19%
1.A.3.c	Railways	0.60	0.21	-65%	-7%	2%	1%
1.A.3.d	Navigation	0.13	0.03	-76%	-27%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	162%	-7%	<1%	<1%
1.A.4	Other Sectors	13.41	7.17	-47%	-8%	49%	50%
1.A.4.a	Commercial/Institutional	0.78	0.29	-62%	-5%	3%	2%
1.A.4.b	Residential	10.10	5.99	-41%	-8%	37%	42%
1.A.4.c	Agriculture/Forestry/Fisheries	2.52	0.88	-65%	-8%	9%	6%
1.A.5	Other	0.02	0.02	10%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	0.11	0.06	-49%	-14%	<1%	<1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	3.82	1.72	-55%	-3%	14%	12%
2.A	MINERAL PRODUCTS	0.71	0.79	11%	-2%	3%	6%
2.A.1	Cement Production	0.14	0.05	-66%	5%	1%	<1%
2.A.2	Lime Production	0.04	0.06	43%	-5%	<1%	<1%
2.A.3	Glass production	IE	IE	IE	IE	IE	IE
2.A.5	Mining, construction, handling of products	0.53	0.68	29%	-2%	2%	5%
2.A.6	Other Mineral products	NO	NO	NO	NO	NO	NO
2.B	CHEMICAL INDUSTRY	0.30	0.11	-64%	-16%	1%	1%
2.C	METAL PRODUCTION	2.13	0.23	-89%	-2%	8%	2%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	0.54	0.41	-24%	-5%	2%	3%
2.H	Other Processes	0.00	0.00	-46%	-8%	<1%	<1%
2.I	Wood processing	0.15	0.18	23%	-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	-24%	-1%	1%	2%
3.B	MANURE MANAGEMENT	0.13	0.11	-11%	-1%	<1%	1%
3.D	AGRICULTURAL SOILS	0.14	0.14	-3%	<1%	1%	1%
3.F	FIELD BURNING OF AGRICULT. RES.	0.09	0.03	-72%	-2%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.23	0.28	21%	-13%	1%	2%
	Total without sinks	**27.17**	**14.26**	**-48%**	**-7%**		

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 2018 by 28% and amounted to 38 kt in 2018, 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 41%, respectively, in national total emissions in 2018. 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 18% as well as *1.A.1 Energy Industries* with 3.2% and *1.A.2 Manufacturing Industries and Construction* with 2.6% in national total emissions. NFR sector *3 Agriculture* also participates with 12%.

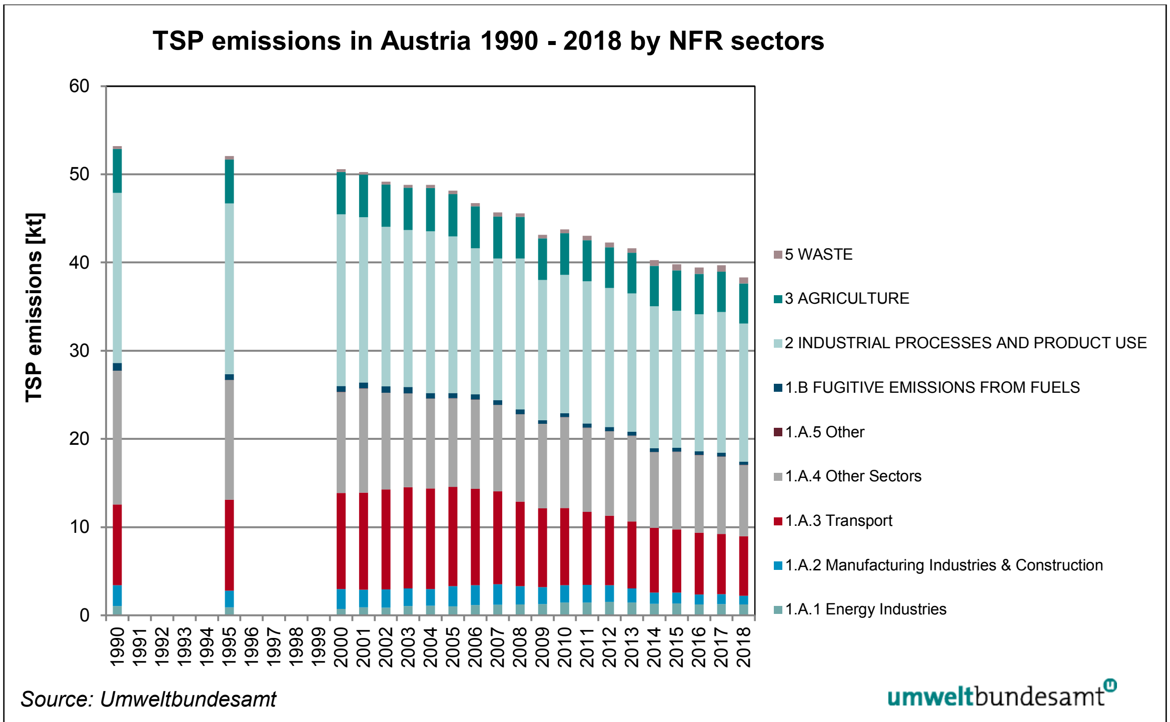


Figure 21: TSP emissions in Austria 1990–2018 by sectors in absolute terms.

Table 53: TSP emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		TSP Emission in [kt]		Trend		Share in National Total	
		1990	2018	1990–2018	2017–2018	1990	2018
1	ENERGY	28.60	17.43	-39%	-6%	54%	45%
1.A	FUEL COMBUSTION ACTIVITIES	27.74	17.05	-39%	-5%	52%	44%
1.A.1	Energy Industries	1.06	1.23	17%	-4%	2%	3%
1.A.2	Manufacturing Industries and Construction	2.37	1.00	-58%	-9%	4%	3%
1.A.2.a	Iron and Steel	0.06	0.01	-78%	-7%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.01	0.01	-21%	2%	<1%	<1%
1.A.2.c	Chemicals	0.23	0.23	-1%	-18%	<1%	1%
1.A.2.d	Pulp, Paper and Print	1.06	0.24	-78%	2%	2%	1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.12	0.03	-72%	8%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.08	0.09	19%	3%	<1%	<1%
1 A 2 g	Manufacturing Industries and Constr. – other	0.81	0.39	-52%	-14%	2%	1%
1.A.3	Transport	9.15	6.74	-26%	-2%	17%	18%
1.A.3.a	Civil Aviation	0.03	0.12	250%	9%	<1%	<1%
1.A.3.b	Road Transportation	6.98	4.98	-29%	-2%	13%	13%
1.A.3.c	Railways	2.00	1.61	-19%	-1%	4%	4%
1.A.3.d	Navigation	0.13	0.03	-76%	-27%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.01	162%	-7%	<1%	<1%
1.A.4	Other Sectors	15.16	8.06	-47%	-8%	28%	21%
1.A.4.a	Commercial/Institutional	0.93	0.33	-65%	-5%	2%	1%
1.A.4.b	Residential	11.63	6.77	-42%	-8%	22%	18%
1.A.4.c	Agriculture/Forestry/Fisheries	2.61	0.97	-63%	-8%	5%	3%
1.A.5	Other	0.02	0.02	10%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	0.85	0.37	-56%	-14%	2%	1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	19.31	15.66	-19%	-2%	36%	41%
2.A	MINERAL PRODUCTS	10.21	13.00	27%	-1%	19%	34%
2.A.1	Cement Production	0.17	0.06	-66%	5%	<1%	<1%
2.A.2	Lime Production	0.06	0.09	43%	-5%	<1%	<1%
2.A.3	Glass production	IE	IE	IE	IE	IE	IE
2.A.5	Mining, construction, handling of products	9.97	12.85	29%	-1%	19%	34%
2.A.6	Other Mineral products	NO	NO	NO	NO	NO	NO
2.B	CHEMICAL INDUSTRY	0.96	0.35	-64%	-16%	2%	1%
2.C	METAL PRODUCTION	6.60	0.71	-89%	-2%	12%	2%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	0.63	0.47	-25%	-5%	1%	1%
2.H	Other Processes	0.00	0.00	-22%	-8%	<1%	<1%
2.I	Wood processing	0.92	1.13	23%	-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	4.54	-8%	<1%	9%	12%
3.B	MANURE MANAGEMENT	1.25	1.11	-11%	-1%	2%	3%
3.D	AGRICULTURAL SOILS	3.59	3.40	-5%	<1%	7%	9%
3.F	FIELD BURNING OF AGRICULTURAL RES.	0.10	0.03	-72%	-2%	<1%	<1%
3.I	Agriculture OTHER	NO	NO	NO	NO	NO	NO
5	WASTE	0.35	0.69	98%	-5%	1%	2%
	Total without sinks	**53.21**	**38.32**	**-28%**	**-3%**		

2.3 Emission Trends for Heavy Metals

In general emissions of heavy metals decreased remarkably from 1990 to 2018. Emission trends for heavy metals from 1990 to 2018 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 1990–2018.

Year	Emissions [t]		
	Cd	**Hg**	**Pb**
1990	1.75	2.17	232.41
1991	1.66	2.06	196.32
1992	1.38	1.66	139.82
1993	1.25	1.41	99.07
1994	1.14	1.20	68.62
1995	1.05	1.22	20.36
1996	1.05	1.18	19.92
1997	1.01	1.15	18.84
1998	0.95	0.97	17.67
1999	1.01	0.95	17.92
2000	0.99	0.91	17.17
2001	1.00	0.97	16.76
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	18.38
2006	1.08	1.02	19.19
2007	1.11	1.03	19.94
2008	1.12	1.04	19.97
2009	1.06	0.93	17.58
2010	1.19	1.03	20.12
2011	1.16	1.02	20.40
2012	1.18	1.04	20.33
2013	1.20	1.09	21.11
2014	1.14	1.04	20.17
2015	1.15	1.01	19.57
2016	1.14	0.95	19.93
2017	1.18	1.03	20.54
2018	1.13	0.96	19.26
Trend 1990–2018	**-35%**	**-56%**	**-92%**

2.3.1 Cadmium (Cd) Emissions

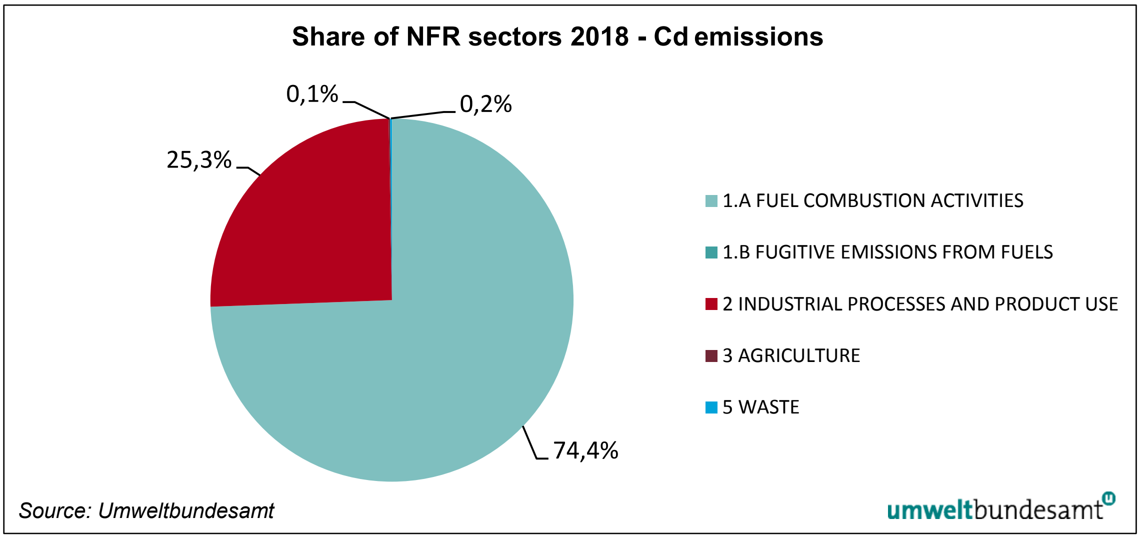
Cadmium (Cd) has been ubiquitously distributed in the natural environment for millions of years. It occurs in the earth's crust with a content estimated to be between 0.08 and 0.5 ppm. Unlike some other heavy metals, such as lead or mercury, which have been used since ancient times, Cd has been refined 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 74% to national total Cd emissions in 2018. The second important source is 2 *Industrial Processes and Product Use* with 25% 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 2018 in Cd emissions.

National total Cd emissions amounted to 1.75 t in 1990; emissions have decreased and by the year 2018 emissions were reduced by 35% to 1.13 t in the period 1990–2018. 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 from industrial processes.

1.A Fuel Combustion Activities

In the period from 1990 to 2018 Cd emissions of *1.A Fuel Combustion Activities* decreased by 20% to 0.84 t. The main sources of Cd emission within NFR sector *1.A. Fuel Combustion Activities* are *1.A.1 Energy Industries, 1.A.4 Other Sectors*, *1.A.2 Manufacturing Industries and Construction.*

- *NFR 1.A.1 Energy Industries*: The increasing Cd emissions since 2001 were due to increasing use of wood and wooden litter in small combustion plants, the combustion of heavy fuel oil and residues from the petroleum processing in the refinery as well as the thermal utilisation of industrial residues and residential waste.
- *NFR 1.A.4 Other Sectors*: Cd emissions decreased by 28% since 1990 to 0.29 t, representing a share of 26% in national total emissions in 2018. The reduction is mainly due to a decreased use of coal.
- *NFR 1.A.2 Manufacturing Industries and Construction*: Between 1990 and 2018 Cd emissions decreased by 20%, however since 2000 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 subcategory *2.C Metal Production*.

- *NFR 2.C Metal Production*: As shown in Table 55 in the period from 1990 to 2018 the Cd emissions decreased by 60% to 0.21 t, which is a share of 19% 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* decreased in 2018 by 16%.

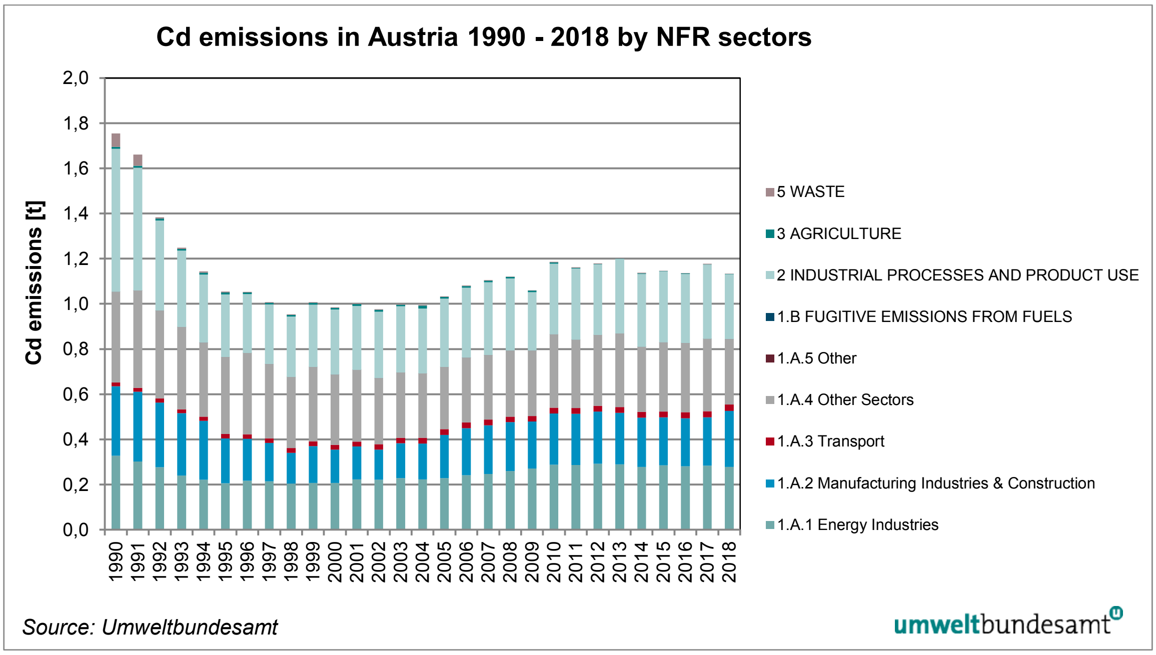


Figure 23: Cd emissions in Austria 1990–2018 by sectors in absolute terms.

Table 55: Cd emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		Cd Emission in [t]		Trend		Share in National Total	
		1990	2018	1990–2018	2017–2018	1990	2018
1	ENERGY	1.05	0.84	-20%	<1%	60%	74%
1.A	FUEL COMBUSTION ACTIVITIES	1.05	0.84	-20%	<1%	60%	74%
1.A.1	Energy Industries	0.33	0.28	-15%	-2%	19%	25%
1.A.1.a	Public Electricity and Heat Production	0.18	0.13	-26%	-4%	10%	12%
1.A.1.b	Petroleum refining	0.15	0.15	-2%	1%	8%	13%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-53%	-8%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	0.31	0.25	-20%	15%	18%	22%
1.A.2.a	Iron and Steel	0.01	0.00	-46%	5%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	-1%	-7%	<1%	<1%
1.A.2.c	Chemicals	0.03	0.01	-54%	-7%	2%	1%
1.A.2.d	Pulp, Paper and Print	0.15	0.14	-4%	35%	9%	13%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.00	-58%	31%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.10	0.02	-77%	-2%	6%	2%
1.A 2.g	Manufacturing Industries and Constr. - other	0.02	0.06	181%	-5%	1%	5%
1.A.3	Transport	0.02	0.03	76%	3%	1%	3%
1.A.3.a	Civil Aviation	0.00	0.00	235%	9%	<1%	<1%
1.A.3.b	Road Transportation	0.02	0.03	80%	3%	1%	3%
1.A.3.c	Railways	0.00	0.00	-88%	-13%	<1%	<1%
1.A.3.d	Navigation	0.00	0.00	-16%	-23%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	162%	-7%	<1%	<1%
1.A.4	Other Sectors	0.40	0.29	-28%	-9%	23%	26%
1.A.4.a	Commercial/Institutional	0.06	0.02	-67%	-12%	3%	2%
1.A.4.b	Residential	0.31	0.22	-29%	-9%	18%	20%
1.A.4.c	Agriculture/Forestry/Fisheries	0.03	0.05	52%	-9%	2%	4%
1.A.5	Other	0.00	0.00	45%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	0.63	0.29	-55%	-13%	36%	25%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.00	0.00	-47%	-16%	<1%	<1%
2.C	METAL PRODUCTION	0.54	0.21	-60%	-16%	31%	19%
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	-23%	-4%	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	-81%	-2%	<1%	<1%
5	WASTE	0.06	0.00	-97%	-13%	3%	<1%
	Total without sinks	**1.75**	**1.13**	**-35%**	**-4%**		

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 55 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 2018 of 64% and 31%, 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 0.03% (*Agriculture*), 0.01% (*1.B*) and 4.1% (*Waste*), respectively.

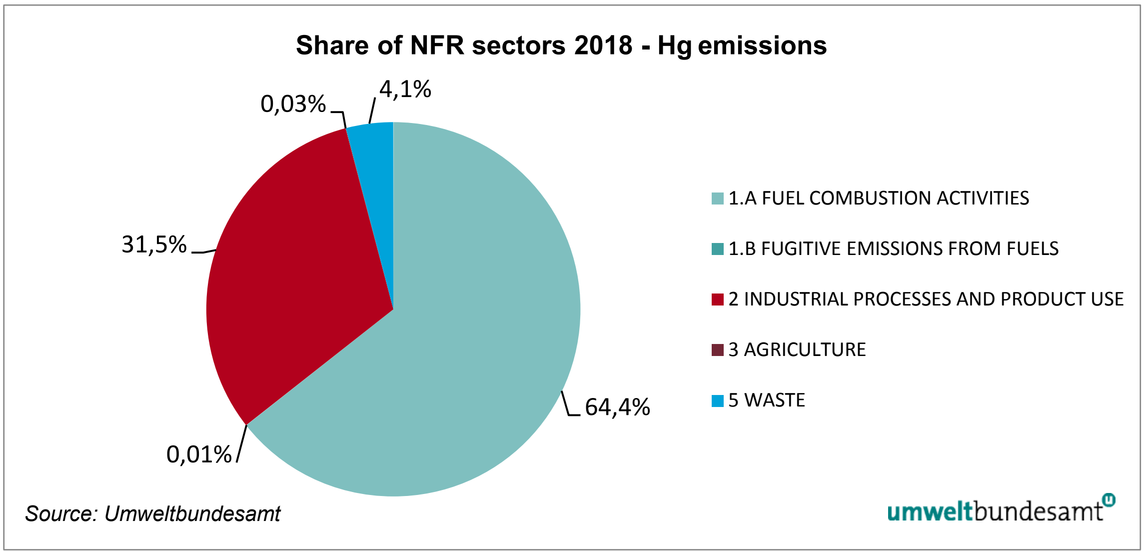


Figure 24: Share of NFR sectors 2018 in Hg emissions.

In 1990 national total Hg emissions amounted to 2.2 t; since then emissions have decreased. In the year 2018 national total Hg emissions were 56% below the level of 1990 (see Table 54). Between 2017 and 2018 emissions decreased by 7.0% mainly because of reduced emissions from NFR *2.C.1 Iron and Steel Production.*

The overall reduction of about 56% for the period 1990 to 2018 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. 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 14% 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 2018. 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.

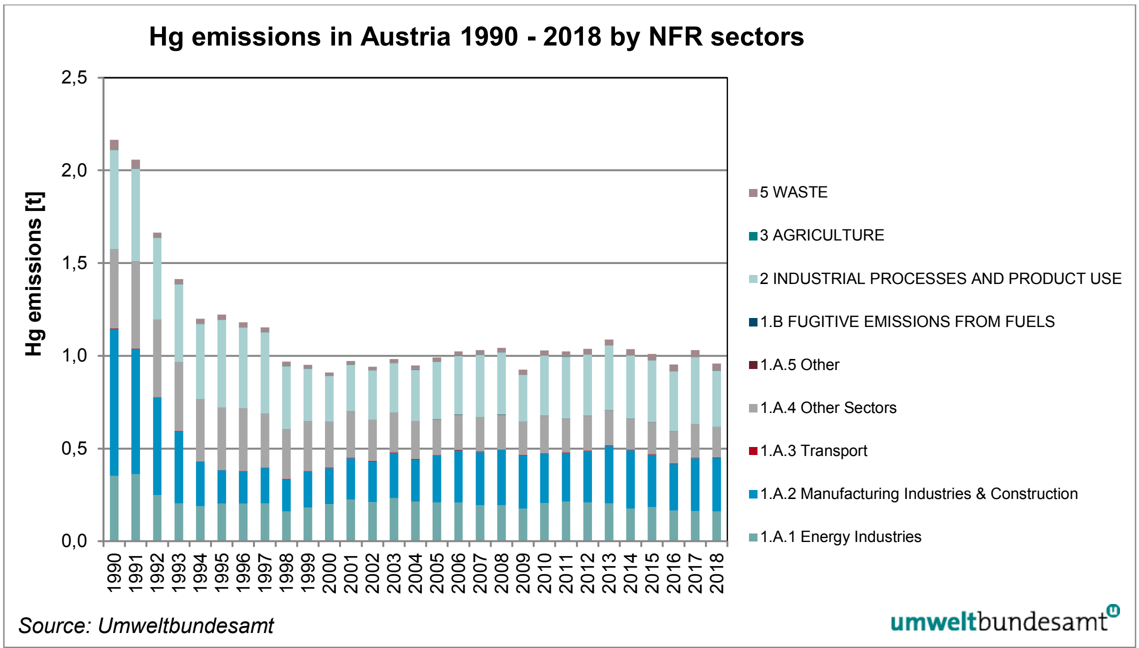


Figure 25: Hg emissions in Austria 1990–2018 by sectors in absolute terms.

Table 56: Hg emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		Hg Emission in [t]		Trend		Share in National Total	
		1990	2018	1990–2018	2017–2018	1990	2018
1	ENERGY	1.57	0.62	-61%	-2%	73%	64%
1.A	FUEL COMBUSTION ACTIVITIES	1.57	0.62	-61%	-2%	73%	64%
1.A.1	Energy Industries	0.35	0.16	-54%	-1%	16%	17%
1.A.1.a	Public Electricity and Heat Production	0.34	0.14	-59%	-2%	16%	15%
1.A.1.b	Petroleum refining	0.01	0.02	143%	7%	<1%	2%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-53%	-8%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	0.79	0.29	-63%	1%	37%	30%
1.A.2.a	Iron and Steel	0.00	0.00	-38%	-2%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	-41%	-25%	<1%	<1%
1.A.2.c	Chemicals	0.01	0.01	-22%	-18%	1%	1%
1.A.2.d	Pulp, Paper and Print	0.07	0.08	23%	12%	3%	9%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.00	-32%	9%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.70	0.17	-76%	-1%	32%	17%
1.A.2.g	Manufacturing Industries and Constr. - other	0.01	0.03	221%	-6%	<1%	3%
1.A.3	Transport	0.00	0.00	38%	-2%	<1%	<1%
1.A.3.a	Civil Aviation	0.00	0.00	235%	9%	<1%	<1%
1.A.3.b	Road Transportation	0.00	0.00	77%	1%	<1%	<1%
1.A.3.c	Railways	0.00	0.00	-92%	-8%	<1%	<1%
1.A.3.d	Navigation	0.00	0.00	-16%	-23%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	162%	-7%	<1%	<1%
1.A.4	Other Sectors	0.43	0.16	-62%	-9%	20%	17%
1.A.4.a	Commercial/Institutional	0.02	0.01	-69%	-9%	1%	1%
1.A.4.b	Residential	0.39	0.14	-63%	-9%	18%	15%
1.A.4.c	Agriculture/Forestry/Fisheries	0.01	0.01	-2%	-9%	1%	1%
1.A.5	Other	0.00	0.00	45%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	0.00	NA	164%	NA	<1%
2	INDUSTRIAL PROCESSES AND PRODUCT USE	0.53	0.30	-43%	-16%	25%	31%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.27	0.00	-100%	-16%	12%	<1%
2.C	METAL PRODUCTION	0.26	0.30	14%	-16%	12%	31%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	NA	NA	NA	NA	NA	NA
2.G	Other product manufacture and use	0.00	0.00	-32%	-10%	<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	-80%	-2%	<1%	<1%
5	WASTE	0.05	0.04	-28%	3%	3%	4%
	Total without sinks	**2.17**	**0.96**	**-56%**	**-7%**		

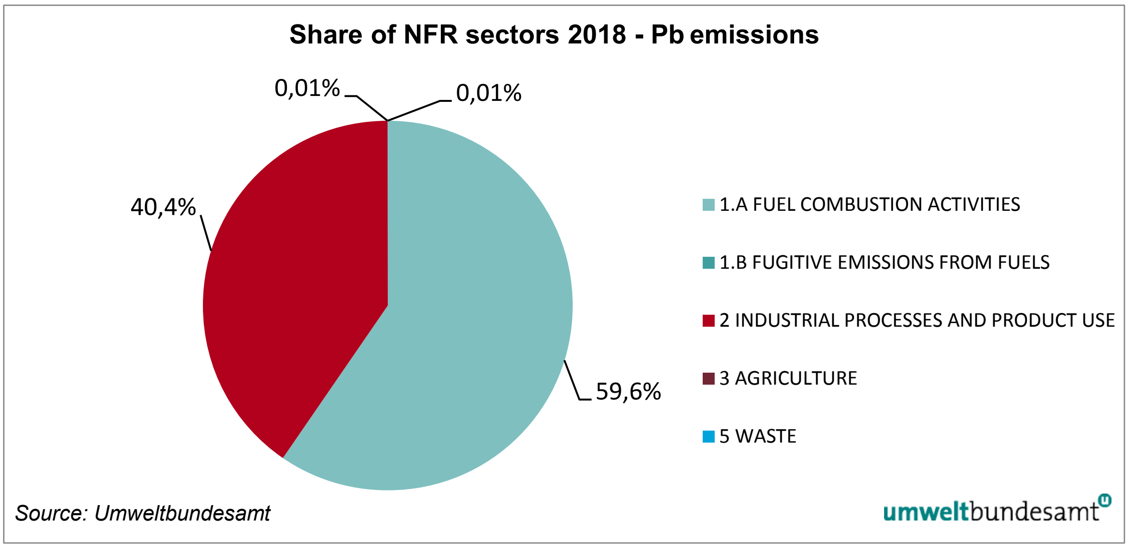
2.3.3 Lead (Pb) Emissions

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 60% and 40%, 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 2018 in Pb emissions.

In 1990 national total Pb emissions amounted to 232 t; emissions have decreased sharply until 1995 mainly due to enforced laws, while since the mid 90ies emissions remained quite stable. In the year 2018 emissions were 92% lower than in 1990 and amounted to 19 t. Compared to the previous year Pb emissions show a decrease of 6.2% as a result of reduced emissions from *Iron and Steel Production* (*2.C.1*).

1.A Fuel Combustion Activities

- *NFR 1.A.2 Manufacturing Industries and Construction and NFR 1.A.4 Other Sectors*: Pb emissions have decreased steadily 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 2018 emissions decreased steadily 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 2018 (-81%) 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.

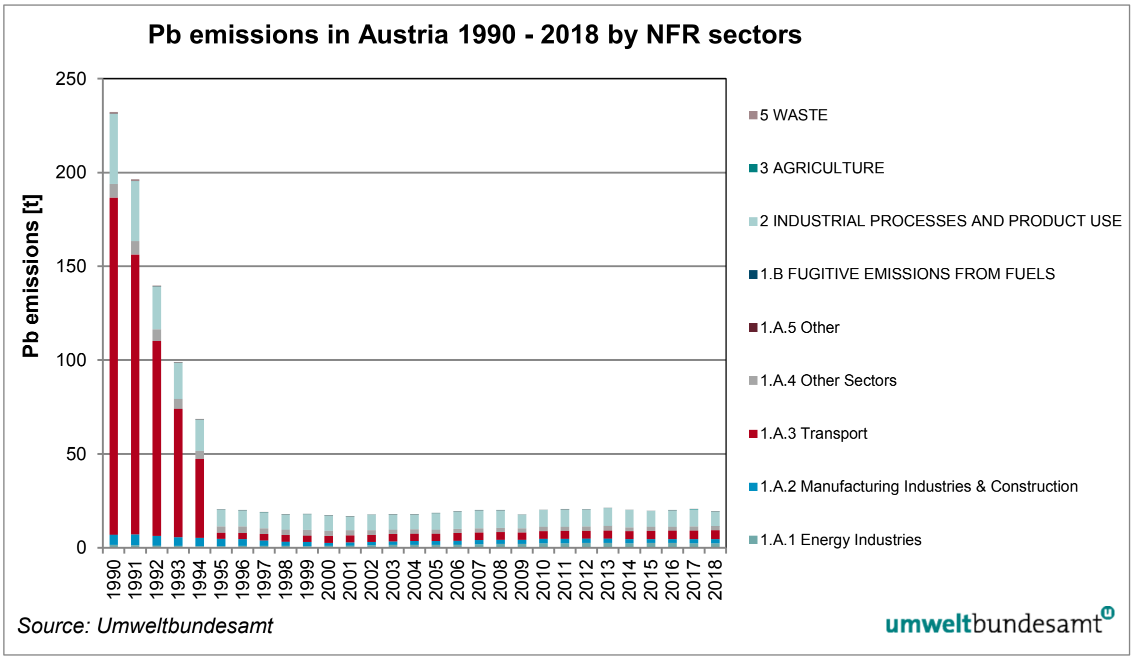


Figure 27: Pb emissions in Austria 1990–2018 by sectors in absolute terms.

Table 57: Pb emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		Pb Emission in [t]		Trend		Share in National Total	
		1990	**2018**	**1990–2018**	**2017–2018**	**1990**	**2018**
1	ENERGY	193.98	11.47	-94%	<1%	83%	60%
1.A	FUEL COMBUSTION ACTIVITIES	193.98	11.47	-94%	<1%	83%	60%
1.A.1	Energy Industries	1.47	2.38	62%	-2%	1%	12%
1.A.1.a	Public Electricity and Heat Production	1.27	1.91	50%	-4%	1%	10%
1.A.1.b	Petroleum refining	0.19	0.47	143%	7%	<1%	2%
1.A.1.c	Manufacture of Solid fuels & Other Energy Ind.	0.00	0.00	-53%	-8%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	5.59	2.25	-60%	4%	2%	12%
1.A.2.a	Iron and Steel	0.26	0.15	-42%	5%	<1%	1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	20%	-10%	<1%	<1%
1.A.2.c	Chemicals	0.21	0.27	29%	-9%	<1%	1%
1.A.2.d	Pulp, Paper and Print	0.65	0.98	51%	15%	<1%	5%
1.A.2.e	Food Processing, Beverages and Tobacco	0.01	0.01	66%	30%	<1%	<1%
1.A.2.f	Non-metallic Minerals	4.27	0.30	-93%	-1%	2%	2%
1.A.2.g	Manufacturing Industries and Constr. - other	0.20	0.54	169%	-6%	<1%	3%
1.A.3	Transport	179.54	4.81	-97%	4%	77%	25%
1.A.3.a	Civil Aviation	1.64	0.00	-100%	<1%	1%	<1%
1.A.3.b	Road Transportation	177.64	4.81	-97%	4%	76%	25%
1.A.3.c	Railways	0.01	0.00	-93%	-6%	<1%	<1%
1.A.3.d	Navigation	0.25	0.00	-100%	-17%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	162%	-7%	<1%	<1%
1.A.4	Other Sectors	7.38	2.04	-72%	-9%	3%	11%
1.A.4.a	Commercial/Institutional	0.36	0.14	-62%	-12%	<1%	1%
1.A.4.b	Residential	6.01	1.75	-71%	-9%	3%	9%
1.A.4.c	Agriculture/Forestry/Fisheries	1.01	0.16	-85%	-9%	<1%	1%
1.A.5	Other	0.00	0.00	45%	1%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	37.41	7.78	-79%	-14%	16%	40%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	0.00	0.00	-47%	-16%	<1%	<1%
2.C	METAL PRODUCTION	36.17	6.93	-81%	-15%	16%	36%
2.D	NON ENERGY PRODUCTS/ SOLVENTS	0.02	0.02	<1%	<1%	<1%	<1%
2.G	Other product manufacture and use	1.22	0.83	-32%	-10%	1%	4%
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	-34%	<1%	<1%	<1%
5	WASTE	1.02	0.00	-100%	-6%	<1%	<1%
	Total without sinks	**232.41**	**19.26**	**-92%**	**-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[71]. PCB emissions are reported from submission 2016 onwards.

Emissions of all POPs decreased remarkably from 1990 to 2018 (HCB -58%, PAH -64%, PCDD/F -73% and PCBs -32%), 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 2018 PCB emissions decreased by 16% compared to the previous year 2017, due to reduced emissions from *sector 2.C.1 Iron and Steel Production*.

PCDD/F emissions decreased by 7.5% compared to the previous year 2017, PAH emissions decreased by 8.1% and HCB emissions by 9.6% in the same time. These reductions are mainly due to the warm weather and thus reduced emissions from residential heating (decreased biomass consumption) as well as due to a decrease of iron and steel production (*2.C.1*) (relevant for HCB and PCDD/F). Dioxin/furan emissions from sector *Waste* (*5.E Other Waste)* also decreased remarkably from 2017 to 2018.

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.

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

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 stopped in 2001.

Table 58: Emissions and emission trends for POPs 1990–2018.

Year	Emission			
	PAH [t]	PCDD/F [g]	HCB [kg]	PCB [kg]
1990	19.03	125.17	85.50	47.23
1991	19.77	124.81	86.39	35.89
1992	14.59	76.55	76.24	28.87
1993	11.75	66.63	71.19	29.16
1994	10.55	56.35	58.03	26.91
1995	10.79	57.66	58.34	29.16
1996	11.29	57.89	58.94	26.37
1997	10.14	58.17	55.99	29.95
1998	9.48	54.95	51.72	30.20
1999	9.25	51.63	49.47	28.76
2000	8.54	50.41	43.33	30.18
2001	8.68	50.68	44.17	30.64
2002	7.82	37.66	40.55	31.46

[71] Austria´s submission 2014 under the Convention on Long-range Transboundary Air Pollution covering the years 1980–2012: http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2014_submissions/

Year	Emission			
	PAH [t]	**PCDD/F [g]**	**HCB [kg]**	**PCB [kg]**
2003	7.45	36.91	39.24	31.71
2004	7.23	36.12	37.72	32.54
2005	7.24	35.77	37.74	34.93
2006	7.47	37.10	38.35	35.24
2007	7.45	36.85	37.73	36.48
2008	7.44	36.47	38.07	36.40
2009	7.33	36.32	37.41	27.54
2010	8.07	41.00	42.87	34.55
2011	7.42	38.18	39.41	35.30
2012	7.69	39.04	64.49	34.83
2013	7.87	39.74	143.67	37.16
2014	7.02	36.66	144.49	36.64
2015	7.29	37.70	37.27	35.69
2016	7.35	37.25	38.09	34.72
2017	7.39	37.18	39.40	38.22
2018	6.80	34.41	35.63	32.09
Trend 1990–2018	**-64%**	**-73%**	**-58%**	**-32%**

2.4.1 Polycyclic Aromatic Hydrocarbons (PAH) Emissions

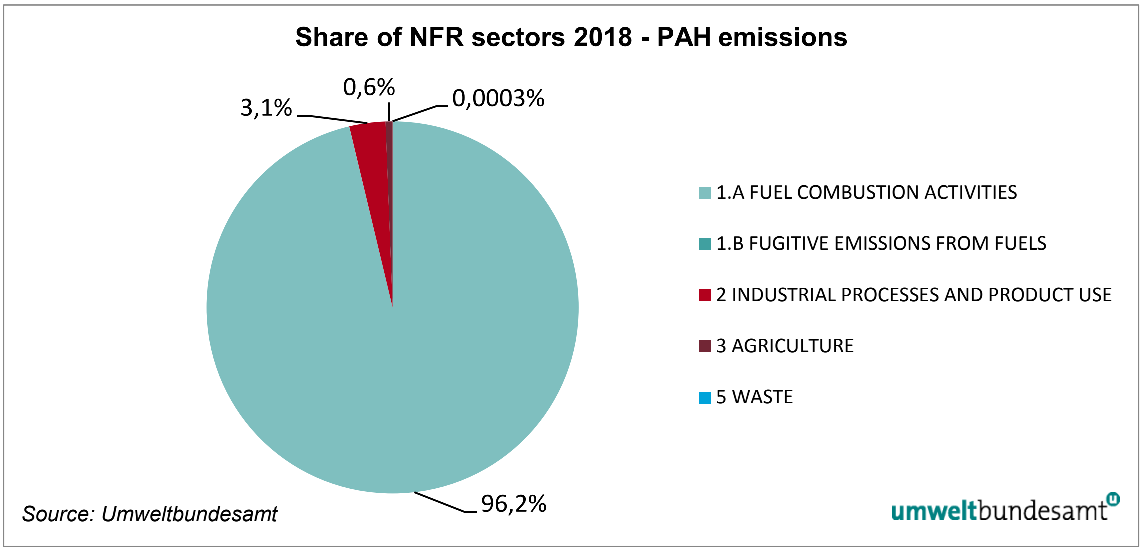
The polycyclic aromatic hydrocarbons (PAH) are molecules built up of benzene rings which resemble fragments of single layers of graphite. PAHs are a group of approximately 100 compounds. Most PAHs in the environment arise from incomplete burning of carbon-containing materials like oil, wood, garbage 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)pyren, benzo(b)fluoranthen, benzo(k)fluoranthen and indeno(1,2,3-cd)pyren are used as indicators for the purposes of emission inventories, which has been specified in the UNECE POPs Protocol mentioned above.

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* (38%). In 2018 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 2018 with 3.1% of national total emissions.

From 1990 to 2018 PAH emissions from Agriculture decreased remarkably by 49% due to prohibition of open field burning. In 2018 NFR sectors *3 Agriculture* (0.6%) and *5 Waste* (<0.1%) are minor sources.



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

Figure 28: Share of NFR sectors 2018 in PAH emissions.

In 1990 national total PAH emissions amounted to 19.0 t; emissions have decreased since then, where the main achievement was made until 1993, by the year 2018 emissions were reduced by about 64% (to 6.8 t in 2018).

1.A Fuel Combustion Activities

In 2018 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 54% because of a decreased use of coal and an increased share of efficient biomass boilers with lower specific emissions. Compared to the previous year 2017 emissions decreased by 8.8% due to the warm weather.
- *1.A.4.c Agriculture/Forestry/Fisheries (stationary):* Compared to 1990 emissions have increased by 81% as a result of a higher biomass consumption. Between 2017 and 2018 emissions decreased by 8.3%, that was also due to the warm weather.
- *1.A.3 Transport:* Emissions have increased by 17% 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.

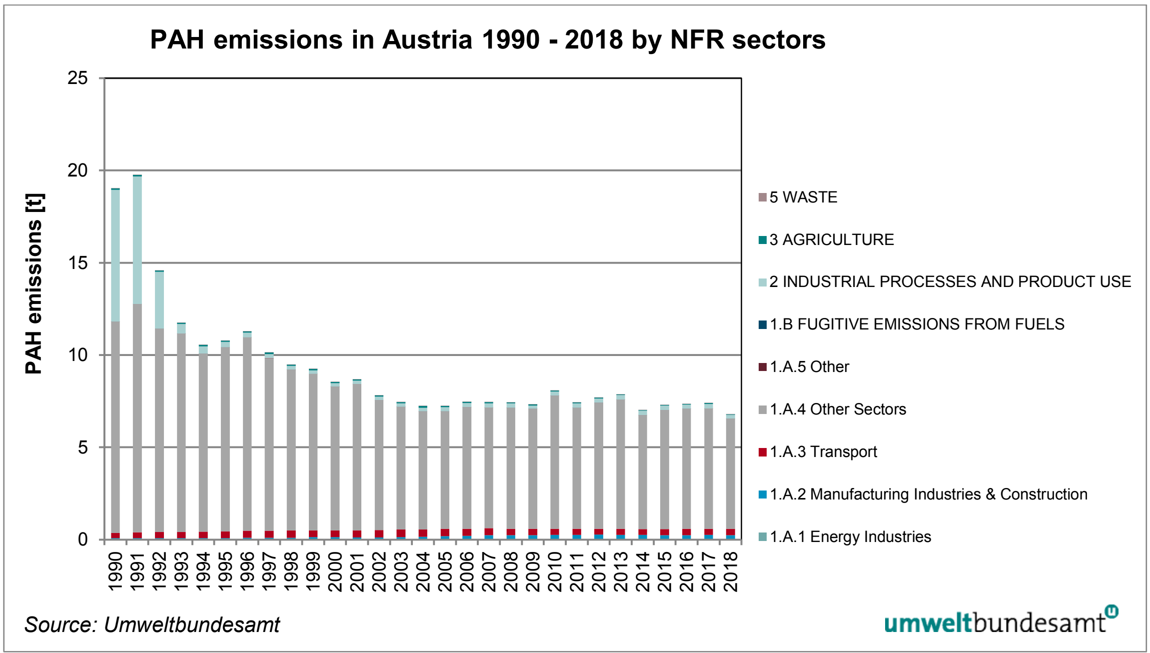


Figure 29: PAH emissions in Austria 1990–2018 by sectors in absolute terms.

Table 59: PAH emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		PAH Emission in [t]		Trend		Share in National Total	
		1990	2018	1990–2018	2017–2018	1990	2018
1	ENERGY	11.81	6.54	-45%	-8%	62%	96%
1.A	FUEL COMBUSTION ACTIVITIES	11.81	6.54	-45%	-8%	62%	96%
1.A.1	Energy Industries	0.01	0.03	389%	-4%	<1%	<1%
1.A.2	Manufacturing Industries and Construction	0.06	0.22	237%	<1%	<1%	3%
1.A.2.a	Iron and Steel	0.00	0.00	-34%	<1%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	-24%	<1%	<1%	<1%
1.A.2.c	Chemicals	0.02	0.02	17%	-13%	<1%	<1%
1.A.2.d	Pulp, Paper and Print	0.00	0.00	25%	5%	<1%	<1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.00	-14%	15%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.00	0.01	122%	3%	<1%	<1%
1.A.2.g	Manufacturing Industries and Constr. - other	0.04	0.18	389%	1%	<1%	3%
1.A.3	Transport	0.29	0.34	17%	<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	23%	1%	1%	5%
1.A.3.c	Railways	0.02	0.01	-58%	-20%	<1%	<1%
1.A.3.d	Navigation	0.01	0.00	-15%	-24%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	162%	-7%	<1%	<1%
1.A.4	Other Sectors	11.45	5.96	-48%	-9%	60%	88%
1.A.4.a	Commercial/Institutional	0.30	0.08	-73%	-2%	2%	1%
1.A.4.b	Residential	10.62	4.93	-54%	-9%	56%	72%
1.A.4.c	Agriculture/Forestry/Fisheries	0.53	0.95	81%	-8%	3%	14%
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	0.21	-97%	-14%	38%	3%
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	0.17	-97%	-16%	34%	3%
2.C.1	Iron and Steel Production	0.35	0.17	-50%	-16%	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	-22%	-4%	<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	-49%	-1%	<1%	1%
5	WASTE	0.00	0.00	-92%	3%	<1%	<1%
	Total without sinks	**19.03**	**6.80**	**-64%**	**-8%**		

2.4.1.1 Benzo(a)pyrene , Benzo(b)floranthene, Benzo(k)fluoranthene, Indeno (1,2,3-cd) pyrene

In the NFR Tables of submission 2020 Austria reports Total 1-4 PAH emissions for all relevant source categories and all years. However, the estimation of emissions by PAH species is work in progress. For some source categories PAH emissions are already calculated on the level of different PAH species including a methodological description in the IIR. Austria will report emissions of 4 PAH species separately in its next inventory submission for all relevant source categories and all years.

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.

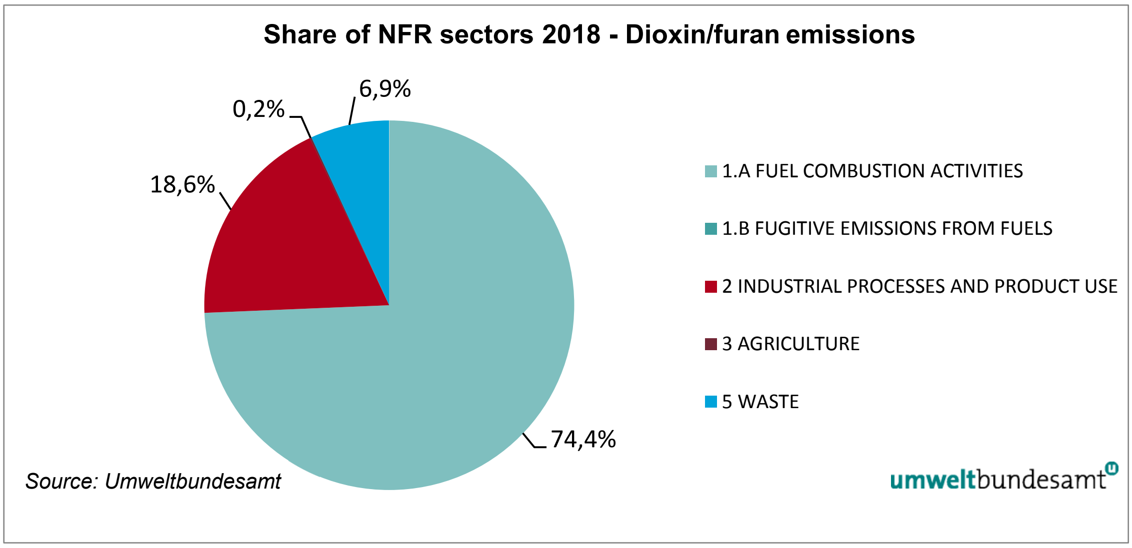
Dioxins are formed as a result of combustion processes such as commercial or municipal waste incineration and from burning fuels like wood, coal or oil as a main source of dioxins. Dioxins can also be formed when household trash is burned and as a result of natural processes such as forest fires. Dioxins 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 74% in 2018, is category *1.A Fuel Combustion Activities* (see Figure 30 and Table 60). Sector *2 Industrial Processes and Product Use* contributes with 19% in national total emissions.

In 2018 PCDD/F emissions from sectors *3 Agriculture* and *5 Waste* are minor sources. Agriculture has a share of 0.2% in national total emissions (*3.F Field burning of agricultural residues* is the only source). NFR sector *5 Waste* contributes with 6.9% in 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 30: Share of NFR sectors 2018 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 2018 emissions were reduced by about 73% (to 34 g in 2018).

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 2018 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 11% to national dioxin/furan (PCDD/F) emissions in 2018.

2 Industrial Processes and Product Use

The second largest source is sector *2 Industrial Processes and Product Use* (19% in national total emissions in 2018).

- *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 2018 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 2018 dioxin/furan emissions decreased to 2.37 g, which is a share of 6.9% 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 2018.

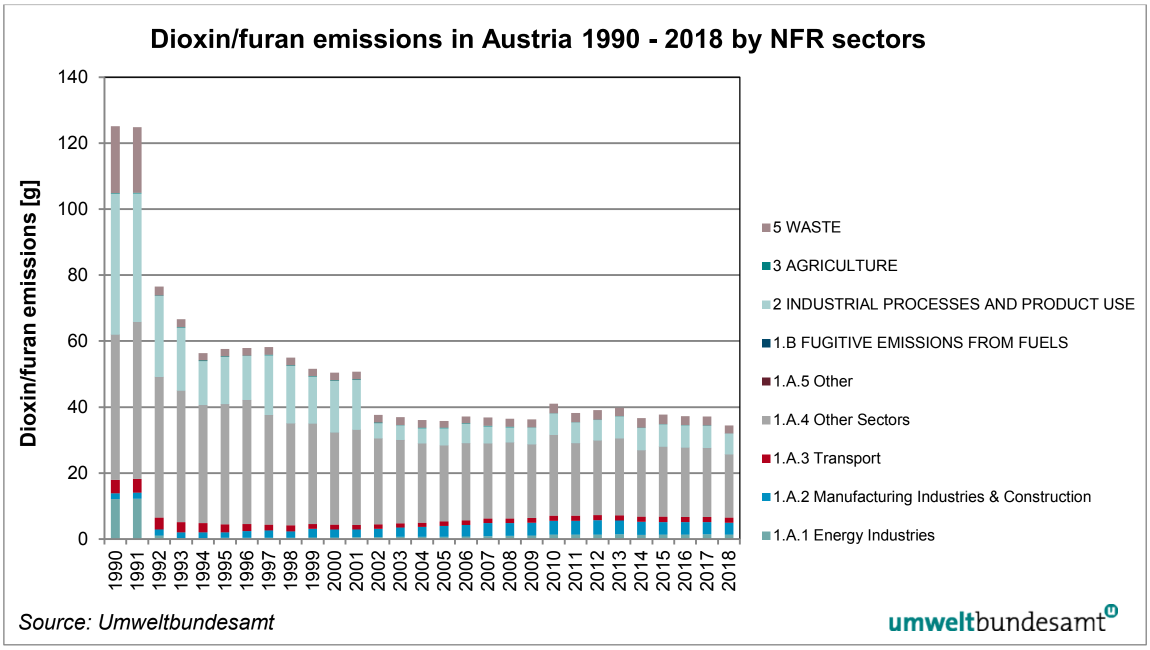


Figure 31: Dioxin/Furan emissions in Austria 1990–2018 by sectors in absolute terms.

Table 60: Dioxin/Furan (PCDD/F) emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		Dioxin Emission in [g]		Trend		Share in National Total	
		1990	**2018**	**1990–2018**	**2017–2018**	**1990**	**2018**
1	ENERGY	61.85	25.58	-59%	-7%	49%	74%
1.A	FUEL COMBUSTION ACTIVITIES	61.85	25.58	-59%	-7%	49%	74%
1.A.1	Energy Industries	12.14	1.34	-89%	-5%	10%	4%
1.A.2	Manufacturing Industries and Construction	1.68	3.62	116%	-3%	1%	11%
1.A.2.a	Iron and Steel	0.03	0.03	-24%	3%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.02	0.04	87%	1%	<1%	<1%
1.A.2.c	Chemicals	0.44	0.52	19%	-12%	<1%	2%
1.A.2.d	Pulp, Paper and Print	0.50	0.62	25%	5%	<1%	2%
1.A.2.e	Food Processing, Beverages and Tobacco	0.03	0.04	52%	14%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.29	0.48	63%	3%	<1%	1%
1.A.2.g	Manufacturing Industries and Constr. - other	0.37	1.90	413%	-5%	<1%	6%
1.A.3	Transport	4.16	1.57	-62%	<1%	3%	5%
1.A.3.a	Civil Aviation	NE	NE	NE	NE	NE	NE
1.A.3.b	Road Transportation	4.11	1.55	-62%	<1%	3%	4%
1.A.3.c	Railways	0.04	0.01	-71%	-18%	<1%	<1%
1.A.3.d	Navigation	0.01	0.01	-18%	-14%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	162%	-7%	<1%	<1%
1.A.4	Other Sectors	43.87	19.05	-57%	-9%	35%	55%
1.A.4.a	Commercial/Institutional	1.74	0.51	-71%	-9%	1%	1%
1.A.4.b	Residential	40.59	17.18	-58%	-8%	32%	50%
1.A.4.c	Agriculture/Forestry/Fisheries	1.53	1.36	-11%	-10%	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	6.40	-85%	-6%	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	6.27	-84%	-6%	32%	18%
2.C.1	Iron and Steel Production	37.21	2.50	-93%	-13%	30%	7%
2.C.2	Ferroalloys Production	NE	NE	NE	NE	NE	NE
2.C.3	Aluminium production	2.40	3.30	37%	<1%	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	-22%	-4%	<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	-70%	-6%	<1%	<1%
5	WASTE	20.29	2.37	-88%	-15%	16%	7%
	Total without sinks	**125.17**	**34.41**	**-73%**	**-7%**		

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.

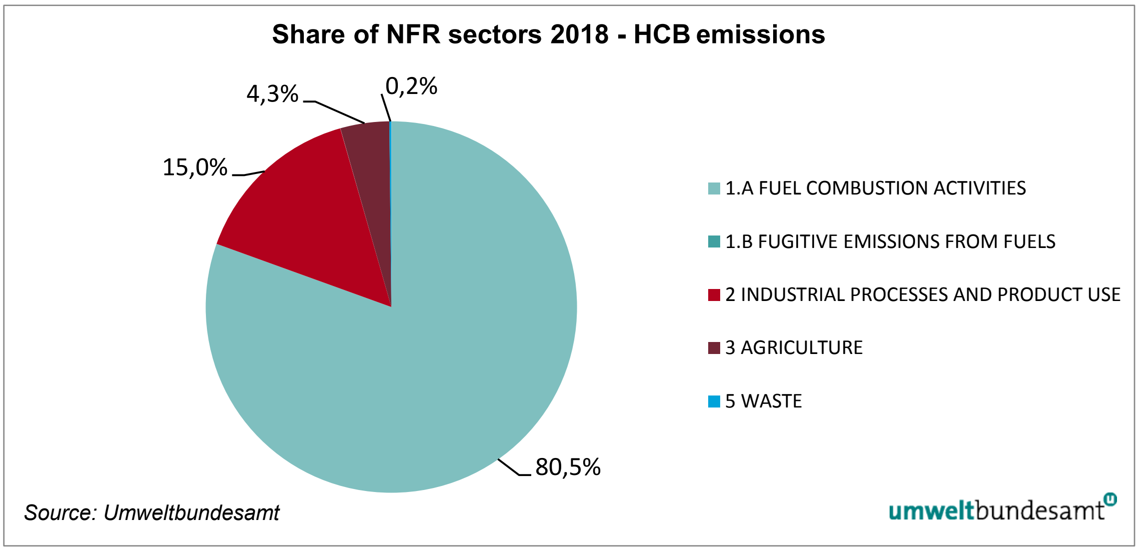
As there is no more hexachlorobenzene production in the EU, the only man-made releases of hexachlorobenzene are as unintentional by-product; it is emitted from the same chemical and thermal processes as Dioxins/Furans (PCDD/F) and formed via a similar mechanism.

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 32 and Table 61 the main HCB emission source in 2018 is NFR sector *1.A Fuel Combustion Activities* with 81% in national total emissions. Sector *2 Industrial Processes and Product Use* has a share of 15% in national total emissions.

From 1990 to 2018 HCB emissions from the sectors NFR *3 Agriculture* as well as NFR *5 Waste* decreased remarkably by 85% and 84%, respectively, due to stringent legislation and modern technology. Both sectors are minor sources of HCB emissions in 2018 with shares of 4.3% (*Agriculture)* and 0.2% (*Waste*) in national total emissions.



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

Figure 32: Share of NFR sectors 2018 in HCB emissions.

Total emissions of HCB are decreasing over the period 1990–2018 by 58%. 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 by 74% can therefore be explained as emissions in 2015 were at the usual level again. Between 2017 and 2018 HCB emissions decreased by 9.6% mainly due to reduced emissions from residential heating (decreased biomass consumption).

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 48% since 1990.

- *1.A.4 Other Sectors:* This subcategory had a share of 63% in 1990 and 77% in 2018 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 49%. Compared to the previous year a decrease of 9.1% can be observed 2018, due to the reduced biomass use as a consequence of lower demand for space heating.

2 Industrial Processes and Product Use

The second largest source for HCB emissions in 2018 was sector *2 Industrial Processes and Product Use* (mainly Iron and Steel Production) with a share of 15% in national total emissions. HCB emissions of this sector decreased by 73% between 1990 and 2018. This reduction could be mainly achieved with abatement measures in iron and steel industry. HCB was also a byproduct of chlorinated pesticides, which production was banned step-by-step in the beginning of the 1990s.

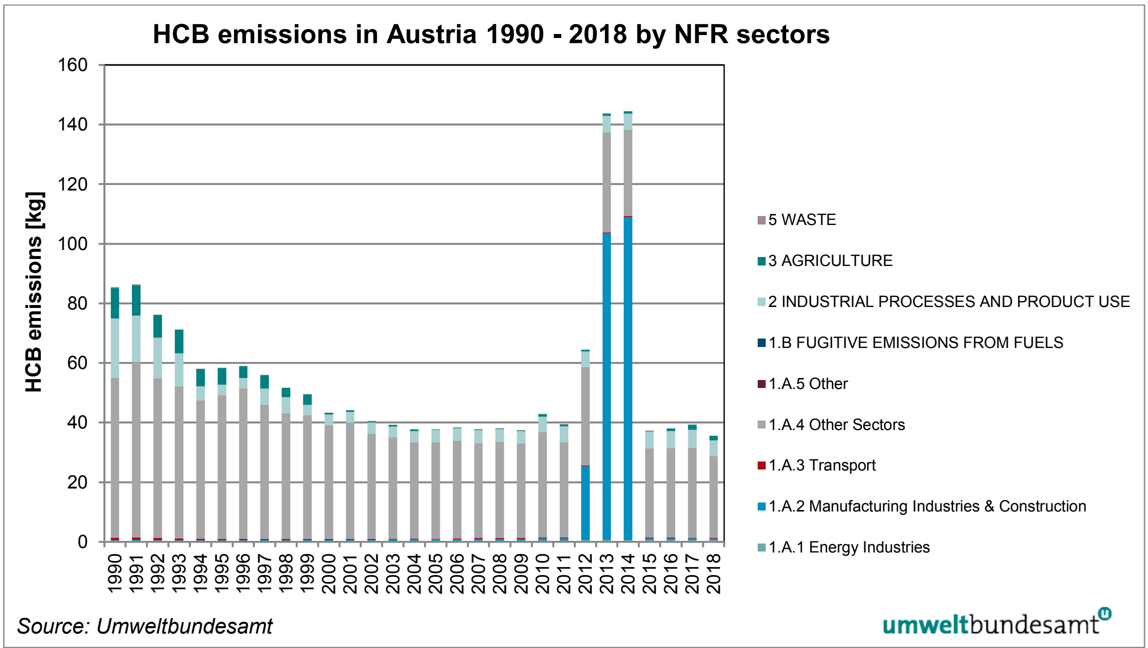


Figure 33: HCB emissions in Austria 1990–2018 by sectors in absolute terms.

Table 61: Hexachlorbenzene (HCB) emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		HCB Emission in [kg]		Trend		Share in National Total	
		1990	2018	1990–2018	2017–2018	1990	2018
1	ENERGY	54.89	28.69	-48%	-9%	64%	81%
1.A	FUEL COMBUSTION ACTIVITIES	54.89	28.69	-48%	-9%	64%	81%
1.A.1	Energy Industries	0.28	0.49	78%	-4%	<1%	1%
1.A.2	Manufacturing Industries and Construction	0.29	0.60	106%	-3%	<1%	2%
1.A.2.a	Iron and Steel	0.01	0.00	-30%	4%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.00	0.00	-48%	6%	<1%	<1%
1.A.2.c	Chemicals	0.07	0.08	19%	-10%	<1%	<1%
1.A.2.d	Pulp, Paper and Print	0.10	0.12	25%	5%	<1%	<1%
1.A.2.e	Food Processing, Beverages and Tobacco	0.00	0.01	65%	18%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.06	0.08	44%	2%	<1%	<1%
1.A.2.g	Manufacturing Industries and Constr. - other	0.06	0.30	441%	-5%	<1%	1%
1.A.3	Transport	0.83	0.31	-62%	<1%	1%	1%
1.A.3.a	Civil Aviation	NE	NE	NE	NE	NE	NE
1.A.3.b	Road Transportation	0.82	0.31	-62%	<1%	1%	1%
1.A.3.c	Railways	0.01	0.00	-71%	-18%	<1%	<1%
1.A.3.d	Navigation	0.00	0.00	-18%	-14%	<1%	<1%
1.A.3.e	Other transportation	0.00	0.00	162%	-7%	<1%	<1%
1.A.4	Other Sectors	53.49	27.29	-49%	-9%	63%	77%
1.A.4.a	Commercial/Institutional	1.55	0.45	-71%	-8%	2%	1%
1.A.4.b	Residential	50.05	24.52	-51%	-9%	59%	69%
1.A.4.c	Agriculture/Forestry/Fisheries	1.89	2.32	23%	-9%	2%	7%
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	5.36	-73%	-12%	23%	15%
2.A	MINERAL PRODUCTS	IE	IE	IE	IE	IE	IE
2.B	CHEMICAL INDUSTRY	1.26	NA	NA	NA	1%	NA
2.C	METAL PRODUCTION	9.40	5.33	-43%	-12%	11%	15%
2.C.1	Iron and Steel Production	8.09	3.54	-56%	-17%	9%	10%
2.C.2	Ferroalloys Production	NE	NE	NE	NE	NE	NE
2.C.3	Aluminium production	1.20	1.65	37%	<1%	1%	5%
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	1.52	-85%	-16%	12%	4%
5	WASTE	0.39	0.06	-84%	4%	<1%	<1%

NFR Category	HCB Emission in [kg]		Trend		Share in National Total	
	1990	2018	1990–2018	2017–2018	1990	2018
Total without sinks	**85.50**	**35.63**	**-58%**	**-10%**		

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)[72].

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[73] 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).

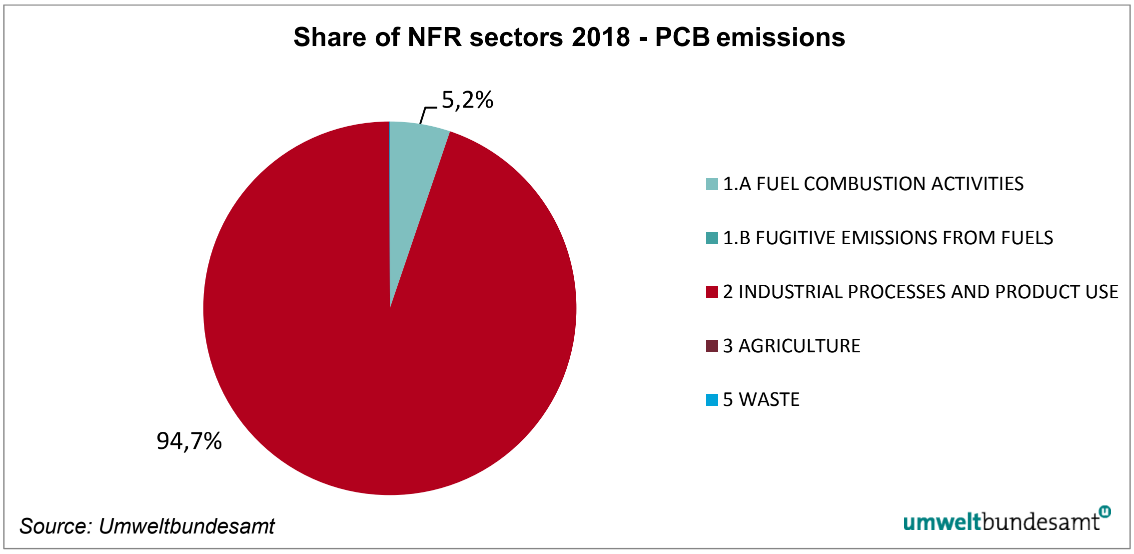
Main sources and emission trends in Austria

Austrian PCB emissions are almost exclusively emitted in NFR sector *2 Industrial Processes and Product Use* with a share of 95% in national total PCB emissions in 2018 (see Figure 34 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 5.2% in total emissions in 2018. PCB emissions from stationary combustion 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.

72 http://chm.pops.int/Implementation/PCBs/Overview/tabid/273/Default.aspx

73 http://chm.pops.int/default.aspx



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

Figure 34: Share of NFR sectors 2018 in PCB emissions.

In 1990 national total PCB emissions amounted to about 47 kg; emissions have decreased by 32% and in 2018 emissions were at the level of 32 kg. The emission trend is largely influenced by metal production. Between 2017 and 2018 emissions decreased by 16%, due to reduced 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 2018. Emissions from *2.C.5 Lead Production* and *2.C.7 Other Metal Production* are minor sources in 2018. 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 21%; the emissions generally follow the production activities but the decrease is also due to abatement technologies.

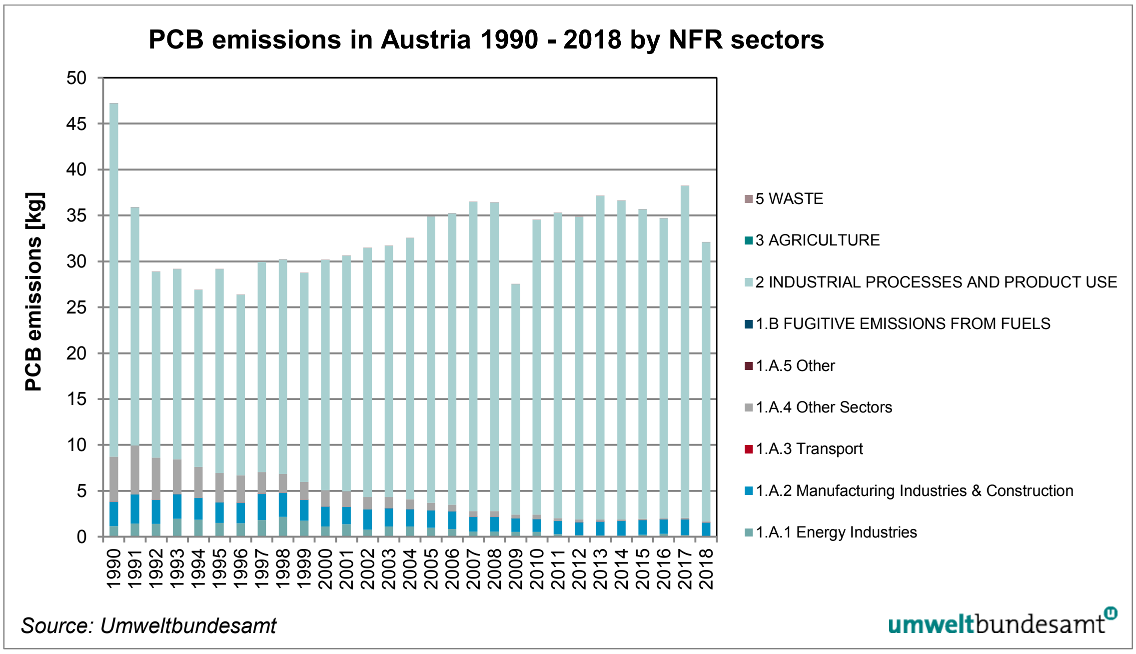


Figure 35: PCB emissions in Austria 1990–2018 by sectors in absolute terms.

Table 62: Polychlorinated biphenyl (PCB) emissions per NFR Category 1990 and 2018, trend 1990–2018 and share in total emissions.

NFR Category		PCB Emission in [kg]		Trend		Share in National Total	
		1990	2018	1990–2018	2017–2018	1990	2018
1	ENERGY	8.73	1.67	-81%	-18%	18%	5%
1.A	FUEL COMBUSTION ACTIVITIES	8.73	1.67	-81%	-18%	18%	5%
1.A.1	Energy Industries	1.16	0.05	-96%	-72%	2%	<1%
1.A.2	Manufacturing Industries and Construction	2.64	1.47	-44%	-13%	6%	5%
1.A.2.a	Iron and Steel	0.08	0.02	-75%	-7%	<1%	<1%
1.A.2.b	Non-ferrous Metals	0.04	0.02	-55%	-9%	<1%	<1%
1.A.2.c	Chemicals	0.21	0.24	14%	-40%	<1%	1%
1.A.2.d	Pulp, Paper and Print	1.49	0.72	-52%	-7%	3%	2%
1.A.2.e	Food Processing, Beverages and Tobacco	0.15	0.02	-85%	-23%	<1%	<1%
1.A.2.f	Non-metallic Minerals	0.48	0.45	-7%	5%	1%	1%
1.A.2.g	Manufacturing Industries and Constr. - other	0.19	0.01	-92%	-66%	<1%	<1%
1.A.3	Transport	0.00	0.00	-1%	-12%	<1%	<1%
1.A.4	Other Sectors	4.92	0.15	-97%	-11%	10%	<1%
1.A.4.a	Commercial/Institutional	0.30	0.00	-100%	-9%	1%	0%
1.A.4.b	Residential	4.53	0.14	-97%	-11%	10%	<1%
1.A.4.c	Agriculture/Forestry/Fisheries	0.09	0.00	-95%	-11%	<1%	<1%
1.A.5	Other	0.00	0.00	-69%	-21%	<1%	<1%
1.B	FUGITIVE EMISSIONS FROM FUELS	NA	NA	NA	NA	NA	NA
2	INDUSTRIAL PROCESSES AND PRODUCT USE	38.50	30.40	-21%	-16%	82%	95%
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	30.40	-21%	-16%	82%	95%
2.C.1	Iron and Steel Production	19.34	30.40	57%	-16%	41%	95%
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	281%	4%	<1%	<1%
	Total without sinks	**47.23**	**32.09**	**-32%**	**-16%**		

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 1990–2018 calculated on the basis of fuels used.

	Austria's Air Emissions not including 'fuel exports' [kt]			
	SO_2	NO_x	NMVOC	NH_3
1990	72.90	199.91	329.26	61.68
1991	69.66	201.55	317.68	62.40
1992	53.15	193.58	298.52	60.94
1993	51.64	185.07	280.44	61.96
1994	46.14	180.89	260.05	61.95
1995	45.85	180.09	244.98	63.06
1996	43.18	180.48	236.83	62.53
1997	39.97	180.78	223.70	62.86
1998	34.97	179.10	213.05	63.10
1999	33.27	179.21	203.49	62.04
2000	31.04	178.87	179.43	60.71
2001	31.81	181.89	172.54	60.64
2002	30.70	181.62	165.43	59.63
2003	30.43	186.13	161.23	59.52
2004	26.54	186.03	148.32	59.35
2005	25.90	189.41	152.63	59.24
2006	26.75	190.95	155.93	59.74
2007	23.41	187.28	151.77	61.05
2008	20.30	180.60	146.55	60.80

	Austria's Air Emissions not including 'fuel exports' [kt]			
	SO_2	**NO_x**	**NMVOC**	**NH_3**
2009	14.76	168.03	133.31	62.22
2010	16.00	168.18	133.44	62.19
2011	15.20	166.85	128.40	61.72
2012	14.83	162.72	126.10	62.04
2013	14.40	159.61	120.34	62.16
2014	14.51	155.79	113.64	62.94
2015	13.95	153.92	110.48	63.72
2016	13.28	150.00	108.85	64.52
2017	12.81	143.42	109.94	65.39
2018	11.73	135.74	106.55	64.38
Trend 90–18	**-83.9%**	**-32.1%**	**-67.6%**	**4.4%**

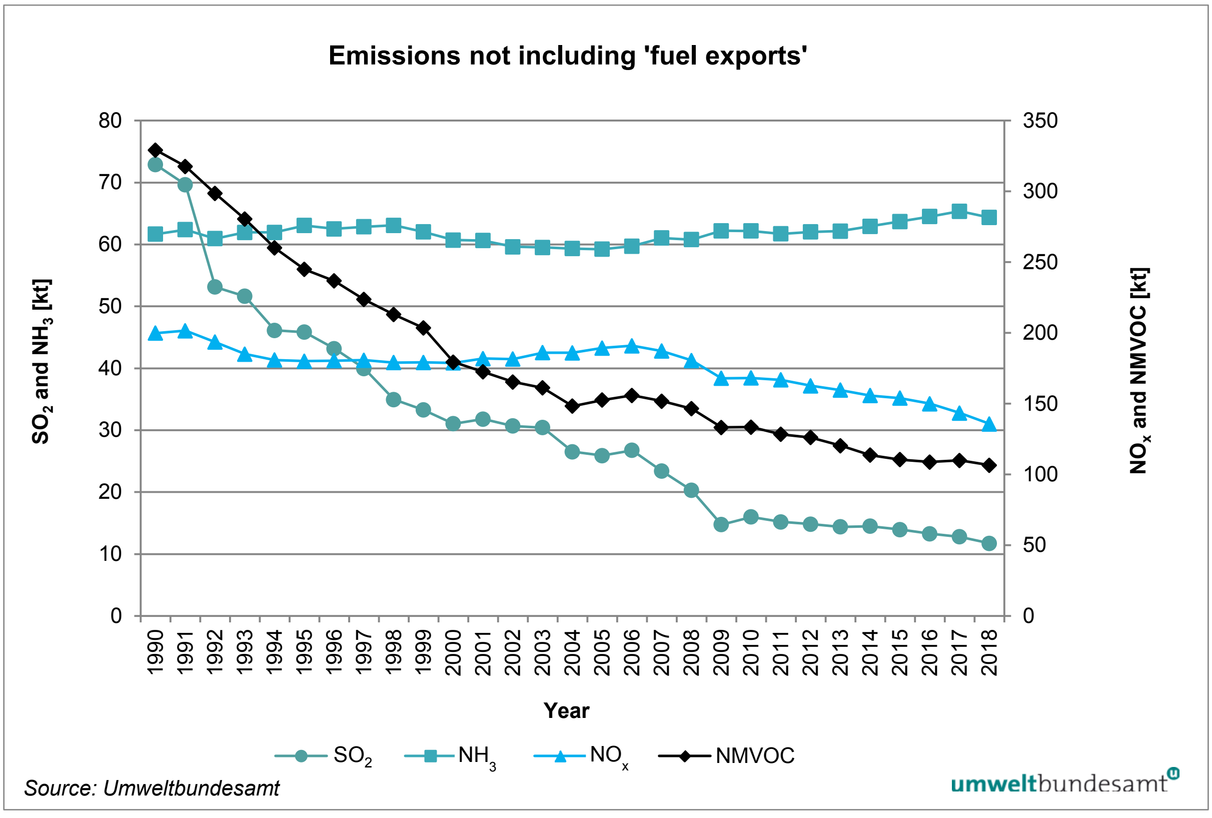


Figure 36: SO_2, NO_x, NMVOC and NH_3 emissions not including 'fuel exports.

SO_2 emissions

In 2018, SO_2 emissions amounted to 11.7 kt (not including 'fuel exports'). Since 1990 (72.9 kt), emissions have decreased continuously.

SO_2 emissions (not including 'fuel exports') have decreased since 1990 by 83.9%. 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 reduced coal consumption 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 2017 to 2018 SO_2 emissions (not including 'fuel exports') decreased by 1.1 kt (– 8.4%). This was mainly caused by reductions in emissions from iron and steel (*1.A.2.a*, – 0.62 kt).

NO_x emissions

In 1990, NO_x emissions without 'fuel exports' amounted to 199.9 kt, and in 2018 to 135.7 kt.

Since 1990, NO_x emissions (not including 'fuel exports') have decreased by 32.1%. 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 from 2008 to 2009.

From 2017 to 2018 the downward trend in NO_x emissions (not including 'fuel exports') continued with a decrease of 7.7 kt (– 5.4%). This was caused by the decline in road traffic, especially of passenger cars (1.A.3.b.1) (-2.1kt) and heavy duty vehicles (*1.A.3.b.3*) (-1.6kt). The main share of the national NO_x emissions originates from fuel combustion. Road transport accounted for the biggest share of Austria's total NO_x emissions in the year 2018 with a contribution of 48.3%, not including 'fuel exports'.

NMVOC emissions

NMVOC emissions without 'fuel exports' amounted to 329.3 kt in 1990, and to 106.6 kt in 2018. This represents a reduction of 67.6%. From 2017 to 2018 NMVOC emissions (not including 'fuel exports') decreased by 3.4 kt (– 3.1%).

Since 1990, the largest reductions were achieved in the road transport sector due to an increased use of catalytic converters and diesel cars. Currently the transport sector contributes only a small share of 5% of total NMVOC emissions.

Reductions in the solvent sector were achieved due to various regulations (Solvent Ordinance, Cogeneration Act, VOC Emissions Ordinance). In 2018, this sector accounted for around 28% of total NMVOC emissions. Compared to the previous year, emissions fell slightly by 1%.

The agriculture sector accounted for the largest share of NMVOC emissions at 34%. Here emissions fell by 1% compared with 2017.

Residential stationary heating accounts for 21% of the total and has declined by 8% compared to 2017, mainly due to the warm weather.

In particular, outdated mixed-fuel wood boilers continue to be the main reason for the relatively high emissions.

NH_3 emissions

NH_3 emissions without 'fuel exports' amounted to 61.7 kt in 1990, and to 64.4 kt in 2018.

Since 1990, NH_3 emissions (not including 'fuel exports') have increased by 4.4%. Austria's NH_3 emissions arise almost entirely from the agriculture sector (93.8%). There have been only slight changes in the emissions since 1990. The slight increase in NH_3 emissions (in spite of a decrease in the number of cattle) can be explained by an increase in loose housing systems (to ensure animal welfare and according to EU law) and an increase of high-capacity dairy cows. Additionally, there has been an increase in the use of urea as nitrogen fertiliser (a cost-efficient but otherwise less efficient fertiliser).

From 2017 to 2018 NH_3 emissions (not including 'fuel exports') decreased by 1.0 kt (– 1.5%). The main reason is the lower amount of mineral fertilizer, in particular urea, which was applied on agricultural soils. Furthermore, the livestock numbers of cattle (dairy cows and other cattle) and swine were falling. However, the decrease of dairy cows was compensated with the rising milk yield.

Emissions from 'fuel export'

In the year 2004, a study[74] 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[75].

The following Table 64 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	0.80	17.31	4.75	0.05
1991	1.06	25.19	10.63	0.17
1992	1.04	21.73	6.18	0.13
1993	1.18	21.70	4.23	0.11
1994	1.05	17.68	2.17	0.06
1995	0.96	17.79	1.60	0.05
1996	0.75	35.20	0.37	-0.08
1997	0.43	21.12	-0.69	-0.13
1998	0.66	34.58	1.53	0.02
1999	0.47	26.22	0.00	-0.13
2000	0.53	32.23	0.36	-0.13
2001	0.64	39.92	1.55	0.02
2002	0.69	48.07	3.52	0.35
2003	0.74	54.77	4.51	0.55
2004	0.06	54.56	4.51	0.60
2005	0.05	56.74	4.49	0.63

[74] 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.

[75] 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**
2006	0.04	45.13	3.33	0.59
2007	0.04	41.28	3.04	0.60
2008	0.03	34.52	2.38	0.51
2009	0.03	33.06	2.21	0.51
2010	0.04	33.97	1.97	0.49
2011	0.03	27.17	1.52	0.41
2012	0.03	26.15	1.33	0.37
2013	0.04	28.45	1.22	0.33
2014	0.03	23.64	0.99	0.28
2015	0.03	22.44	0.96	0.29
2016	0.04	20.30	0.88	0.29
2017	0.04	18.53	0.79	0.28
2018	0.04	15.12	0.67	0.26

In 2018, about 10% of the reported NO_x emissions were due to 'fuel exports'. NOx-Emissions from fuel export increased between 1990 and 2005 (228%). From then emissions show a falling trend which is in line with decreasing activities (amount of fuel consumption) from 2005 onwards and improved specific NO_x emissions per kilometer in each vehicle fleet category (diesel cars showing the smallest decrease with 11%). Especially NO_x after treatment systems of trucks are working very well. In the model NEMO fuel export is allocated to truck traffic (35%) and passenger car traffic (65%). In 2018, NO_x emissions of total fuel export were 13% 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 2020a) which is part of the submission under the UNFCCC.

- Additionally to information provided in this document, Annex 2 of (UMWELTBUNDESAMT 2020a) 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 2020a).

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[2)], 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, Pb, Hg	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, HCB[1)], $PM_{2.5}$	LA, TA

LA = Level Assessment (if not further specified – for the years 1990 and 2018)

TA = Trend Assessment 2018

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 2016 (EEA 2016). Further information on the uncertainty assessment of activity data can be found in Austria`s National Inventory Report (UMWELTBUNDESAMT 2020a). 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 2016 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	21.54	750.04	200.16	21.54	60.53
1.A.1.b	Petroleum refining	10.05	750.00	-	10.05	40.01
1.A.1.c	Manufacture of Solid fuels and Other Energy Industries	40.05	750.00	200.01	125.02	40.05
1.A.2.a	Iron and Steel	11.18	750.02	200.06	11.18	125.10
1.A.2.b	Non-ferrous Metals	40.31	750.02	200.06	20.62	125.10
1.A.2.c	Chemicals	40.31	750.02	200.06	20.62	125.10
1.A.2.d	Pulp, Paper and Print	41.23	750.07	200.25	22.36	125.40

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	40.31	750.02	200.06	20.62	125.10
1.A.2.f	Non-metallic Minerals	40.31	750.02	200.06	20.62	125.10
1.A.2.g.7	Mobile Combustion in Manufacturing Industries and Construction	40.01	125.00	40.01	20.02	40.01
1.A.2.g.viii	Other Stationary Combustion in Manufacturing Industries and Construction	41.23	125.40	41.23	22.36	60.83
1.A.4.a	Commercial/Institutional	40.31	125.10	70.18	20.62	60.21
1.A.4.b	Residential	42.72	125.90	71.59	25.00	61.85
1.A.4.c	Agriculture/Forestry/ Fisheries	100.12	125.10	100.12	20.62	100.12
1.A.5	Other	125.00	200.00	125.00	40.01	125.00

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 2020a). 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 2019).

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

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

Measured emissions

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

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

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

3.1.3 NFR 1.A.1 Energy Industries

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

General Methodology

The following Table 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). 2005–2018: 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 2005–2018: 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) 2005–2018: ETS data	Reported by plant operator: SO_2, NO_x, CO, NMVOC (yearly)	NH_3: national study
1.A.1.c	Energy balance 2005–2018: ETS data		Main pollutants and Dioxin: national studies Other Pollutants: EMEP/EEA 2016 GB

For 2005–2018, 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**

	Total	Hydro[1)]	Combustible Fuels	Geothermal	Solar	Wind	Production [TJ] by Combustible Fuels
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	55 898	36 907	17 212	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	73 110

[1)] *including pumped storage; Source: IEA JQ 2019*

As shown in Table 72 electricity supply increased by 13.2 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

	Electricity [GWh]				
	Supply[1)]	Gross production[2)]	Imports	Exports	Net Imports
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	64 375	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	65 423	71 128	19 909	17 472	2 437
2011	65 602	65 813	24 977	16 777	8 199
2012	66 480	72 603	23 430	20 627	2 803
2013	67 088	68 357	24 960	17 689	7 270
2014	65 967	65 439	26 712	17 437	9 275
2015	67 051	65 299	29 389	19 328	10 062
2016	67 767	68 309	26 366	19 207	7 159
2017	68 848	71 324	29 362	22 817	6 546
2018	68 933	68 597	28 076	19 129	8 947

Source: IEA JQ 2019

[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 2019) 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 1990–2018.

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	143.14	15.99	61.40	59.46	1.63	4.66
1991	151.43	19.42	67.33	57.55	2.57	4.55
1992	117.37	18.86	39.97	49.50	3.00	6.05
1993	119.26	26.17	30.81	53.89	3.12	5.27
1994	124.03	24.09	32.97	58.28	3.39	5.29
1995	137.34	20.64	45.49	62.07	4.02	5.13
1996	160.38	19.96	47.52	79.65	6.12	7.12

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]			
1997	156.78	24.41	50.96	68.42	6.15	6.85
1998	150.06	28.13	35.81	73.53	6.81	5.78
1999	148.94	22.44	37.88	76.56	6.47	5.60
2000	141.01	15.84	49.16	62.51	8.05	5.46
2001	159.96	19.95	59.76	63.59	11.08	5.59
2002	155.61	10.42	56.12	69.22	13.07	6.77
2003	191.20	16.07	70.88	82.38	14.01	7.85
2004	188.33	14.92	69.06	78.93	15.34	10.09
2005	205.28	16.33	61.63	96.56	20.42	10.33
2006	198.15	14.54	60.20	80.80	29.54	13.08
2007	189.99	11.96	54.48	73.50	37.13	12.92
2008	199.99	11.60	47.87	83.32	44.09	13.11
2009	194.13	11.99	32.45	86.00	46.92	16.77
2010	218.97	9.78	41.47	94.55	55.30	17.86
2011	211.34	5.96	45.64	84.63	55.67	19.44
2012	195.21	3.07	37.18	75.07	60.01	19.88
2013	177.63	2.64	35.78	60.79	58.62	19.80
2014	157.60	2.19	24.74	50.63	58.31	21.73
2015	178.44	3.99	24.98	65.54	61.35	22.57
2016	177.68	5.59	16.91	71.80	59.05	24.32
2017	195.92	3.77	14.55	92.49	62.23	22.87
2018	174.77	1.46	14.78	79.34	57.19	21.99
Trend 1990–2018	22.1%	-90.8%	-75.9%	33.4%	3 412.9%	372.0%
Trend 2017–2018	-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	12.13	10.98	91%	11.81	10.90	92%	0.78	0.69	88%	1.36	1.12	82%
1995	7.74	5.20	67%	5.95	3.03	51%	0.69	0.33	48%	1.72	1.18	68%
2000	7.10	5.29	75%	3.62	3.20	89%	0.49	0.24	48%	1.93	1.17	61%
2005	10.33	7.60	74%	3.36	2.88	86%	0.76	0.38	50%	2.55	1.29	51%
2010	11.17	5.39	48%	2.12	1.45	68%	1.21	0.21	18%	4.38	0.80	18%
2015	10.08	3.55	35%	1.20	0.60	50%	1.07	0.07	7%	4.21	0.58	14%
2016	9.32	2.99	32%	1.00	0.41	42%	1.00	0.05	5%	4.01	0.54	13%
2017	10.07	3.33	33%	0.97	0.36	37%	1.05	0.04	4%	4.21	0.55	13%
2018	8.92	3.01	34%	0.96	0.37	39%	0.99	0.03	3%	3.96	0.48	12%

In the approach above different coal types and residual fuel classifications are considered. Table 75 shows some selected aggregated results for 2018. 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 2018.

	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 2018.

Fuel	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
Light Fuel Oil	78	159.4	10/45(1)	0.8	92	2.7
Heavy Fuel Oil	600	26/317.4(1)	3/15(1)	8.0	50/398(1)	2.7
Gasoil	115	65	10	4.8	0.5	2.7
Diesel oil	0	700	15	0.8	18.8	2.7
Liquified Petroleum Gas	260	150	5	0.5	6	1
Natural Gas/power and CHP	6 234	30	4	0.5	0.3	1
Natural Gas/district heating	2 065	41	5	0.5	0.3	1
Solid Biomass	47 356	94	72	5.0	11	5
Biogas, Sewage Sludge Gas, Landfill Gas	7 622	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 1990–2018.

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	35.82	27.93	-	7.88	-	-
1991	36.21	26.84	-	9.37	-	-
1992	35.80	27.27	-	8.53	-	-
1993	38.56	28.68	-	9.88	-	-
1994	37.13	30.20	-	6.93	-	-
1995	34.65	27.05	-	7.61	-	-
1996	40.23	31.85	-	8.38	-	-
1997	40.77	32.03	-	8.74	-	-
1998	39.61	31.29	-	8.32	-	-
1999	33.36	26.83	-	6.52	-	-
2000	33.76	27.23	-	6.53	-	-
2001	33.72	28.06	-	5.66	-	-
2002	35.81	30.71	-	5.10	-	-
2003	37.43	32.25	-	5.17	-	-
2004	40.20	31.69	-	8.51	-	-
2005	40.33	31.00	-	9.32	-	-
2006	40.60	31.92	-	8.68	-	-
2007	41.13	32.96	-	8.18	-	-
2008	40.47	31.34	-	9.13	-	-
2009	38.88	34.71	-	4.16	-	-
2010	39.29	30.29	-	9.00	-	-
2011	39.84	30.84	-	9.00	-	-
2012	39.76	32.01	-	7.75	-	-
2013	39.33	32.54	-	6.79	-	-
2014	37.71	31.77	-	5.95		
2015	38.77	32.74	-	6.03	-	-
2016	37.59	34.38	-	3.21	-	-
2017	38.23	31.07	-	7.16	-	-
2018	39.20	32.17		7.02		
Trend 1990–2018	**9.4%**	**15.2%**		**10.9%**		
Trend 2017–2018	**2.5%**	**3.5%**		**-1.9%**		

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 1990–2018.

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	5.13	-	5.10	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	4.50	-	4.47	0.04
2015	4.99	-	4.95	0.04

NFR	1.A.1.c	1.A.1.c	1.A.1.c	1.A.1.c
Fuel		Liquid	Gaseous	Biomass
		[PJ]		
2016	4.94	-	4.90	0.04
2017	4.71	-	4.68	0.03
2018	4.36		4.32	0.04
Trend 1990–2018	**-52.7%**	**-100.0%**	**-52.7%**	**26.4%**
Trend 2017–2018	**-7.4%**	**-**	**-7.6%**	**12.4%**

Emission factors and activity data 2018

Table 80 summarizes the selected emission factors for main pollutants and activity data for the year 2018. It is assumed that emissions are uncontrolled.

Table 80: NFR 1.A.1.c main pollutant emission factors and fuel consumption for the year 2018.

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)	4 363	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 $PM_{2.5}$. Char coal 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: Char coal production activity data 1990–2018.

Year	Char coal production (t)	Year	Char coal production (t)
1990	1 000	2004	1 000
1991	1 000	2005	1 101
1992	1 000	2006	1 220
1993	1 000	2007	1 149
1994	1 000	2008	1 253
1995	1 000	2009	1 365
1996	1 000	2010	1 181
1997	1 000	2011	1 130
1998	1 000	2012	1 377
1999	1 000	2013	1 269
2000	1 000	2014	1 263
2001	1 000	2015	1 447
2002	1 000	2016	1 382
2003	1 000	2017	1 222
-	-	2018	1 375

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 2003b).

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
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 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[76]) 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.

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).

[76] http://edm.gv.at

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	**1995**	**2000**	**2018**	**[%]**	**[%]**
Public Power (0101)(1)	5.51	3.34	2.74	0.27	95	80
District Heating (0102) (1)	3.58	1.37	0.73	0.22	95	80
Petroleum Refining (010301)(2)	4.3	2.8	3.4	1.2	95	80
Wood waste (116A)	55	55	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.[77]

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).

[77] 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	2018	[%]	[%]
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

3.1.3.7 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 recalculations for the year 2017 took place for categories:

1.A.1.a: +0.7 kt NO_x, +0.05 kt $PM_{2.5}$

1.A.1.b: - 0.04 t Cd

Petroleum refining (1.A.1.b)

Cd emissions from 1A1b refineries have been re-estimated using a method developed by CONCAWE (CONCAWE 2017). This results in higher Cd emissions 1990 but lower Cd emissions 2017.

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)[78]
- 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 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 2005–2017: ETS data.		All pollutants: National studies
1.A.2.b	Non-ferrous Metals	Energy balance 2005–2017: ETS data.		All pollutants: National studies
1.A.2.c	Chemicals	Energy balance 2005–2017: 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 2005–2017: 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 2005–2017: ETS data.		All pollutants: National studies
1.A.2.f	Cement Clinker Production	National Studies 2005–2017: 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 2005–2017: 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 2005–2017: ETS data.		All pollutants: National studies
1.A.2.f	Bricks and Tiles Production	Association of Bricks and Tiles Industry 2005–2017: ETS data.		All pollutants: National studies
1.A.2.g	Other	Energy balance 2005–2017: 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,

[78] methodologies for mobile sources are described in Chapter 3.2.7.1

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.

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

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

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 2018. 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 2018.

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)	84	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)	74	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)	6 589	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 1.1.4.10 and 1.1.4.11).

Activity data

Fuel consumption is taken from (IEA JQ 2019).

Table 97: Fuel consumption from NFR 1.A.2.b Non-ferrous Metals 1990–2018.

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	-	-
1991	1.87	0.49	0.17	1.21	-	-
1992	2.11	0.45	0.08	1.58	-	-
1993	2.56	0.46	0.19	1.92	-	-
1994	4.44	0.57	0.14	3.73	-	-
1995	4.36	0.57	0.09	3.70	-	-
1996	2.84	0.68	0.15	2.02	-	-
1997	3.50	0.94	0.19	2.37	-	-
1998	3.29	0.83	0.16	2.30	-	-
1999	3.03	0.66	0.21	2.16	-	-
2000	3.12	0.64	0.17	2.31	-	-
2001	3.41	0.72	0.10	2.60	-	-
2002	3.42	0.60	0.16	2.67	-	-
2003	3.53	0.56	0.15	2.82	-	-
2004	3.67	0.51	0.16	3.01	-	-
2005	3.68	0.45	0.13	3.10	-	-
2006	3.76	0.45	0.12	3.19	-	-
2007	4.28	0.40	0.14	3.74	-	-
2008	4.35	0.32	0.14	3.89	-	-
2009	4.02	0.26	0.16	3.60	-	-
2010	4.10	0.26	0.07	3.77	-	-
2011	4.31	0.30	0.07	3.94	-	-
2012	4.19	0.28	0.06	3.85	-	-
2013	5.08	0.46	0.13	3.99	0.48	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**
2014	4.89	0.43	0.15	4.26	0.03	0.01
2015	5.07	0.38	0.13	4.52	0.03	0.01
2016	5.28	0.27	0.13	4.83	0.03	0.02
2017	5.19	0.24	0.11	4.80	0.02	0.02
2018	5.87	0.10	0.10	5.63	0.03	0.01
Trend 1990–2018	**182.4%**	**-81.3%**	**-52.5%**	**316.0%**		
Trend 2017–2018	**13.2%**	**-59.9%**	**-8.9%**	**17.2%**	**87.5%**	**-47.0%**

The following Table 98 shows fuel consumption and main pollutant emission factors of category *1.A.2.b* for the year 2018.

Table 98: NFR 1.A.2.b main pollutant emission factors and fuel consumption for the year 2018.

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)	100	220.0	150.0	8.0	500.0	0.01
Residual fuel oil < 1% S	(BMWA 1996) (1)	16	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)	5 628	41.0	5.0	0.5	0.3(7)	1.00
LPG	(BMWA 1996) (4)	79	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 2019). 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 2019).

Table 99: Fuel consumption from NFR 1.A.2.c Chemicals 1990–2018.

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	25.52	1.14	3.24	14.65	4.98	1.51
2000	25.45	0.85	2.61	15.78	3.95	2.26
2001	23.96	1.20	2.65	15.46	1.84	2.81
2002	24.27	0.97	2.64	14.95	1.58	4.13
2003	26.73	1.06	2.62	15.11	2.11	5.82
2004	27.73	1.03	2.48	15.28	1.68	7.26
2005	24.45	0.98	1.57	18.04	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	25.91	1.15	0.75	17.31	3.11	3.59
2009	25.85	1.60	0.74	17.82	2.49	3.21
2010	28.69	1.89	0.81	18.29	3.51	4.19
2011	27.69	1.68	0.72	18.35	3.25	3.69
2012	28.15	1.35	0.73	18.62	3.67	3.78
2013	26.22	1.10	0.88	18.04	3.35	2.86
2014	25.82	0.71	1.29	17.72	2.86	3.25
2015	26.10	0.75	1.08	18.15	3.06	3.06
2016	28.87	0.79	1.11	20.18	3.42	3.36
2017	30.03	0.73	2.17	20.51	3.59	3.02
2018	27.55	0.42	1.28	20.09	3.00	2.77
Trend 1990–2018	**69.1%**	**-67.1%**	**17.3%**	**114.5%**	**3.4%**	**66.2%**
Trend 2017–2018	**-8.3%**	**-43.1%**	**-41.3%**	**-2.1%**	**-16.5%**	**-8.2%**

Table 100 summarizes activity data and emission factors for 2018. Underlined values indicate non default emission factors.

Table 100: NFR 1.A.2.c main pollutant emission factors and fuel consumption for the year 2018.

Fuel	Source of NO_x, CO, NMVOC, SO_2 emission factors	Activity [TJ]	NO_x [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]	SO_2 [kg/TJ]	NH_3 [kg/TJ]
Hard coal	(BMWA 1990) (1)	1 276	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)	84	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA 1996) (1)	214	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	94	40.0	10.0	0.5	6.0	2.68
Natural Gas	(BMWA 1996) (1)	20 087	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)	2 775	29.4(6)	0.8(6)	0.54	6.9(6)	0.02
Solid biomass	(BMWA 1996) (1)	2 653	100.0(7)	72.00	5.0	30.0	5.00
Biogas	(BMWA 1990) (8)	351	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 2019).

Table 101: Fuel consumption from NFR 1.A.2.d Pulp, Paper and Print 1990–2018.

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	69.69	2.97	3.79	31.29	31.50	0.14
2000	67.11	2.20	4.70	31.83	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	70.82	1.33	3.80	31.84	33.75	0.10
2010	75.30	0.93	3.55	34.91	35.84	0.08
2011	74.54	0.68	3.94	33.88	35.96	0.09
2012	70.48	0.51	3.95	29.86	36.10	0.06
2013	69.21	0.83	4.23	26.04	37.94	0.17
2014	65.39	0.44	4.19	23.63	36.95	0.18
2015	64.76	0.46	4.29	24.71	35.11	0.18
2016	66.21	0.32	4.38	24.69	36.68	0.15
2017	66.48	0.22	4.44	24.99	36.66	0.18
2018	69.51	0.18	4.15	27.37	37.51	0.29
Trend 1990–2018	**25.7%**	**-98.3%**	**0.4%**	**60.9%**	**62.9%**	**49.4%**
Trend 2017–2018	**4.6%**	**-18.5%**	**-6.5%**	**9.6%**	**2.3%**	**62.4%**

Table 102 shows activity data and emission factors for 2017. 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.

For the year 2017, NO_X and TSP/PM_{10}/$PM_{2.5}$ emission factors are updated by means of a new study (WINDSPERGER2019) 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 2018.

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)	4 152	75.0(9)	150.0	15.0	84.8	0.01
Brown coal	(BMWA 1990) (1)	0	170.0	150.0	23.0	70.2	0.02
Brown coal briquettes	(BMWA 1990) (1)	0	170.0	150.0	23.0	70.2	0.02
Coke oven coke	(BMWA 1990) (1)	0	220.0	150.0	8.0	02.7	0.01
Residual fuel oil < 1% S	(BMWA 1996) (1)	18	118.0	10.0	0.8	12.2	2.70
Residual fuel oil ≥ 1% S	(BMWA 1996) (1)	142	235.0	15.0	8.0	52.7	2.70
Heating oil	(BMWA 1996) (2)	5	65.0	15.0	4.8	0.1	2.70
Kerosene	(BMWA 1996) (6)	0	118.0	15.0	4.8	12.2	2.70
LPG	(BMWA 1996) (3)	15	41.0	5.0	0.5	6.0(4)	1.00
Natural Gas (including lime kilns)	(BMWA 1996) (1)	27 374	46.9(9)	5.0	0.5	IE	1.00
Industrial waste	(BMWA 1990) (1)	289	100.0	200.0	0.54	17.2	0.02
Black liquor	(BMWA 1990) (1)	29 792	68.0(9)	20.0	4.0	17.2	0.02
Fuel wood	(BMWA 1996) (8)	0	110.0	370.0	5.00	7.9	5.00
Solid biomass + Sewage sludge	(BMWA 1996) (1)	5 908	86.0(9)	72.00	5.0	7.9	5.00
Biogas	(BMWA 1990) (5)	997	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 2019).

Table 103: Fuel consumption from NFR 1.A.2.e Food Processing, Beverages and Tobacco 1990–2018.

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	14.28	2.14	0.08	11.83	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	16.95	2.65	0.15	13.47	0.67	0.0039
2012	16.97	2.08	0.16	13.87	0.86	0.0037
2013	15.90	0.97	0.15	14.23	0.55	0.0016
2014	16.48	1.15	0.17	14.59	0.56	0.0005
2015	16.29	0.90	0.22	14.52	0.64	0.0001
2016	14.82	0.77	0.15	13.34	0.56	0.0003
2017	14.62	0.64	0.17	13.36	0.45	0.0004
2018	14.23	0.46	0.13	13.10	0.54	0.0045
Trend 1990–2018	**2.3%**	**-89.7%**	**-25.6%**	**43.2%**	**311.2%**	**-**
Trend 2017–2018	**-2.7%**	**-28.8%**	**-21.5%**	**-1.9%**	**19.3%**	**1151.6%**

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 2018.

Table 104: NFR 1.A.2.e main pollutant emission factors and fuel consumption for the year 2018.

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)]	132	220.0	150.0	8.0	500.0	0.01
Residual fuel oil < 1% S	(BMWA 1996) [(1)]	210	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)]	61	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)]	179	41.0	5.0	0.5	6.0 [(4)]	1.00
Natural Gas	(BMWA 1996) [(1)]	13 098	41.0	5.0	0.5	0.3 [(9)]	1.00
Industrial waste	(BMWA 1990) [(1)]	4	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)]	352	143.0	72.00	5.0	60.0	5.00
Biogas	(BMWA 1990) [(5)]	78	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 1990–2018.

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

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**
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
1997	24.60	3.40	5.85	13.25	-	2.10
1998	24.58	3.41	5.63	12.87	-	2.66
1999	21.45	3.81	3.80	10.97	-	2.88
2000	22.79	2.32	5.34	11.58	-	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
Trend 1990–2018	**19.2%**	**-77.5%**	**-57.7%**	**20.0%**	**-**	**525.8%**
Trend 2017–2018	**3.6%**	**-4.8%**	**9.7%**	**0.5%**	**9.0%**	**5.9%**

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 2018.

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	13 821	2.31	5.35	0.21	0.32	0.119	Included in 2A1
SNAP 030312 Lime Production	2 759	0.78	0.12	0.01	0.18	0.002	Included in 2A2
SNAP 030317 Glass Production	3 332	0.56	0.02	0.00	0.16	0.003	0.001
SNAP 030319 Bricks and Tiles Production	2 954	0.76	0.09	0.01	0.18	0.005	0.034
SNAP 030323 Magnesia Production	4 949	1.38	0.14	0.01	0.07	0.005	0.033
Total	**27 815**	**5.78**	**5.71**	**0.24**	**0.91**	**0.134**	**0.068**

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, 2010–2019). Table 107 shows detailed fuel consumption data for 2018.

Table 107: Cement clinker manufacturing industry. Fuel consumption for the year 2018.

Fuel	Activity [TJ]
Hard coal	712
Brown coal	1 266
Petrol coke	444
Residual fuel oil < 1% S	21
Residual fuel oil 0.5% S	0
Residual fuel oil ≥ 1% S	55
Heating oil	12
Natural Gas	114
Industrial waste	8 128
Pure biogenic residues	3 068
Total	**13 821**

HCB accidental release

Within the period, 2012 to 2014 high amounts of HCB were released from a cement plant unintentionally[79]. 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 1990 to 2018.

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

[79] http://www.ktn.gv.at/302524_DE-HCB-Messberichte

Year	Lime [kt]	Year	Lime [kt]
-	-	2018	735

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 1990 to 2017.

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

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 2018 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 2018 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)	281	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)	1	65.0	15.0	4.8	0.5	2.70
Natural Gas	(BMWA 1996) (1)	2 475	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)	4	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)	3 328	167.2 (12)	5.0	0.5	44.9 (7)	1.00
SNAP 030319 Bricks and tiles manufacturing							
Brown coal	(BMWA 1990) (1)	147	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)	61	220.0	150.0	8.0	323.0 (8)	0.01
Residual fuel oil < 1% S	(BMWA 1996) (1)	2	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA 1996) (1)	79	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)	2 133	294.0 (5)	5.0	0.5	0.3 (10)	1.00
Industrial waste	(BMWA 1990) (1)	50	100.0	200.0	38.0	130.0	0.02
Solid biomass	(BMWA 1996) (1)	476	143.0	72.00	5.0	60.0	5.00
SNAP 030323 Magnesia Production							
Petrol coke	(BMWA 1990) (1)	717	220.0	150.0	8.0	81.0 (9)	0.01
Natural Gas	(BMWA 1996) (1)	4 051	294.0 (5)	5.0	0.5	0.3 (10)	1.00
Industrial waste	(BMWA 1990) (1)	27	100.0	200.0	38.0	130.0	0.02
Solid biomass	(BMWA 1996) (1)	151	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 1990–2018.

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	35.29	8.26	1.17	15.88	9.10	0.87
2000	36.46	8.15	0.29	19.32	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	37.32	8.66	0.12	18.19	9.64	0.72
2004	38.55	8.86	0.13	18.37	10.07	1.11
2005	52.40	9.41	0.33	23.65	17.48	1.52
2006	54.39	9.63	0.38	23.53	19.30	1.55

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**
2007	57.13	7.81	0.30	23.07	24.32	1.62
2008	54.30	6.69	0.31	24.24	21.72	1.34
2009	57.33	6.73	0.00	25.72	23.69	1.20
2010	60.29	6.86	-	27.93	23.64	1.85
2011	58.80	7.05	-	24.38	24.45	2.92
2012	62.41	7.79	-	25.14	27.50	1.97
2013	60.84	4.08	0.01	28.56	25.90	2.30
2014	54.50	3.62	0.00	24.96	24.90	1.02
2015	50.76	3.43	0.00	23.08	23.81	0.43
2016	50.79	3.43	0.00	24.30	22.21	0.85
2017	50.65	3.05	0.02	25.08	21.68	0.82
2018	49.89	2.01	0.00	26.73	20.34	0.80
Trend 1990–2018	**61.9%**	**-75.4%**	**-99.9%**	**46.1%**	**499.4%**	**1645.4%**
Trend 2017–2018	**-1.5%**	**-34.0%**	**-96.2%**	**6.6%**	**-6.1%**	**-2.4%**

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 2018.

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)]	1	220.0	150.0	8.0	500.0	0.01
Residual fuel oil < 1% S	(BMWA 1996)[(1)]	681	118.0	10.0	0.8	92.0	2.70
Residual fuel oil ≥ 1% S	(BMWA 1996)[(1)]	170	235.0	15.0	8.0	398.0	2.70
Heating oil, Diesel oil	(BMWA 1996)[(2)]	215	65.0	15.0	4.8	0.5	2.70
LPG	(BMWA 1996)[(3)]	949	41.0	5.0	0.5	6.0[(4)]	1.00
Natural gas	(BMWA 1996)[(1)]	26 727	41.0	5.0	0.5	0.3[(7)]	1.00
Industrial waste	(BMWA 1990)[(1)]	803	100.0	200.0	0.54	11.0	0.02
Fuel wood	(BMWA 1996)[(6)]	11	110.0	370.0	5.00	11.0	5.00
Solid biomass	(BMWA 1996)[(1)]	19 988	143.0	72.00	5.0	60.0	5.00
Sewage sludge	(BMWA 1996)[(1)]	178	100.0	200.0	38.00	NA	0.02
Biogas	(BMWA 1990)[(5)]	167	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, 2019); 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	2018
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	2018
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	2018
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
Oil			
204A Heating and other gas oil		0.02 (all years)	

LEAD EF [mg/GJ]	1990	1995	2018
2050 Diesel			
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
2018	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
2001	75	3 061
2002	71	3 118

Year	Cast Iron Production [kt]	Cement clinker [kt]
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

Table 121: Asphalt concrete production 1990 and 2018.

Year	Asphalt concrete [kt]
1990	403
2018	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[80]	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 PAK emission factors are provided in the following table.

[80] 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[81].

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
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

81 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]
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 PAK 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[82]	–

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

3.1.4.12 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 2002–2018) and default national emission factors for industrial boilers have been adapted to fit the emissions. From the year 2018 onwards, emissions 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.

	TSP Emission Factors [g/GJ]				PM_{10}	$PM_{2.5}$
	1990	1995	2000	2018	[%]	[%]
Gas						
Natural gas & LPG		0.5			90	75
Natural gas – Pulp & Paper (IEF)	0.20	0.10	0.11	0.78	90	75
Coal						
Hard coal & Coke oven coke		45			90	75
Brown coal & Brown coal briquettes		50			90	75
Coal – Pulp & Paper industries (IEF)	7.94	3.92	4.46	8.20	95	80
Oil						
Light fuel oil & Gasoil		3.0			90	75
Medium fuel oil		35			90	75
Heavy fuel oil		65			90	75
Other kerosene		3.0			95	80
Oil – Pulp & Paper industries (IEF)	19.85	9.81	11.16	7.64	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

3.1.4.13 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 recalculations for the year 2017 took place for categories:

1.A.2.d: -0.8 kt NO_x

1.A.2.c: -0.2 kt SO_2, -0.14 kt $PM_{2.5}$

1.A.2.e: -0.3 kt NO_x, -0.05 kt $PM_{2.5}$

Non-ferrous metals (1A2b)

Activity data of secondary nickel production have been updated. SO_2, Cd and Hg emissions from nickel production are now plant specific and SO_2 emission are reported the first time.

Pulp and paper industry (1A2d)

Based on a new study performed in 2019, NO_x and $PM_{2.5}$ emission factors from hard coal, black liqueur and wood waste used in pulp and paper industries have been revised, resulting in about -0.8 kt lower NO_x and slightly higher $PM_{2.5}$ emissions 2017.

Chemicals industry (1A2c)

NO_x, SO_2 and PM_{10} emissions from a large waste incineration plant are now taken from measured data. This results in about -0.1 kt lower NO_x, -0.3 kt lower SO_2 and -0.2 kt lower $PM_{2.5}$ emissions from category 1A2c in the year 2017.

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 2018.

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) 33.0(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 2018.

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

Federal statistics office "Statistik Austria" revised the energy balance for the years 1990 to 2017 with the following main implications for energy consumption as used in the inventory:

- Natural gas gross inland consumption 2014 and 2015 has been revised by -1 to -1.8 TJ. However, natural gas consumption has been shifted between sectors: For 2005 and 2006, about 1 to 1.2 PJ have been shifted from the power sector (1A1a) to the commercial sector (1A4a). For 2011, about 0.7 PJ have been shifted from the power sector (1A1a) to the commercial sector (1A4a). For 2013, about 1.7 PJ have been shifted from the commercial and residential sector (1A4a and 1A4b) to the industry sector (1A2). For 2014, about 1.1 PJ have been shifted from the residential and commercial sector (1A4a and 1A4b) to the industrial sector (1A2). For 2016, about 3 PJ have been shifted from petroleum refineries (1A1b) to the residential and industry sector (1A4b, 1A2).
- For liquid fuels, gross inland consumption has been revised between -0.1 to -2.2 PJ for the years 2005 to 2011 (crude oil input into refineries) and by -1.3 PJ PJ for the year 2017, which does not have an effect on final consumption, because lower fuel imports have been counterbalanced by a higher refinery fuel output. For 2013 to 2017, between 1.1 to 4.6 PJ of liquid fuels have been shifted from the industry sector (mostly from 1A2e food processing and 1A2g other manufacturing industries) to the residential (1A4b) and commercial (1A4a) sector.
- For solid fuels, mainly the residential sector has been revised since the year 2005 (+ 1 PJ in 2005 and + 0.2 PJ in 2017).
- For 'biomass', gross inland consumption has been revised upwards for the whole time series since 2005 – 2017 (2005: + 7 PJ, 2010: +15.7 PJ, 2015: 9.4 PJ, 2017: +14.5 PJ). For the years 2005 to 2016 the transformation input to the power sector (1A1a) has been revised downwards (between -0.4 to -2.7 PJ) while for 2017 it has been revised upwards by +3.5 PJ which explains most of the higher NOX (+7%) and PM2.5 (+6%) emissions 2017 of category 1A1a. The highest revision of biomass consumption took place in the 1A4 stationary combustion sub categories, with increases of +6.4 PJ in 2005 and + 12.6 PJ in 2017.

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 2018.

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) [83]	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.

[83] methodologies for mobile sources are described in Chapter 3.2.7.1

Code Number and Name				Definitions
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 [83]	Fuels combusted in traction vehicles and other mobile machinery on farm land and in forests.
1.A.4	c	3	National Fishing [83]	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.

Twenty-two technology and fuel dependent main sub categories (heating types) are considered in this category as presented in the following table:

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 char coal 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) (BMNT 2018, STATCUBE 2014a, 2014b, 2014c, 2019a,b STATISTIK AUSTRIA 1973, 1982, 1992a, 2004, 2013, 2018, 2019a)
- 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 2019b)
- 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 2014, 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 2019) and calibrated according to the energy statistics supplier to maintain consistency with fuel demand reported in (IEA JQ 2019)

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 2019) 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 *1990–2018.*

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	35.55	18.66	0.96	12.75	2.06	1.11
1991	37.87	17.91	1.27	15.64	2.08	0.97

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**
1992	46.05	18.29	0.92	24.22	1.93	0.69
1993	50.33	17.69	0.86	28.86	2.59	0.33
1994	41.71	15.57	0.80	22.32	2.50	0.51
1995	52.14	17.64	0.64	30.79	2.55	0.52
1996	52.14	23.72	0.67	24.80	2.40	0.55
1997	52.68	27.53	0.92	20.93	2.73	0.58
1998	50.15	24.73	0.74	21.37	2.71	0.61
1999	59.14	27.78	0.92	25.83	4.00	0.61
2000	49.00	17.84	1.10	25.24	4.26	0.56
2001	63.82	23.65	1.23	35.03	3.29	0.63
2002	60.91	24.92	0.86	31.38	3.13	0.62
2003	70.48	30.58	1.18	34.46	3.62	0.65
2004	69.86	23.40	0.83	40.83	4.27	0.52
2005	51.56	26.86	0.72	19.99	2.92	1.07
2006	54.60	28.67	0.52	21.02	3.66	0.72
2007	42.57	19.87	0.41	18.05	3.91	0.33
2008	45.53	20.92	0.25	19.95	4.35	0.05
2009	37.20	16.92	0.19	16.48	3.56	0.05
2010	30.55	9.49	0.22	16.65	4.13	0.06
2011	26.29	8.83	0.15	13.95	3.32	0.05
2012	24.48	5.99	0.00	15.85	2.64	NO
2013	24.09	5.87	0.01	15.52	2.62	0.07
2014	22.35	6.01	0.00	13.70	2.57	0.08
2015	23.97	5.95	0.00	14.74	3.19	0.08
2016	22.08	5.60	NO	13.72	2.67	0.09
2017	26.27	7.73	NO	14.54	3.92	0.08
2018	24.71	6.72	NO	14.38	3.51	0.09
Trend 1990–2018	**-30.5%**	**-64,0%**	**-100,0%**	**12,8%**	**70,4%**	**-91,5%**
Trend 2016–2018	**-5.9%**	**-13,0%**	**NO**	**-1,0%**	**-10,4%**	**13,1%**

Table 132: Share of 1.A.4.a heating type on fuel category for the year 2018.

Fuel	No.	Heating type	Share of heating type [% TJ]
			1.A.4.a

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 #3 #4 #5 #6	Gas oil stoves Vaporizing burners Yellow burners Blue burners with conventional technology Blue burners with low temperature or condensing technology	4.9% 2.0% 42.8% 1.6% 48.8%

Fuel	No.	Heating type	Share of heating type [% TJ]
			1.A.4.a
Natural gas	#7 #8 #9	Natural gas convectors Atmospheric burners Forced-draft natural gas burners	18.9% 47.1% 33.9%
Biogas and landfill gas	#8 #9	Atmospheric burners Forced-draft natural gas burners	58.1% 41.9%
LPG and gas works gas	#10 #11	LPG stoves LPG boilers	66.9% 33.1%
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	4.1% 95.9% NO NO NO
Wood waste	#17 #18 #19 #20	Wood chips boilers with conventional technology Wood chips boilers with oxygen sensor emission control Pellet stoves Pellet boilers	3.8% 31.2% 5.0% 60.1%
Hard coal and hard coal briquettes	#21 #22	Coal stoves Coal boilers	NO NO
Lignite and brown coal	#21 #22	Coal stoves Coal boilers	NO NO
Brown coal briquettes	#21 #22	Coal stoves Coal boilers	NO NO
Coke	#21 #22	Coal stoves Coal boilers	NO NO
Peat	#21 #22	Coal stoves Coal boilers	NO NO
Industrial waste	#22	Coal boilers	100.0%
Char coal	BBQ	Barbecue	100.0%

NO…not occurring (in 2018)

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	29.9	57.0	13.1	91.5	7.5	0.9	11.8	1.5	77.2	1.7	7.8
1991	27.5	57.9	14.6	84.6	13.6	1.8	11.7	1.5	75.8	1.7	9.2
1992	25.7	57.9	16.3	74.9	22.1	3.0	11.6	1.4	73.9	2.1	11.0
1993	23.8	58.2	18.0	72.2	24.3	3.4	11.4	1.4	72.0	2.8	12.5
1994	22.3	57.7	20.1	71.4	24.9	3.7	11.2	1.3	69.5	3.7	14.2
1995	20.7	57.2	22.1	79.2	18.0	2.8	11.0	1.3	67.1	4.8	15.8
1996	19.1	56.7	24.2	89.0	9.5	1.5	10.9	1.2	63.6	6.2	18.1
1997	18.0	55.9	26.1	80.5	16.7	2.8	10.6	1.2	61.1	7.2	19.9
1998	16.9	55.1	28.0	78.8	18.0	3.2	10.4	1.1	58.0	8.3	22.2

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]				
1999	15.9	54.2	29.9	83.4	14.0	2.6	10.2	1.1	56.5	8.8	23.4
2000	15.1	53.4	31.5	82.8	14.5	2.8	9.9	1.1	55.6	9.1	24.3
2001	15.1	52.4	32.5	85.9	11.6	2.5	9.7	1.1	54.6	9.4	25.2
2002	15.4	51.2	33.4	75.5	19.8	4.7	9.3	1.1	53.9	9.7	26.1
2003	15.4	50.4	34.2	71.1	23.0	5.9	8.9	1.1	53.7	9.8	26.5
2004	15.7	49.4	34.8	49.8	39.2	11.0	8.5	1.1	52.8	10.0	27.6
2005	15.8	48.9	35.3	51.4	37.4	11.2	8.1	1.1	52.7	9.6	28.6
2007	16.1	48.2	35.7	68.2	24.1	7.7	7.7	1.2	52.6	9.1	29.4
2007	16.5	47.7	35.8	54.3	34.0	11.7	7.4	1.2	52.1	8.6	30.7
2008	16.7	47.3	36.0	42.0	42.6	15.4	7.1	1.3	51.6	8.0	32.0
2009	16.9	47.0	36.2	46.5	38.7	14.8	6.7	1.3	51.1	7.4	33.4
2010	16.8	46.9	36.4	7.4	66.2	26.4	6.4	1.4	50.5	6.7	35.0
2011	17.3	46.5	36.2	24.4	53.2	22.4	6.1	1.4	49.7	6.0	36.8
2012	17.5	46.4	36.1	71.1	20.1	8.8	5.8	1.5	48.9	5.2	38.6
2013	17.7	46.3	36.0	74.6	17.5	8.0	5.6	1.6	48.0	4.3	40.5
2014	18.3	46.1	35.6	82.4	11.9	5.7	5.3	1.7	47.1	3.4	42.6
2015	18.2	46.4	35.4	79.5	13.7	6.8	5.0	1.8	46.1	2.3	44.8
2016	18.0	46.8	35.2	90.2	6.6	3.3	5.0	1.9	45.0	1.7	46.5
2017	17.9	47.3	34.8	65.8	22.9	11.3	4.9	1.9	43.8	1.6	47.7
2018	18.0	47.7	34.3	48.7	34.4	17.0	4.9	2.0	42.8	1.6	48.8

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	2.1	51.4	44.9	NO	1.6	89.3	10.7	NO	NO	39.2	60.8
1991	1.9	51.5	44.4	NO	2.2	76.5	10.9	0.0	12.6	46.3	53.7
1992	2.0	51.2	43.9	NO	2.9	63.9	12.6	0.0	23.4	46.8	53.2
1993	2.0	51.2	43.4	NO	3.5	54.6	13.0	0.1	32.3	57.0	43.0
1994	2.1	50.8	42.9	NO	4.2	46.3	13.6	0.3	39.9	50.1	49.9
1995	1.9	50.7	42.6	NO	4.8	39.5	13.8	0.6	46.1	46.4	53.6
1996	1.7	50.5	42.3	NO	5.5	34.2	13.4	1.1	51.3	46.7	53.3
1997	1.9	49.8	42.0	NO	6.3	29.6	13.0	1.6	55.9	51.9	48.1
1998	2.0	49.1	41.9	NO	7.0	25.6	12.6	2.0	59.8	47.7	52.3
1999	2.0	48.4	41.8	NO	7.8	22.1	12.3	2.4	63.2	53.1	46.9
2000	2.2	47.4	41.8	NO	8.6	18.9	12.0	2.8	66.3	58.8	41.2

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]	
2001	2.1	51.2	38.2	NO	8.6	21.5	15.7	3.3	59.5	58.7	41.3
2002	2.2	54.4	34.8	0.0	8.5	21.8	18.2	3.5	56.5	52.2	47.8
2003	2.1	57.9	31.5	0.1	8.3	21.4	20.3	3.6	54.8	57.2	42.8
2004	2.3	61.1	28.3	0.2	8.1	20.6	22.0	3.6	53.8	54.5	45.5
2005	2.2	64.5	25.7	0.2	7.4	10.9	14.4	4.9	69.8	37.0	63.0
2007	2.4	67.6	23.2	0.2	6.6	14.5	23.5	4.1	57.9	38.6	61.4
2007	2.7	70.6	20.6	0.2	5.9	14.7	27.5	3.8	54.0	49.4	50.6
2008	2.7	73.9	18.0	0.2	5.2	17.1	38.7	3.0	41.2	69.2	30.8
2009	2.8	77.2	15.4	0.1	4.4	13.9	38.1	3.2	44.8	65.4	34.6
2010	2.6	80.8	12.8	0.1	3.7	13.4	43.3	3.0	40.3	64.9	35.1
2011	3.1	83.7	10.2	0.1	2.9	10.6	40.3	3.3	45.7	61.7	38.3
2012	3.1	87.0	7.6	0.1	2.2	11.5	50.8	2.6	35.1	75.8	24.2
2013	3.3	90.2	5.0	0.0	1.4	10.1	51.2	2.7	36.0	9.5	90.5
2014	4.1	92.6	2.5	0.0	0.7	6.8	38.7	3.7	50.8	1.0	99.0
2015	3.8	96.2	NO	NO	NO	8.7	54.9	2.5	33.9	0.7	99.3
2016	3.7	96.3	NO	NO	NO	5.7	39.9	3.9	50.6	NO	100.0
2017	3.7	96.3	NO	NO	NO	4.3	33.4	4.7	57.6	NO	100.0
2018	4.1	95.9	NO	NO	NO	3.8	31.2	5.0	60.1	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 & 2019b). 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 1990–2018.

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	190.86	72.50	26.62	33.34	58.40	NO
1991	213.14	79.16	29.12	39.82	65.04	NO
1992	198.04	72.69	25.06	38.79	61.50	NO
1993	199.95	73.98	20.81	42.37	62.79	NO
1994	185.98	69.12	18.52	40.17	58.16	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**
1995	199.14	75.59	17.56	43.19	62.80	NO
1996	218.05	83.89	16.64	48.58	68.94	NO
1997	193.54	68.05	12.58	48.52	64.39	NO
1998	196.62	71.31	11.05	51.37	62.89	NO
1999	198.32	73.12	10.22	50.92	64.06	NO
2000	189.20	72.60	9.05	47.49	60.07	NO
2001	197.02	71.55	8.57	53.11	63.79	NO
2002	185.37	68.92	6.87	49.83	59.73	NO
2003	186.78	69.07	5.78	52.81	59.11	NO
2004	180.77	66.55	5.49	51.84	56.89	NO
2005	194.25	63.88	3.97	67.58	58.82	0.00
2006	192.71	61.36	3.77	65.64	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	199.33	55.88	2.63	65.44	75.38	0.00
2011	179.86	48.34	1.69	58.12	71.71	0.00
2012	180.81	44.01	1.77	59.22	75.81	0.00
2013	187.22	47.32	1.35	59.84	78.70	0.00
2014	163.53	41.46	1.13	51.93	69.00	0.00
2015	172.77	43.18	0.91	56.54	72.12	0.00
2016	179.83	42.84	0.87	62.41	73.72	0.00
2017	180.43	43.35	0.94	61.52	74.62	0.00
2018	164.43	39.07	0.84	56.58	67.94	0.00
Trend 1990–2018	**-13.8%**	**-46.1%**	**-96.8%**	**69.7%**	**16.3%**	**NO**
Trend 2017–2018	**-8.9%**	**-9.9%**	**-10.8%**	**-8.0%**	**-8.9%**	**0.4%**

Table 136: Share of 1.A.4.b heating type on fuel category for the year 2018.

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	Gas oil stoves	2.0%
	#3	Vaporizing burners	0.3%
	#4	Yellow burners	45.7%
	#5	Blue burners with conventional technology	1.6%
	#6	Blue burners with low temperature or condensing technology	50.4%
Natural gas	#7	Natural gas convectors	10.1%
	#8	Atmospheric burners	46.5%
	#9	Forced-draft natural gas burners	43.4%
Biogas and landfill gas	#8	Atmospheric burners	NO
	#9	Forced-draft natural gas burners	NO
LPG and gas works gas	#10	LPG stoves	13.1%
	#11	LPG boilers	86.9%
Fuel wood	#12	Wood stoves and cooking stoves	9.5%
	#13	Tiled wood stoves and masonry heaters	8.4%
	#14	Mixed-fuel wood boilers	46.3%
	#15	Natural-draft wood boilers	5.6%
	#16	Forced-draft wood boilers	30.2%
Wood waste	#17	Wood chips boilers with conventional technology	4.7%
	#18	Wood chips boilers with oxygen sensor emission control	35.1%
	#19	Pellet stoves	2.5%
	#20	Pellet boilers	57.7%
Hard coal and hard coal briquettes	#21	Coal stoves	23.0%
	#22	Coal boilers	77.0%
Lignite and brown coal	#21	Coal stoves	23.0%
	#22	Coal boilers	77.0%
Brown coal briquettes	#21	Coal stoves	23.0%
	#22	Coal boilers	77.0%
Coke	#21	Coal stoves	23.0%
	#22	Coal boilers	77.0%
Peat	#21	Coal stoves	NO
	#22	Coal boilers	NO
Industrial waste	#22	Coal boilers	NO
Char coal	BBQ	Barbecue	100.0%

NO…not occurring (in 2018)

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	11.4
1993	34.6	54.5	10.9	90.9	1.6	7.5	13.8	10.5	60.0	2.3	13.4
1994	33.0	54.7	12.2	87.6	2.0	10.4	13.3	10.2	58.4	3.0	15.2
1995	31.5	54.9	13.6	86.7	1.9	11.4	12.7	9.8	56.8	3.8	17.0
1996	30.0	55.0	15.0	85.8	1.7	12.4	12.1	9.3	55.2	4.8	18.6
1997	28.5	55.0	16.5	84.6	1.8	13.6	11.5	8.9	53.6	5.8	20.2
1998	27.0	55.0	17.9	84.2	1.8	14.0	10.9	8.5	52.6	6.5	21.5
1999	25.5	55.0	19.5	84.3	1.6	14.1	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	7.8	50.7	7.5	23.6
2001	22.5	55.3	22.2	82.9	1.5	15.6	9.1	7.6	50.7	8.0	24.6
2002	21.0	55.5	23.5	81.6	1.7	16.7	7.9	7.5	50.9	8.2	25.4
2003	19.5	55.9	24.6	85.2	1.3	13.5	6.7	7.5	51.3	8.4	26.1
2004	18.0	56.3	25.8	84.9	1.4	13.7	4.8	7.6	52.2	8.7	26.8
2005	15.8	56.7	27.5	70.1	2.5	27.4	4.2	7.2	52.3	8.3	28.0
2007	15.6	55.8	28.6	68.3	2.7	29.0	3.6	6.9	52.4	7.9	29.2
2007	15.6	54.8	29.6	59.3	3.7	37.1	3.0	6.5	52.3	7.5	30.6
2008	15.0	54.1	30.9	59.0	4.2	36.8	2.9	6.1	51.9	7.0	32.1
2009	14.4	53.4	32.2	53.5	5.7	40.8	2.8	5.6	51.3	6.5	33.7
2010	14.2	52.4	33.5	45.1	6.5	48.4	2.7	5.1	51.0	6.0	35.3
2011	14.5	50.9	34.6	32.2	9.3	58.4	2.5	4.5	50.3	5.4	37.3
2012	12.3	50.8	36.9	19.1	10.4	70.5	2.4	3.9	49.8	4.8	39.1
2013	10.4	50.3	39.3	12.3	10.8	76.9	2.3	3.3	49.1	4.1	41.2
2014	11.2	48.3	40.4	NO	15.7	84.3	2.4	2.6	48.4	3.3	43.3
2015	10.7	47.7	41.6	NO	15.6	84.4	2.3	1.8	47.7	2.5	45.7
2016	10.2	47.0	42.8	NO	14.0	86.0	2.1	1.0	47.3	1.8	47.8
2017	9.9	46.7	43.4	NO	12.9	87.1	2.0	0.5	46.6	1.7	49.2
2018	10.1	46.5	43.4	NO	13.1	86.9	2.0	0.3	45.7	1.6	50.4

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	27.2	4.1	66.2	NO	2.5	88.0	12.0	NO	NO	30.0	70.0
1991	25.5	5.5	65.7	NO	3.4	70.0	11.7	NO	18.3	29.3	70.7
1992	23.2	6.9	65.4	NO	4.5	57.9	12.3	NO	29.8	28.6	71.4
1993	21.0	8.3	65.0	NO	5.7	49.5	13.1	NO	37.4	28.0	72.0
1994	19.2	9.3	64.5	NO	7.0	43.2	13.9	NO	42.9	27.3	72.7
1995	17.6	10.1	64.1	NO	8.2	38.6	14.4	NO	47.0	26.6	73.4
1996	16.0	10.8	63.6	NO	9.6	34.8	15.1	NO	50.1	25.9	74.1
1997	14.7	11.2	63.1	NO	10.9	31.5	15.9	NO	52.7	25.2	74.8
1998	13.7	11.5	62.7	NO	12.2	28.5	16.7	NO	54.8	24.5	75.5
1999	12.6	11.7	62.1	NO	13.6	26.0	17.5	NO	56.5	23.8	76.2
2000	12.5	11.8	60.8	NO	14.9	23.6	18.4	NO	58.1	23.1	76.9
2001	12.0	9.9	61.5	NO	16.6	27.9	25.3	0.2	46.5	22.4	77.6
2002	11.1	8.4	62.2	0.1	18.2	30.9	32.2	1.1	35.8	21.7	78.3
2003	9.9	7.2	62.9	0.3	19.8	32.7	38.6	1.6	27.0	21.1	78.9
2004	10.1	6.9	61.8	0.5	20.7	28.5	38.3	1.8	31.5	20.4	79.6
2005	9.1	6.7	60.9	0.9	22.4	23.6	38.4	2.0	36.0	18.3	81.7
2007	9.5	7.2	58.1	1.6	23.6	18.4	35.5	2.4	43.7	18.4	81.6
2007	10.1	7.8	56.0	2.1	24.0	15.2	33.3	2.6	49.0	18.6	81.4
2008	9.6	7.8	55.4	2.7	24.5	13.5	34.6	2.6	49.3	16.7	83.3
2009	9.1	8.0	54.4	3.2	25.4	10.7	32.2	3.0	54.1	14.2	85.8
2010	8.8	8.1	53.4	3.6	26.1	8.4	29.0	3.3	59.2	18.0	82.0
2011	8.5	7.8	52.5	4.0	27.1	6.5	25.7	3.3	64.5	24.0	76.0
2012	8.7	8.1	51.1	4.3	27.8	5.0	22.2	3.0	69.8	23.7	76.3
2013	9.0	8.3	49.8	4.6	28.3	7.1	35.6	1.9	55.3	22.8	77.2
2014	9.3	8.7	48.6	4.8	28.7	6.5	35.6	1.9	56.0	20.9	79.1
2015	9.5	9.2	47.3	5.0	28.9	6.2	37.6	2.0	54.1	18.7	81.3
2016	9.3	9.1	46.9	5.2	29.5	5.4	35.8	2.2	56.6	20.3	79.7
2017	9.3	8.8	46.6	5.4	29.9	4.7	33.2	2.4	59.7	21.7	78.3
2018	9.5	8.4	46.3	5.6	30.2	4.7	35.1	2.5	57.7	23.0	77.0

NO…not occurring

Figure 37 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 2018 (ZAMG 2019).

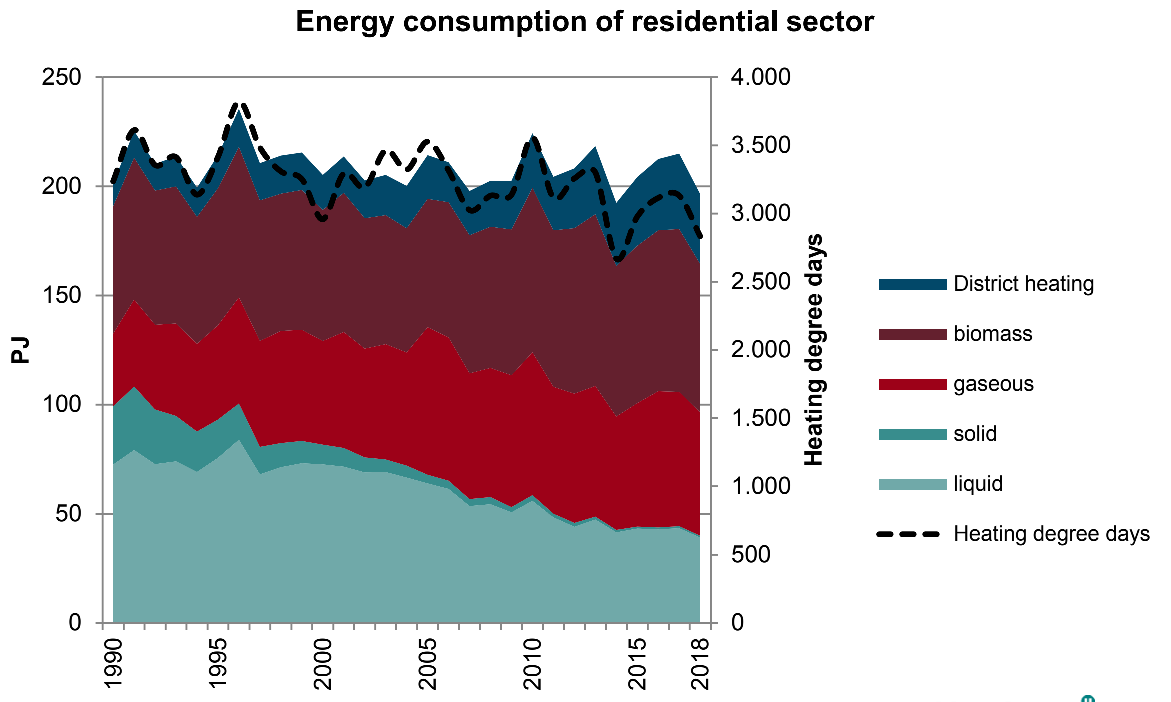


Figure 37: Energy consumption [PJ] of residential sector by type of fuel and number of heating degree days 1990–2018.

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

The fuel consumption reported in (IEA JQ 2019) 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 1990–2018.

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

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**
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
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	7.59	0.42	0.04	0.46	6.66	NO
2013	8.34	0.53	0.03	0.51	7.28	NO
2014	7.84	0.56	0.03	0.55	6.70	NO
2015	8.33	0.50	0.02	0.62	7.19	NO
2016	8.44	0.60	0.02	0.74	7.09	NO
2017	8.73	0.28	0.03	1.01	7.41	NO
2018	7.90	0.25	0.02	0.91	6.71	NO
Trend 1990–2018	**-23.0%**	**-95.4%**	**-95.5%**	**150.1%**	**67.6%**	**NO**
Trend 2016–2018	**-9.5%**	**-10.5%**	**-11.0%**	**-10.0%**	**-9.4%**	**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 2017c) 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, (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 2001–2018.

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	1.3%	1.0%	98.7%	99.0%
2002	2.5%	2.1%	97.5%	97.9%
2003	3.6%	3.2%	96.4%	96.8%
2004	4.8%	4.3%	95.2%	95.7%
2005	5.9%	5.4%	94.1%	94.6%
2006	7.1%	6.5%	92.9%	93.5%
2007	8.3%	7.6%	91.7%	92.4%
2008	9.4%	8.7%	90.6%	91.3%
2009	10.6%	9.7%	89.4%	90.3%
2010	11.7%	10.8%	88.3%	89.2%
2011	12.9%	11.9%	87.1%	88.1%
2012	14.1%	13.0%	85.9%	87.0%
2013	15.2%	14.1%	84.8%	85.9%

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
2014	16.4%	15.2%	83.6%	84.8%
2015	17.5%	16.3%	82.5%	83.7%
2016	18.7%	17.4%	81.3%	82.6%
2017	19.9%	18.4%	80.1%	81.6%
2018	21.0%	19.5%	79.0%	80.5%

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 1990–2018.

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%

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 2001–2018.

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	0.3%	1.8%	99.7%	98.2%
2002	1.5%	3.0%	98.5%	97.0%
2003	2.7%	4.2%	97.3%	95.8%
2004	3.9%	5.3%	96.1%	94.7%
2005	5.1%	6.4%	94.9%	93.6%
2006	6.3%	7.5%	93.7%	92.5%
2007	7.5%	8.6%	92.5%	91.4%
2008	8.7%	9.8%	91.3%	90.2%
2009	9.9%	10.9%	90.1%	89.1%
2010	11.2%	12.0%	88.8%	88.0%
2011	12.4%	13.1%	87.6%	86.9%
2012	13.6%	14.2%	86.4%	85.8%
2013	14.8%	15.4%	85.2%	84.6%
2014	16.0%	16.5%	84.0%	83.5%
2015	17.2%	17.6%	82.8%	82.4%
2016	18.4%	18.7%	81.6%	81.3%
2017	19.6%	19.8%	80.4%	80.2%
2018	20.8%	21.0%	79.2%	79.0%

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 2001–2018.

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%	1.5%	99.8%	98.5%
2002	1.4%	2.6%	98.6%	97.4%
2003	2.6%	3.7%	97.4%	96.3%
2004	3.9%	4.8%	96.1%	95.2%
2005	5.1%	5.9%	94.9%	94.1%
2006	6.4%	7.1%	93.6%	92.9%
2007	7.6%	8.2%	92.4%	91.8%
2008	8.8%	9.3%	91.2%	90.7%
2009	10.1%	10.4%	89.9%	89.6%
2010	11.3%	11.6%	88.7%	88.4%
2011	12.5%	12.7%	87.5%	87.3%
2012	13.8%	13.8%	86.2%	86.2%
2013	15.0%	15.0%	85.0%	85.0%
2014	16.3%	16.1%	83.7%	83.9%
2015	17.5%	17.2%	82.5%	82.8%
2016	18.7%	18.3%	81.3%	81.7%
2017	20.0%	19.5%	80.0%	80.5%
2018	21.2%	20.6%	78.8%	79.4%

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 2019) 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 2018.

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	36.4[(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	33.2	33.1	
#7	Natural gas convectors	Natural gas	51.0	51.0	41.8[(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	36.5 150.0	36.6 NO	
#10	LPG stoves	LPG and gas works gas	51.0	51.0	48.7[(1)]
#11	LPG boilers	LPG and gas works gas	44.0	44.0	
#12	Wood stoves and cooking stoves	Fuel wood Char coal	106.0 40.0	106.0 40.0	81.1[(1)]
#13	Tiled wood stoves and masonry heaters	Fuel wood	80.0	80.0	
#14	Mixed-fuel wood boilers	Fuel wood	NO	122.1	
#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	68.0[(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	
#21	Coal stoves	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	132.0 132.0 132.0 132.0 NO	90.4[(1)]
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 100.0	78.0 78.0 78.0 78.0 NO	

NO…not occurring (in 2018)

[(1)] *Implied emission factor*

Table 150: NFR 1.A.4. NMVOC emission factors for the year 2018.

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 Diesel Petroleum, other petroleum products	0.75 0.80 NO	NO NO NO	0.75 NO NO
#2	Gas oil stoves	Gas oil	1.50	1.50	0.80
#3	Vapourizing burners	Gas oil	0.80	0.80	
#4	Yellow burners	Gas oil	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	0.69(1)
#8	Atmospheric burners	Natural gas Biogas and landfill gas	0.51 0.51	0.51 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	0.20 0.20	0.20 NO	
#10	LPG stoves	LPG and gas works gas	2.00	2.00	1.50(1)
#11	LPG boilers	LPG and gas works gas	0.50	0.50	
#12	Wood stoves and cooking stoves	Fuel wood Char coal	579.05 2 000.00	583.59 2 000.00	347.92(1)
#13	Tiled wood stoves and masonry heaters	Fuel wood	338.00	338.00	
#14	Mixed-fuel wood boilers	Fuel wood	NO	422.99	
#15	Natural-draft wood boilers	Fuel wood	NO	350.00	
#16	Forced-draft wood boilers	Fuel wood	NO	325.00	
#17	Wood chips boilers with conventional technology	Wood waste	432.40	432.40	62.06(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 Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	333.30 333.30 333.30 333.30 NO	295.64(1)
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 0.54	284.40 284.40 284.40 284.40 NO	

NO…not occurring (in 2018)

(1) Implied emission factor

Table 151: NFR 1.A.4. CO emission factors for the year 2018.

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 Diesel Petroleum, other petroleum products	45.0 15.0 NO	NO NO NO	45.0 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 Biogas and landfill gas	48.0 48.0	48.0 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	37.0 37.0	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	
#12	Wood stoves and cooking stoves	Fuel wood Char coal	3 891.5[(1)] 8 100.0	3 920.6[(1)] 8 100.0	2 408.9[(2)]
#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	4 209.4	
#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	460.8[(2)]
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	776.2[(1)]	776.2[(1)]	
#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 Lignite and brown coal Brown coal briquettes Coke Peat	NO NO NO NO NO	3 705.0 3 705.0 3 705.0 3 705.0 NO	4 206.0
#22	Coal boilers	Hard coal and hard coal briquettes Lignite and brown coal Brown coal briquettes Coke Industrial waste	NO NO NO NO 200.0	4 206.0 4 206.0 4 206.0 4 206.0 NO	

NO…not occurring (in 2018)

[(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 2018.

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 Diesel Petroleum, other petroleum products	90.00 18.76 NO	NO NO NO	90.0 NO NO
#2	Gas oil stoves	Gas oil	0.47	0.47	0.47
#3	Vapourizing burners	Gas oil	0.47	0.47	
#4	Yellow burners	Gas oil	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	
#7	Natural gas convectors	Natural gas	0.30	0.30	0.30
#8	Atmospheric burners	Natural gas Biogas and landfill gas	0.30 NA	0.30 NO	
#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 Char coal	11.00	11.00	11.00
#13	Tiled wood stoves and masonry heaters	Fuel wood	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	11.00
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	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 2018)

Table 153: NFR 1.A.4. NH_3 emission factors for the year 2018.

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	2.68	NO	2.68
		Diesel	2.68	NO	NO
		Petroleum, other petroleum products	NO	NO	NO
#2	Gas oil stoves	Gas oil	2.68	2.68	
#3	Vapourizing burners	Gas oil	2.68	2.68	
#4	Yellow burners	Gas oil	2.68	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	
#8	Atmospheric burners	Natural gas	1.00	1.00	
		Biogas and landfill gas	1.00	NO	1.00
#9	Forced-draft natural gas burners	Natural gas	1.00	1.00	
		Biogas and landfill gas	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	5.00	5.00	
		Char coal			
#13	Tiled wood stoves and masonry heaters	Fuel wood	5.00	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	
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	5.00	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	NO	0.0089	
		Lignite and brown coal	NO	0.023	
		Brown coal briquettes	NO	0.023	
		Coke	NO	0.0088	
		Peat	NO	NO	0.018[1)]
#22	Coal boilers	Hard coal and hard coal briquettes	NO	0.0089	
		Lignite and brown coal	NO	0.023	
		Brown coal briquettes	NO	0.023	
		Coke	NO	0.0088	
		Industrial waste	0.023	NO	

NO…not occurring (in 2018)

[(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

NFR 1.A.4.c

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.

NFR 1.A.4.b

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

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 50% higher.

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 2017c).

Table 154: NFR 1.A.4. Cd emission factors for the year 2018.

No.	Heating type	Fuel	Emission factors Cd [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
#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	0.00025	0.00025	NE
#8	Atmospheric burners	Natural gas Biogas and landfill gas	0.00025 0.00025	0.00025 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	0.00025 0.00025	0.00025 NO	
#10	LPG stoves	LPG and gas works gas	0.02	0.02	NE
#11	LPG boilers	LPG and gas works gas	0.02	0.02	
#12	Wood stoves and cooking stoves	Fuel wood Char coal	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	4.50	
#15	Natural-draft wood boilers	Fuel wood	NO	4.50	
#16	Forced-draft wood boilers	Fuel wood	NO	4.50	
#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	4.30[(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 2018)

NE…not estimated

NA…not applicable

[(1)] *Implied emission factor*

Table 155: NFR 1.A.4. Hg emission factors for the year 2018.

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	
#7	Natural gas convectors	Natural gas	0.10	0.10	NE
#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	NE
#11	LPG boilers	LPG and gas works gas	0.007	0.007	
#12	Wood stoves and cooking stoves	Fuel wood Char coal	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	9.73[(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 2018)

NA…not applicable

[(1)] *Implied emission factor*

Table 156: NFR 1.A.4. Pb emission factors for the year 2018.

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
#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	NE
#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	NE
#11	LPG boilers	LPG and gas works gas	0.02	0.02	
#12	Wood stoves and cooking stoves	Fuel wood Char coal	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	45.90[(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 2018)

NA…not applicable

[(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 2016, the national study (HÜBNER et al. 2002) and 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).

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 2018.

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 0.00069[1]	0.0025 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	0.0016 0.00069[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	
#12	Wood stoves and cooking stoves	Fuel wood Char coal	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	0.10[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	0.47[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 2018)

[1] Implied emission factor

Table 158: NFR 1.A.4. HCB emission factors for the year 2018.

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	
#7	Natural gas convectors	Natural gas	0.60	0.60	0.25
#8	Atmospheric burners	Natural gas Biogas and landfill gas	0.14 0.078[(1)]	0.25 NO	
#9	Forced-draft natural gas burners	Natural gas Biogas and landfill gas	0.14 0.078[(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 Char coal	600	600	600
#13	Tiled wood stoves and masonry heaters	Fuel wood	600	600	
#14	Mixed-fuel wood boilers	Fuel wood	NO	600	
#15	Natural-draft wood boilers	Fuel wood	NO	160	
#16	Forced-draft wood boilers	Fuel wood	NO	100	
#17	Wood chips boilers with conventional technology	Wood waste	240	240	81.93[(1)]
#18	Wood chips boilers with oxygen sensor emission control	Wood waste	160	160	
#19	Pellet stoves	Wood waste	100	100	
#20	Pellet boilers	Wood waste	30	30	
#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 2018)

(1) Implied emission factor

Table 159: NFR 1.A.4. PAH4 emission factors for the year 2018.

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	0.040
#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	0.040
#11	LPG boilers	LPG and gas works gas	0.011	0.040	
#12	Wood stoves and cooking stoves	Fuel wood	345	345	177.20[(1)]
#13	Tiled wood stoves and masonry heaters	Fuel wood Char coal	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	85
#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	81.41[(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 2018)

[(1)] *Implied emission factor*

Table 160: NFR 1.A.4.a.1 share of total PAH4 emissions 2018.

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 2018)

Table 161: NFR 1.A.4.b.1 share of total PAH4 emissions 2018.

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%
#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 2018)

Table 162: NFR 1.A.4. PCB emission factors for the year 2018.

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	
#12	Wood stoves and cooking stoves	Fuel wood Char coal	0.0675	0.0675	0.0244[(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	0.0092[(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 2018)

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 2017c) 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 2018.

No.	Heating type	Fuel	Conden-sable fraction	Emission factors PM [kg/TJ]		
				1.A.4.a	1.A.4.b	1.A.4.c
#1	Fuel oil boilers	Residual fuel oil[84] Diesel[85] Petroleum, other petroleum products	unknown unknown NO	6.67 50 NO	NO NO NO	6.67 NO NO
#2	Gas oil stoves	Gas oil[86]	unknown	3.0	3.0	2.25 (1)
#3	Vapourizing burners	Gas oil[86]	unknown	3.0	3.0	
#4	Yellow burners	Gas oil[86]	unknown	3.0	3.0	
#5	Blue burners with conventional technology	Gas oil[87]	excluded	2.0	2.0	
#6	Blue burners with low temperature or condensing technology	Gas oil[87]	excluded	1.5	1.5	
#7	Natural gas convectors	Natural gas[88]	excluded	2.20	2.20	0.72(1)
#8	Atmospheric burners	Natural gas[86] Biogas and landfill gas[86]	unknown unknown	0.50 0.50	0.50 NO	
#9	Forced-draft natural gas burners	Natural gas[89] Biogas and landfill gas[89]	unknown unknown	0.20 0.20	0.20 NO	
#10	LPG stoves	LPG and gas works gas[90]	unknown	2.20	2.20	1.64(1)
#11	LPG boilers	LPG and gas works gas[86]	unknown	0.50	0.50	
#12	Wood stoves and cooking stoves	Fuel wood[91] Char coal[91]	included	148	148	101.98(1)
#13	Tiled wood stoves and masonry heaters	Fuel wood[92]	unknown	100	100	
#14	Mixed-fuel wood boilers	Fuel wood[93]	included	NO	122.1	
#15	Natural-draft wood boilers	Fuel wood[94]	excluded	NO	75	

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

[85] For diesel a value similar to locomotive diesel engines has been selected

[86] WINIWARTER et al. (2001)

[87] EMEP/EEA Guidebook 2016, Table 3-21 Boilers burning liquid fuels

[88] EMEP/EEA Guidebook 2016, Table 3-13 Fireplaces burning natural gas

[89] EMEP/EEA Guidebook 2016, Table 3-19 Boilers burning natural gas

[90] EMEP/EEA Guidebook 2016, Table 3-20 Stoves burning liquid fuels

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

[92] FOEN (2015)

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

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

No.	Heating type	Fuel	Condensable fraction	Emission factors PM [kg/TJ]		
				1.A.4.a	1.A.4.b	1.A.4.c
#16	Forced-draft wood boilers	Fuel wood[92]	unknown	NO	50	
#17	Wood chips boilers with conventional technology	Wood waste[92]	unknown	100	100	
#18	Wood chips boilers with oxygen sensor emission control	Wood waste[91]	included	55	55	33.82[(1)]
#19	Pellet stoves	Wood waste[91]	included	30	30	
#20	Pellet boilers	Wood waste[95]	unknown	19	19	
#21	Coal stoves	Hard coal and hard coal briquettes[86]	unknown	NO	153	
		Lignite and brown coal[86]	unknown	NO	153	
		Brown coal briquettes[86]	unknown	NO	153	
		Coke[86]	unknown	NO	153	
		Peat[86]	unknown	NO	NO	107.56[(1)]
#22	Coal boilers	Hard coal and hard coal briquettes[86]	unknown	NO	94	
		Lignite and brown coal[86]	unknown	NO	94	
		Brown coal briquettes[86]	unknown	NO	94	
		Coke[86]	unknown	NO	94	
		Industrial waste[86]	unknown	55	NO	

NO…not occurring (in 2018)

(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 char coal 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 char coal has been selected which is 69 347 g/t char coal 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 char coal consumption (validation not possible at current) and the high uncertainty of PM estimates from this source it has been chosen to keep this approach.

[95] GERMAN ENVIRONMENT AGENCY (2008)

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*).

Changes according to revision of energy demand model for space heating

The module 'Heating type by technology' was updated with a new approach considering recent market data and expert consultation (on sales by fuel technology). This information was used for remodelling the heating stock and turnover based on two studies (E7 ENERGIE MARKT ANALYSE GMBH 2009, 2017) resulting in revised percentual consumption by type of heating (see Table 132 to Table 134, Table 136 to Table 138).

Additionally, the mixed-fuel wood boiler stock was subdivided into two categories (advanced and conventional, see Table 143). Advanced technology is considered with (slightly) lower NO_x, CO, NMVOC, CH_4 and PM emissions than conventional equipment.

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
NFR 1.A.4 Other Sectors			
● Residential	1.A.4.b.2	0809	Other Mobile Sources and Machinery-Household and gardening

Activity	NFR Category	SNAP	
• 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 161 provides information on the status of emission estimates of all sub categories. A "✓" indicates that emissions from this sub category have been estimated. Table 160 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 162.

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, CO, Pb[1)], TSP[1)], PM_{10}, $PM_{2.5}$	LA, TA
1.A.3.b.2	R.T., Light duty vehicles	NO_x, PM_{10}, $PM_{2.5}$	LA, TA
1.A.3.b.3	R.T., Heavy duty vehicles	NO_x, PAH[1)] TSP[1)], PM_{10}[1)], $PM_{2.5}$	LA, TA
1.A.3.b.4	R.T., Mopeds & Motorcycles	NMVOC, CO	LA, TA
1.A.3.b.5	R.T., Gasoline evaporation	NMVOC	TA
1.A.3.b.6	R.T., Automobile tyre and break wear	Cd, TSP, PM_{10}, $PM_{2.5}$	LA, TA
1.A.3.b.7	R.T., Automobile road abrasion	TSP, PM_{10}, $PM_{2.5}$	LA, TA
1.A.3.c	Railways	TSP, PM_{10}	LA

LA = Level Assessment (if not further specified – for the years 1990 and 2017)

TA = Trend Assessment 2016

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 2016 (EEA 2016), using an average of the default values, based on the definitions of the qualitative ratings (see Chapter 1.7 and Table 25). 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 have been consulted. For NMVOC, cold start and aged gasoline vehicles are very uncertain (rating level C – 125%); for $PM_{2.5}$ lies the uncertainty before all in the non-exhaust emissions (rating level C – 125%); for NH_3 the rating level 3 (200%) has been suggested.

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* contains flights according to Visual Flight Rules (VFR) and Instrument Flight Rules (IFR) for domestic aviation (national LTO – landing/take off) and for international aviation (international LTO – landing/take off). 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

For the years 1990–1999 a country-specific methodology was applied. The calculations are based on a study commissioned by the Umweltbundesamt finished in 2002 (KALIVODA/KUDRNA 2002). This methodology is consistent with the very detailed IPCC 2006 GL Tier 3B methodology (advanced version based on the MEET model (KALIVODA/KUDRNA 1997): air traffic movement data[96] (flight distance and destination per aircraft type) and aircraft/engine performances data were used for the calculation.

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.

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

VFR – Visual Flight Rules

The EMEP/EEA 2016 (EEA 2016) 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: 1990–2018.

Year	Activity		
	dom. LTO	dom. LTO	int. LTO
	Kerosene [TJ]	Gasoline [TJ]	Kerosene [TJ]
1990	137	103	1,241
1991	148	106	1,417
1992	159	109	1,593
1993	170	113	1,769
1994	181	116	1,945
1995	192	93	2,121
1996	222	89	2,266
1997	252	100	2,412
1998	283	108	2,557
1999	290	115	2,614
2000	265	84	2,890
2001	217	77	2,743
2002	226	99	3,207
2003	221	107	3,342
2004	237	99	3,987
2005	225	115	3,714
2006	269	119	3,680
2007	274	118	3,979
2008	305	121	4,044
2009	280	135	3,700
2010	267	121	3,794
2011	231	182	4,314
2012	232	105	4,147
2013	232	108	4,035
2014	211	99	4,080
2015	205	111	4,309
2016	203	135	4,406
2017	189	98	4,267
2018	221	95	4,639
1990–2018	61%	-8%	274%

IFR flights

For the years 1990–1999 fuel consumptions for the different transport modes IFR national LTO, IFR international LTO, IFR national cruise and IFR international cruise as obtained from the MEET model (KALIVODA & KUDRNA 1997) were summed up to a total fuel consumption figure. This value was compared with the total amount of kerosene sold in Austria of the national energy balance. As „fuel sold" is a robust value, the fuel consumption of IFR international cruise was adjusted so that the total fuel consumption of the calculations according to the MEET model is consistent with national fuel sales figures from the energy balance. The reason for choosing IFR international cruise for this adjustment is that this mode is assumed to have the highest uncertainty.

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 above.

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. Up to the submission 2017 flight movements were obtained from special analyses by Statistik Austria (STATISTIK AUSTRIA 2008[97], 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016). In addition, domestic flight movements were compared with a second data source for flight movements, Austrocontrol (AUSTRO CONTROL 2007[98], 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018). Since the submission 2018 flight movements are only taken from Austrocontrol, as they seem to be more representative compared with international data.

Up to the submission 2017 the distances between airport pairs have been extracted based on IATA codes from single queries on the internet.[99] This approach has been changed in the submission 2018, as an automatic distance generator has been applied in the calculation model based on the great circle distance:

$$e = r \cdot \arccos(\sin(\varphi A) \cdot \sin(\varphi B) + \cos(\varphi A) \cdot \cos(\varphi B) \cdot \cos(\lambda B - \lambda A))$$

A…departure aerodrome
B…arrival aerodrome

Each 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 always been and is still being compared to the total fuel sold reported by the national energy balance (IEA 2017). If the bottom up approach underestimates fuel sold, the delta has been fully allocated to international cruise, as the domestic flight movements had already been increased in line with Austrocontrol data. From the submission 2018 onwards any delta between the bottom up result and the official amount of kerosene sold is being allocated to domestic LTO, international LTO, national cruise and international cruise depending on their relative shares in total kerosene consumption.

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[97] for the years 2000–2007

[98] for the years 2000–2006

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

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.

The following table shows activity data and the numbers of national LTOs (IFR) which were obtained from the MEET Model (KALIVODA & KUDRNA 1997) for the years 1990–1999. Numbers of flight movements from 2000 onwards are taken from Statistik Austria, and for the year 2016 and onwards from Austrocontrol.

Table 170: Fuel consumption for VFR and IFR flights and number of IFR LTO cycles: 1990–2018.

Year	Activity				
	VFR Gasoline [kt]	**nat. LTO IFR Kerosene [kt]**	**nat. LTO IFR [flight mvts]**	**int. LTO Kerosene [kt]**	**int. LTO IFR [flight mvts]**
1990	2.49	3.16	6,220	28.65	41,689
1991	2.56	3.42	6,644	32.71	41,689
1992	2.64	3.67	7,450	36.77	48,574
1993	2.72	3.92	7,947	40.83	55,459
1994	2.81	4.18	8,219	44.90	62,344
1995	2.24	4.43	8,923	48.96	69,230
1996	2.15	5.13	10,233	52.31	76,115
1997	2.42	5.83	11,013	55.67	81,721
1998	2.60	6.53	12,025	59.03	87,327
1999	2.77	6.70	12,210	60.34	92,933
2000	2.04	6.11	22,611	66.71	95,033
2001	1.87	5.01	20,325	63.33	97,740
2002	2.39	5.21	21,422	74.04	95,961
2003	2.60	5.10	20,243	77.15	97,873
2004	2.41	5.47	20,175	92.03	110,470
2005	2.79	5.20	20,179	85.74	117,837
2006	2.87	6.20	20,727	84.94	120,757
2007	2.86	6.33	20,740	91.85	129,737
2008	2.94	7.04	21,457	93.35	132,466
2009	3.27	6.46	20,530	85.41	120,723
2010	2.92	6.16	20,532	87.57	123,759
2011	4.40	5.32	16,185	99.58	140,058
2012	2.54	5.37	16,405	95.73	135,691
2013	2.61	5.35	15,741	93.14	129,500
2014	2.38	4.87	14,776	94.11	130,674
2015	2.65	4.73	13,282	99.39	129,921
2016	3.28	4.70	15,515	101.76	151,241
2017	2.39	4.37	14,781	98.55	145,143
2018	2.30	5.11	19,735	107.15	157,722
1990–2018	-8%	62%	217%	274%	278%

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 the years 1990–1999 SO_2 emissions were taken from the national aviation study commissioned by Umweltbundesamt (KALIVODA & KUDRNA 2002).

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 2016 Guidebook per aircraft type and distance class are applied.

NO_x, CO

For the years 1990–1999 emission estimates for fuel consumption, NO_x and CO were taken from an aviation study commissioned by Umweltbundesamt (KALIVODA & KUDRNA 2002) and the emission factors are aircraft/engine specific.

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 2016 Guidebook per aircraft type and distance class are applied.

NMVOC

For the years 1990–1999 NMVOC emissions for IFR flights have been calculated like NO_x (VOC emissions calculated with a country specific method where the percentile rate share of NMVOC from total HC emission was calculated. (KALIVODA & KUDRNA 2002).

For the years 2000–2015 NMVOC emissions for IFR flights have been calculated in this way: Total VOC_HC emissions have been calculated with the implied emission factor for the year

1999 as obtained from the national aviation study (KALIVODA & KUDRNA 2002) and deducted by CH_4 emissions.

For the years from 2016 onwards total HC emissions have been calculated applying the EFs from Annex 5 of the EMEP/EEA 2016 Guidebook (per aircraft type and distance class) and deducted by CH_4 emissions to estimate NMVOC emissions.

NH_3

For the years 1990–1999 NH_3 emissions for IFR flights have been calculated like NO_x (KALIVODA & KUDRNA 2002).

For the years from 2000 onwards NH_3 emissions for IFR flights have been calculated with an IEF from the year 2000 obtained from the study mentioned above (KALIVODA & KUDRNA 2002).

No NH_3 EFs are included in Annex 5 of the EMEP/EEA 2016 Guidebook per aircraft type and distance class.

$PM_{2.5}$

For the years 1990–1999 emission estimates were taken from the national aviation study (KALIVODA & KUDRNA 2002).

For the years from 2000 onwards $PM_{2.5}$ emissions for IFR flights have been calculated with an IEF from the year 2000 obtained from the study mentioned above (KALIVODA & KUDRNA 2002).

VFR flights

For the years 1990–1999 emission estimates were taken from the national aviation study (KALIVODA & KUDRNA 2002).

From the submission 2018 onwards, for the years from 2000 onwards SO_2, NO_x, NMVOC and CO emissions of VFR flights have been calculated with EFs according to the EMEP/EEA 2016 Guidebook (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 & KUDRNA 2002).

Table 171: Tier 1 EF according to the EMEP/EEA GB 2016

EFs (EMEP/EEA 2016, Tier 1)	
	[kg/t fuel]
SO_x	1.0
NO_x	4.0
NMVOC	19.0
CO	1200.0

Table 172: IEF for the year 2000 according to (KALIVODA & KUDRNA 2002)

IEF (Kalivoda & Kudrna 2002)		
2000	**[t]**	**[kg/t fuel]**
Fuel	2 039	
NH_3	0.06	0.03

$PM_{2.5}$	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 173: Activities and Implied emission factors for NEC gases for 1.A.3.a.ii Civil Aviation (domestic LTO + international LTO): 1990–2018.

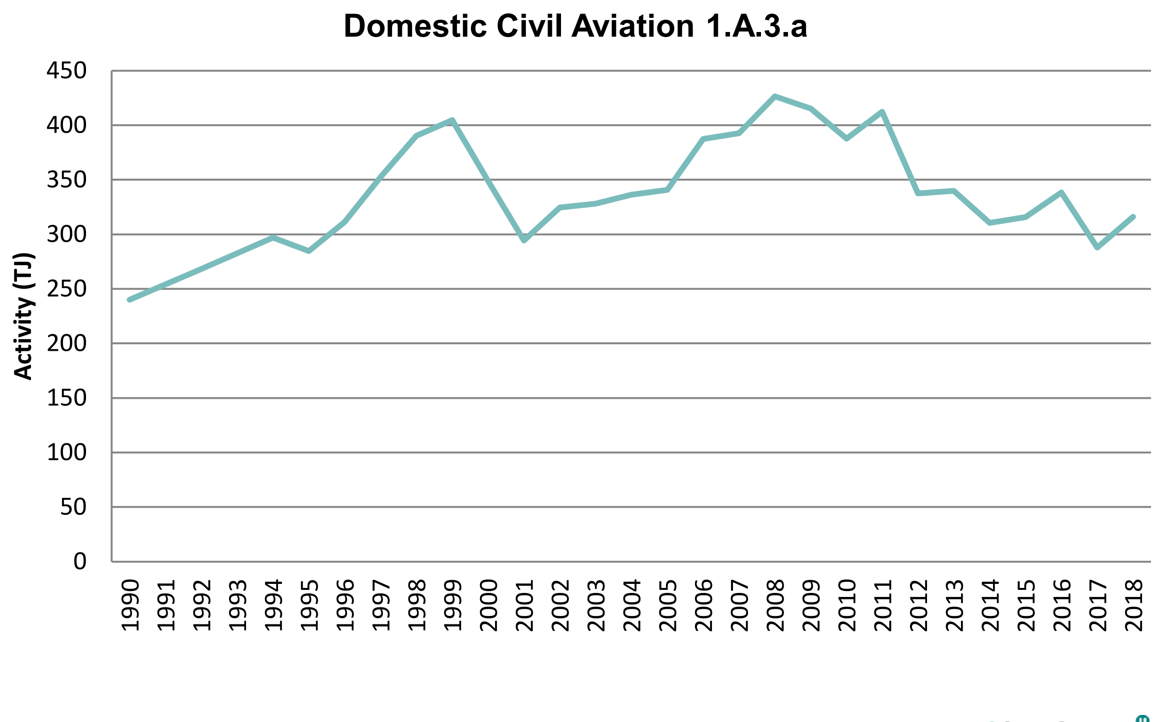
Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	1,481	22.2	275.5	137.8	0.20	23.5
1991	1,671	22.3	276.8	128.4	0.19	23.6
1992	1,861	22.3	277.9	121.0	0.19	23.7
1993	2,051	22.4	278.8	115.0	0.19	23.8
1994	2,242	22.4	279.4	110.0	0.19	23.9
1995	2,405	22.6	282.3	101.9	0.18	24.2
1996	2,577	22.6	282.5	110.7	0.18	24.3
1997	2,764	22.6	281.7	120.1	0.18	24.2
1998	2,948	22.6	281.1	128.0	0.18	24.2
1999	3,018	22.6	284.3	125.0	0.18	24.2
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	4,955	19.5	326.7	41.7	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)



Source: Umweltbundesamt

Figure 38:Activity data from 1.A.3.a domestic Civil Aviation: 1990–2018.

<u>Tier 3B (1990–1999) & Tier 3A (2000–2015)</u>

From 1999 onwards a different methodology of emissions estimation has been applied for IFR flights. For the years 1990–1999 a country-specific methodology (consistent with the IPCC 2006 GL Tier 3B methodology), for the years from 2000 onwards the Tier 3A methodology was applied.

To show that there is no underestimation of domestic aviation emissions, domestic fuel consumption is multiplied with the default CO_2 emission factor of 3 150 kg CO_2/Mg fuel (CORINAIR, KALIVODA & KUDRNA 2002). Total reported CO_2 emissions for domestic aviation in the year 2000 are consistent with the IPCC 2006 GL Tier 3A methodology (new method), whereas the Tier 3B methodology (old method) deviates by 22%.

Table 174: Methodology dependent calculation of CO_2 emissions from 1.A.3.a Civil Aviation in 2000.

	dom LTO	**dom. LTO**	**dom. cruise**	**dom.**	**deviation**
	gasoline	**kerosene**		**total**	
2000		**CO_2 [kt]**			**%**
OLI2016 (1990–2015)	6.4	19.3	41.6	67.24	
CORINAIR CO_2 default EF Tier 3B methodology	6.4	21.6	54.1	82.11	22.1
CORINAIR CO_2 default EF Tier 3A methodology	6.4	19.2	41.5	67.18	-0.1

Since there is no systematic deviation between the two models' results, Austria has decided not to replace the more accurate data applied for the period 1990–1999 (FCCC/ARR/2011/AUT§46).

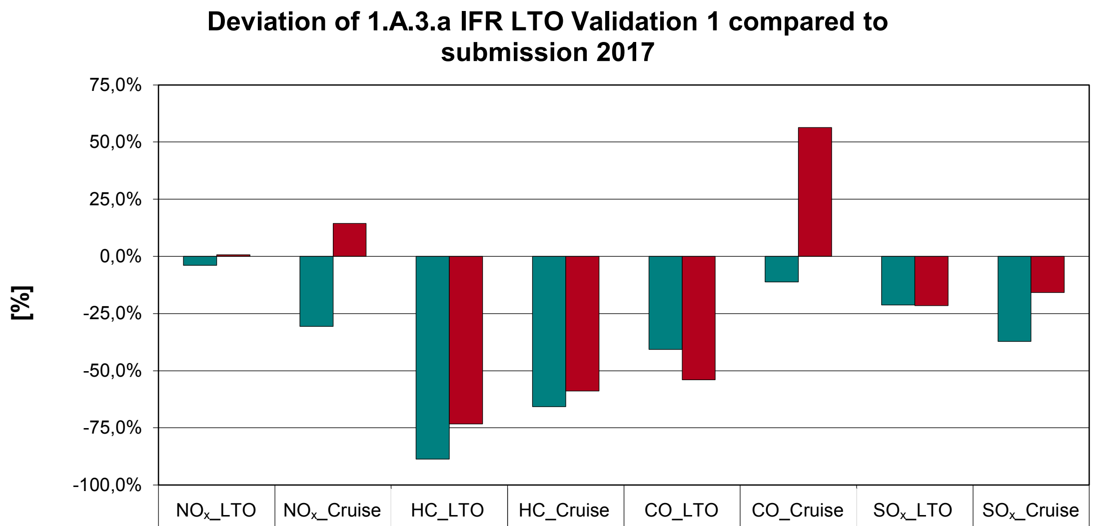
The peak of activity data and GHG emissions in 1999, followed by a decrease within two years by nearly 30% is an artefact due to the shortcomings of the method used from 1999 onwards. The old methodology reflects much better real-world effects, because this methodology is consistent with the very detailed IPCC 2006 GL Tier 3B methodology (advanced version based on MEET (KALIVODA & KUDRNA 1997): air traffic movement data (flight distance and destination per aircraft type) and aircraft/engine performances data were used for the calculation. Due to budgetary constraints such a detailed study has not been repeated since then.

<u>Tier 3A updated (from submission 2018 onwards)</u>

For the 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 year 2015 has been calculated within 2 steps:

In a first step (validation 1), for the validation of the updated calculation tool, the results for the 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 <u>with the new set of available aircraft types and emission factors</u>.



	NO_x_LTO	NO_x_Cruise	HC_LTO	HC_Cruise	CO_LTO	CO_Cruise	SO_x_LTO	SO_x_Cruise
Domestic	-3,9%	-30,6%	-88,6%	-65,7%	-40,7%	-11,2%	-21,3%	-37,2%
International	0,6%	14,4%	-73,2%	-58,9%	-54,0%	56,3%	-21,6%	-15,8%

Source: Umweltbundesamt

Figure 39: 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 previous submission with activity data from 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 40: Comparison of FC and emissions of known aircraft types.

An analysis of domestic flight movements in the 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[100] with 25%

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 aircrafts 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%

[100] 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.

- 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 anymore 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%	
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/KUDRNA 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 39. The HC IEF for domestic cruise is 64% lower; for international cruise 59% lower which is in line with the deviations shown in Figure 39.

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

kg/kg fuel	**DOMESTIC**		**INTERNATIONAL**	
	KALIVODA/KUDRNA 2002 IEFs	**Tier 3A updated IEFs**	**KALIVODA/KUDRNA 2002 IEFs**	**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/KUDRNA 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 39.

Table 178: Implied emission factors of HC for IFR kerosene for 2015.

kg/kg fuel	DOMESTIC		INTERNATIONAL	
	KALIVODA/KUDRNA 2002 IEFs	Tier 3A updated IEFs	KALIVODA/KUDRNA 2002 IEFs	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

In a second step (validation 2), the results for the 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.

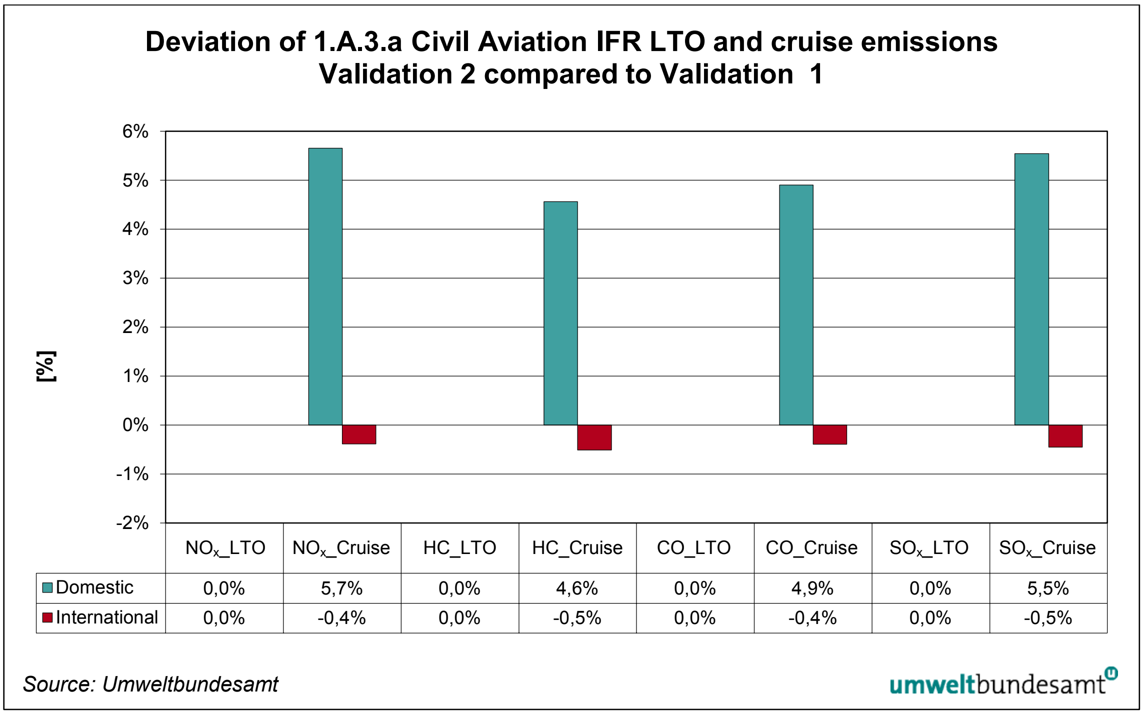


Figure 41: Deviation of emissions of 1.A.3.a Civil Aviation – Validation 2.

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[101], an underestimation of emissions can be excluded.

Category-specific Recalculations

No recalculations were made

Category-specific Planned Improvements

No category-specific improvements are planned.

3.2.5 NFR Memo Item 1.A.3.a Civil Aviation – Cruise

In 2018, 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.

[101] GHG emissions from fuel export are included in 1.A.3.b, and are presented separately in Table 66 (Chapter 3.2.12.2)

Methodological Issues

Emissions from International Bunkers have been calculated using the methodology and emission factors as described in Chapter *1.A.3.a Civil aviation*.

Activity Data

Activity data of domestic and international cruise increased over the period from 1990–2018 by about 61% and 175% respectively which is shown in the following table.

Table 179: Activities for Civil Aviation – Cruise: 1990–2018.

Year	Kerosene	
	Domestic cruise [TJ]	International cruise [TJ]
1990	195	10,943
1991	257	12,251
1992	318	13,224
1993	380	13,909
1994	442	14,361
1995	503	16,134
1996	558	17,900
1997	612	18,568
1998	667	19,147
1999	705	18,588
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
1990–2018	61%	175%

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: 1990–2018.

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	11,138	23.1	219.0	16.2	0.16	25.0
1991	12,508	23.1	220.3	16.3	0.16	25.0
1992	13,543	23.1	221.4	16.5	0.16	25.0
1993	14,289	23.1	222.5	16.7	0.16	25.0
1994	14,802	23.1	223.5	16.9	0.16	25.0
1995	16,638	23.1	224.4	17.2	0.16	25.0
1996	18,458	23.1	224.1	18.3	0.16	25.0
1997	19,181	23.1	223.9	19.2	0.16	25.0
1998	19,814	23.1	223.8	20.0	0.16	25.0
1999	19,293	23.1	224.2	20.0	0.16	25.0
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

Emission factors for heavy metals are presented in chapter 3.2.8.

Category-specific Recalculations

No recalculations have been made in this year's submission

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 is needed.

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.

The traffic volumes up to and including 2007 are taken from Austrian National Transport Model "VMOe 2025+" Verkehrs-Mengenmodell-Österreich (Federal Transport Model, Ministry of Transport, BMVIT, not published).

Mileage data after 2007 to submission 2019 is calculated from the growth rates according to the final results of the automatic traffic counting stations and the toll data.

In this year's submission the traffic volume sources are as follows:

For the first time, data from the periodic roadworthiness tests has been evaluated resulting in new age-related mileage data. This affects the categories PC, LDV and MC. In the case of cars, the analysis of this new data source led to the following findings (SCHWINGSHACKL, M.; REXEIS, M.. (2019a)::

- old vehicles drive more than previously assumed and in general
- the specific mileage per car per vehicle age- year is lower than previously assumed
- These facts generally lead to a decrease in the total domestic mileage of passenger cars over the entire time series

The data quality for these vehicle categories could thus be significantly improved.

The data source of the previous submissions has been retained for heavy commercial vehicles and buses (VMOe 2025+" Verkehrs-Mengenmodell-Österreich + growth rates according to the final results of the automatic traffic counting stations and the toll data).

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[102]

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 et al. 2004; MOLITOR 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.

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[102] 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).

Gasoline fuel export is calculated from the inland gasoline consumption and the difference to the total sales of gasoline in Austria. The difference is being assigned to the gasoline fuel export in cars. Fuel consumption of diesel fuel export with cars is being calibrated in proportion to the diesel share of the foreign car fleet based on the relation between FC of gasoline cars in fuel export and FC of gasoline cars in inland. After having calculated the diesel export in cars the diesel export of trucks can be estimated by total diesel sales minus diesel FC inland minus diesel export in cars (HAUSBERGER/SCHWINGSHACKL/REXEIS 2015, p.22).

NEMO – Network Emission Model

Emissions from *Mobile Combustion* have so far been calculated with the model GLOBEMI (HAUSBERGER 1997; HAUSBERGER/SCHWINGSHACKL/REXEIS 2015a,b). The calculations have been based on a detailed depiction of fleet composition, driving behaviour, related energy consumption and emission factors.

From the submission in 2015 (1990–2013) onwards calculations are based on the model NEMO – Network Emission Model (DIPPOLD/REXEIS/HAUSBERGER 2012; HAUSBERGER/ SCHWINGSHACKL/ REXEIS 2015a,b, 2018). NEMO is set up on the same methodology as the former model GLOBEMI and 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 42 shows a schematic picture of the methodology of NEMO.

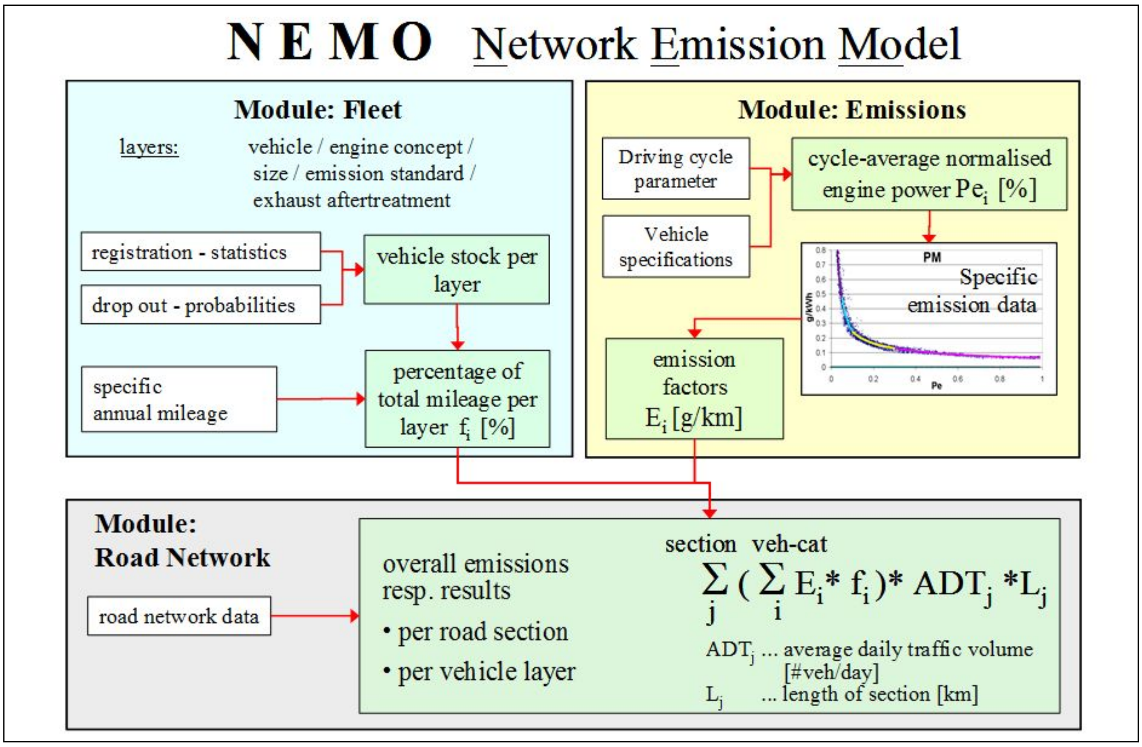

Figure 42: Schematic picture of the NEMO model.

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.

$$stock_{Jg_i,\mathrm{year}\,i} = stock_{Jg_i,\mathrm{year}\,i-1} \times \mathrm{survival\ probability}_{Jg_i}$$

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)

$$\mathrm{total\ mileage}_{E_i} = \sum_{Jg=\mathrm{start.}}^{\mathrm{end}} (\mathrm{stock}_{Jg,\mathrm{year}\,i} \times \mathrm{km/vehicle}_{Jg_i,\mathrm{year}\,i})$$

4) Calculation of the total fuel consumption and emissions of each emission category

$$\mathrm{Emission}_{E_i} = \mathrm{total\ mileage}_{E_i} \times \mathrm{emission\ factor}_{K_j,E_i}$$

5) Calculation of the total fuel consumption and emissions of each vehicle category

$$\mathrm{Emission}_{\mathrm{veh.category}} = \sum_{E_i=1}^{end} \mathrm{Emission}_{E_i}$$

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 2017 to 2018 fuel consumption in TJ (gasoline, diesel and alternative fuels including liquid biomass) of road transport increased by 0.7%. Specific consumption per average vehicle kilometer per vehicle category did not improve for diesel passenger cars and light duty vehicles between 2017 and 2018; it declined by 0.9% for gasoline passenger cars, and by 0.7% 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: 1990–2018.

	Fuel consumption (based on fuel sold) [TJ]					
Year	**total**	**gasoline**	**diesel oil**	**LPG**	**gaseous**	**biomass**
1990	176,826	103,899	72,514	413	-	-
1991	196,386	113,961	81,998	428	-	-
1992	196,215	108,959	86,811	444	-	-
1993	198,243	104,519	93,273	451	-	-
1994	199,009	100,775	97,772	462	-	-
1995	202,791	97,340	104,957	494	-	-
1996	224,095	90,040	133,386	670	-	-
1997	210,964	85,342	125,092	530	-	-
1998	237,523	89,286	147,648	590	-	-
1999	229,403	82,982	145,799	622	-	-
2000	241,747	80,175	160,901	672	-	-
2001	259,856	80,754	178,379	722	-	-
2002	288,170	86,946	200,239	984	-	-
2003	311,792	88,915	221,744	1,132	-	-
2004	318,769	86,497	231,311	947	14	-
2005	325,692	84,058	238,568	977	16	2,073
2006	313,467	80,670	223,912	1,005	15	7,865
2007	317,097	78,772	228,455	968	76	8,827
2008	299,955	70,770	217,129	1,002	137	10,916
2009	295,039	70,553	209,058	945	330	14,153
2010	306,694	69,420	220,849	889	453	15,083

	Fuel consumption (based on fuel sold) [TJ]					
Year	**total**	**gasoline**	**diesel oil**	**LPG**	**gaseous**	**biomass**
2011	296,496	66,867	213,508	854	485	14,782
2012	296,250	65,089	214,317	900	533	15,412
2013	309,917	63,803	229,446	901	648	15,118
2014	302,483	62,558	222,523	788	700	15,914
2015	309,533	63,137	227,440	613	723	17,620
2016	319,311	62,428	239,071	473	717	16,622
2017	327,189	61,695	248,726	478	710	15,581
2018	329,567	63,172	249,600	373	689	15,733
1990–2018	86%	-39%	244%	-10%	4695%[103]	659%[104]

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 1990–2018.

Year	**Passenger cars**		**light duty vehicles**	**heavy duty vehicles**		**mopeds & motorcycles**
	inland	**fuel export**	**inland**	**inland**	**fuel export**	**inland**
	NO_x [kt]					
1990	56.20	3.76	7.30	29.94	13.55	0.13
1991	53.70	9.24	7.34	33.00	15.96	0.13
1992	52.21	5.31	7.59	33.34	16.42	0.13
1993	49.37	3.50	7.67	32.74	18.20	0.14
1994	48.10	1.57	7.93	32.79	16.11	0.14
1995	46.07	0.96	8.02	32.98	16.83	0.15
1996	45.09	-1.69	8.25	33.17	36.89	0.16
1997	43.95	-2.46	8.36	33.68	23.58	0.18
1998	43.54	0.16	8.47	34.21	34.42	0.19
1999	43.41	-2.05	8.48	34.71	28.27	0.21
2000	43.45	-1.97	8.38	35.75	34.21	0.21
2001	44.01	0.18	8.42	35.48	39.74	0.22
2002	45.43	5.53	8.76	35.21	42.54	0.23
2003	47.04	9.44	9.28	35.61	45.33	0.24
2004	48.06	11.03	9.79	35.46	43.54	0.25

[103] Trend 2004-onwards

[104] Trend 2005-onwards

Year	Passenger cars		light duty vehicles	heavy duty vehicles		mopeds & motorcycles
	inland	fuel export	inland	inland	fuel export	inland
			NO_x [kt]			
2005	48.05	12.46	10.08	35.37	44.27	0.26
2006	48.23	12.05	10.45	35.49	33.08	0.26
2007	48.77	13.38	10.80	33.46	27.90	0.26
2008	46.93	11.98	10.65	29.68	22.53	0.26
2009	45.82	12.87	10.65	25.33	20.19	0.26
2010	46.58	12.83	10.95	23.69	21.13	0.25
2011	47.27	11.81	11.12	22.55	15.36	0.25
2012	47.09	11.44	11.05	20.60	14.71	0.25
2013	47.77	10.73	11.07	19.08	17.72	0.25
2014	49.08	10.39	11.16	17.55	13.24	0.25
2015	49.83	11.63	11.23	15.27	10.81	0.24
2016	49.06	11.87	11.03	13.20	8.42	0.24
2017	46.32	11.69	10.34	11.24	6.84	0.23
2018	44.21	9.87	9.99	9.80	5.25	0.23
1990–2018	-21%	163%	37%	-67%	-61%	84%

In 2018, the total share of fuel export in *1.A.3.b* amounted to 19% or 15.1 kt NO_x of which 65% are attributed to passenger road transport and 35% to road freight transport.

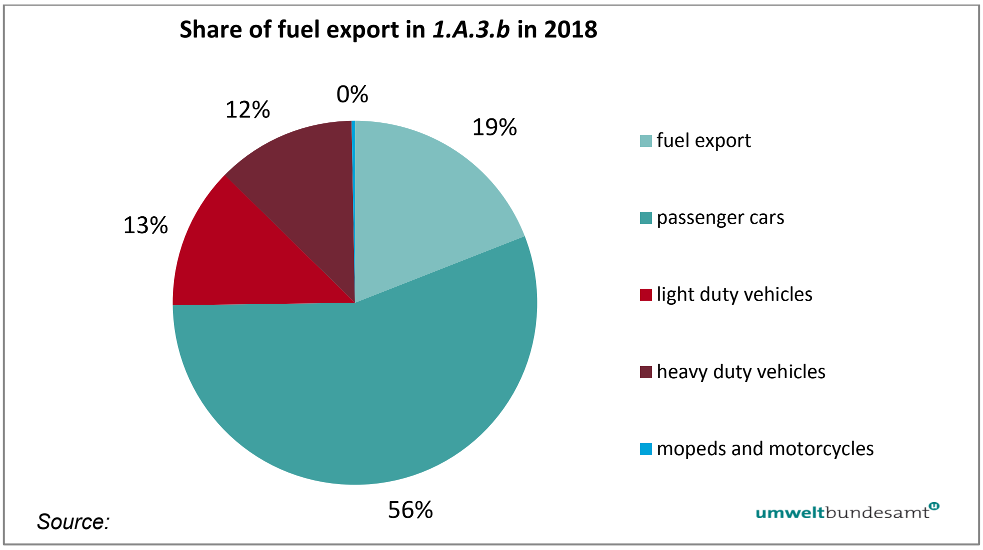

Figure 43: Share of fuel export (NO_x) in 1.A.3.b Road Transport in 2018.

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%[105]
- 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 201 the energetic substitution by biofuels amounted to 6.25% in the road transport sector (BMNT 2019a).[106] 2005, the first year of blending biofuels, the substitution amounted to only 0.8% (UMWELTBUNDESAMT 2006c).

For the year 2018 a consumption of 462 396 tons of HVO[107] & biodiesel (for blending with diesel) and 88.206 tons of bioethanol (for blending with gasoline) are used as input data in the calculation models based on NEMO and GEORG (see 1.A.2.g.vii). The following amounts are used in pure form: 63 177 tons of biodiesel and plant oil; 310 (in 1 000m^3) of biogas (BMNT 2018a).

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Table 183: Use of biofuels in absolute figures 2005–2018.

Year	pure		blended		biofuels total [t]
	biofuel pure [t]	biogas [1000m^3]	biodiesel [t]	bioethanol [t]	
2005	17.000	0	75.000	0	92.000
2006	52.500	0	288.000	0	340.500
2007	89.209	0	298.828	20.391	408.428
2008	121.276	0	304.291	84.910	510.477
2009	133.690	2	405.909	99.424	639.025
2010	92.377	1	427.000	105.883	625.261
2011	101.824	3	422.072	102.755	626.652
2012	74.983	13	440.938	105.378	621.312
2013	80.536	25	443.389	88.842	612.792
2014	159.153	640	474.692	87.688	722.173

105 An allocation to agriculture is not possible at the moment, because of the technical model framework.

106 The required substitution target amounts to 5.75%, measured by energy content.

107 HVO…Hydrotreated Vegetable Oils

Year	pure		blended		biofuels total [t]
	biofuel pure [t]	biogas [1000m³]	biodiesel [t]	bioethanol [t]	
2015	174.255	490	528.944	89.557	793.246
2016	80.875	469	495.764	86.912	664.020
2017	46.613	186	459.032	85.226	591.057
2018	63.177	310	462.396	88.206	614.089
2005–2018	***272%***	***19495%***[108]	***517%***	***333%***[109]	***567%***

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 & KELLER et al. 1998) and on ARTEMIS measurements (basically for passenger cars, light duty vehicles and motorcycles) which are taken into account in HBEFA. The latest HBEFA Version V4.1 published end of August 2019 has been applied (MATZER C., WELLER K.,et. al 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 NOX 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)
- 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).

[108] Trend 2009-onwards

[109] Trend 2007-onwards

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 for particulate matter emissions (exhaust) in two-wheeled vehicles. This improvement has been made following a recommendation of the stage 3 CLRTAP Review 2017.

In this year's submission, 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 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 Guidebook 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. 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
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

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 (EMEP Guidebook if available) 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
N2O	1.00	0.64	0.34
NO2	1.00	1.51	1.11
NH3	1.00	1.00	0.68
CH4	1.00	1.94	2.94
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
NOx	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
N2O	1.00	1.20	1.20	1.04
NO2	1.00	1.00	1.00	1.00
NH3	1.00	1.00	1.00	1.00
CH4	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

Diesel	blended diesel	biodiesel (RME)	plant oil	diesel B20
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: 1990–2018.

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	176,826	27.0	659.4	546.4	4.5	3.78
1991	196,386	27.4	637.8	486.0	6.0	3.54
1992	196,215	28.8	616.1	433.3	7.2	3.70
1993	198,243	30.4	591.9	376.9	8.3	3.74
1994	199,009	31.4	564.4	333.3	9.1	3.88
1995	202,791	28.0	545.3	288.0	9.8	3.91
1996	224,095	12.4	568.8	225.8	9.2	3.66
1997	210,964	11.5	534.6	203.5	10.2	3.98
1998	237,523	10.9	532.7	167.5	10.4	3.66
1999	229,403	10.2	516.7	145.7	10.8	3.90
2000	241,747	9.6	519.2	121.9	10.4	3.80
2001	259,856	9.2	513.5	104.2	10.0	3.61
2002	288,170	7.9	496.3	90.4	9.7	3.35
2003	311,792	7.2	488.3	78.8	9.1	3.18
2004	318,769	0.6	480.3	70.4	8.5	3.16
2005	325,692	0.5	476.9	62.8	7.9	3.11
2006	313,467	0.4	460.2	52.2	7.9	3.31
2007	317,097	0.4	438.4	46.4	7.3	3.33
2008	299,955	0.4	420.4	42.0	6.9	3.44
2009	295,039	0.4	401.6	38.0	6.5	3.41
2010	306,694	0.4	386.7	33.1	6.0	3.34
2011	296,496	0.4	375.4	30.3	5.5	3.53
2012	296,250	0.4	364.0	27.3	5.0	3.53
2013	309,917	0.4	352.0	24.0	4.3	3.41
2014	302,483	0.4	343.4	22.2	4.0	3.59
2015	309,533	0.4	326.0	20.4	3.8	3.59
2016	319,311	0.4	298.9	18.4	3.6	3.60
2017	327,189	0.4	269.3	16.5	3.4	3.59
2018	329,567	0.4	244.7	15.5	3.4	3.72

Emission factors for heavy metals and POPs are presented in chapter 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

There have been recalculations in all subcategories of 1.A.3.b.Road Transport due to the new version of the emissions factor database (HBEFA Version 4.1).

Overall shifts of Fuel Cosumption and emissions between inland and fuel export

The domestic activity data (fuel consumption/mileage) has fundamentally been updated with new specific mileage per vehicle category: For the first time, data from the periodic roadworthiness tests has been evaluated resulting in new age-related mileage data and improved data-accuracy. This affects the categories passenger cars (PC), light duty vehicles (LDV) and motorcycles (MC).

Update/Improvement of methodology and emission factors

By using the latest version of the emission model "NEMO" from the Graz University of Technology to calculate traffic emissions, the following improvements to the model and the input data resulted in emission changes as described below:

- New specific mileage per vehicle category: For the first time, data from the periodic roadworthiness tests has been evaluated resulting in new age-related mileage data. This affects the categories PC, LDV and MC. In the case of cars, the analysis of this new data source led to the following findings:
  - old vehicles drive more than previously assumed and in general
  - the specific mileage per car per vehicle age-year is lower than previously assumed
  - These facts generally lead to a decrease in the total domestic mileage of passenger cars over the entire time series.
- New and improved emissions factors for all vehicle categories
- The most recent version of the emission calculation model NEMO (TU-Graz) includes the recently released emission factor database HBEFA 4.1. Within this new software version, all consumption factors were checked or revised.
- The implementation of the new HBEFA Version 4.1 resulted in an increase in emission factors for all vehicle categories. Due to the diesel gate and the mandatory PEMS measurements for the Euro 6d_temp standard, large amounts of new measurement data were available. New findings, such as the influence of ambient temperature on the functional efficiency of NOx exhaust after treatment systems (such as SCR), new aging functions of such systems, new improved traffic situations combined with revised dynamic parameters, led to an increase in specific emissions per vehicle category

For 2018, the above mentioned overlapping recalculations lead to the following overall changes to emissions from *1.A.3 Transport* (excluding fuel exports): – 4,36 kt NO_x, – 0.21 kt NMVOC, + 0.02 kt NH_3, – 0.13 kt $PM_{2.5}$. (Changes to emissions from *1.A.3 Transport* including fuel exports: – 7,77 kt NO_x, – 0.34 kt NMVOC, – 0,002 kt NH_3, – 0.21 kt $PM_{2.5}$.)

NB: In the model NEMO every revision of inland FC leads to a direct shift between fuel consumption in inland and fuel export. In the emission model a lower fuel consumption in inland leads to higher activities in fuel export. Due to the Austrian methodology for estimating GHG from road transport (please see Methodology *1.A.3.b - fuel export*), where the total fuel sold in Austria is subtracted by the inland road transport and the off-road transport to derive fuel exports, there is no underestimation in total fuel consumption of *1.A.3 Transport* plus mobile machinery of NRMM, because the amount of total fuel sold in Austria taken from the energy balance is the value which determines the GHG emissions of transport. The recalculation therefore did not change the total GHG emissions from transport but only the contributions from the subcategories.

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 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 2000),
- Interviews with experts and expert judgment validating the questionnaire results (HAUSBERGER 2000) and
- Information from vehicle and machinery manufacturers (HAUSBERGER 2000).

An allocation of pure biofuels 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 187. Activities include liquid fuels (diesel, gasoline and biofuels).

Emission Factors

The specific emission factors for mobile machinery and equipment used in *1.A.2.g.vii Industry* and *1.A.4.c.2 Agriculture and Forestry* were updated in the submission 2018 on the basis of available measurements (SCHWINGSHACKL/REXEIS/HAUSBERGER 2017). Emission factors for NO_x, PM, CO and HC of diesel engines were updated for stages I up to IV of industrial and agricultural equipment. The NO_x levels for example of stages I and II were slightly lowered by the update. For the emission levels IIIA, IIIB and IV, the update resulted in an increase of the NO_x emission factors to a level well above the limit values.

The following tables show the updated 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*. They represent emissions according to the engine power output and also fuel consumption. They are close to the emission standards for diesel NRMM (Non-Road Mobile Machinery)..

Table 188: Emission factors for diesel engines < 56 kW.

Year	NO_x	NH_3	NMVOC	PM
		[g/kwh]		
AG1	11,992	0,0060	1,894	2,184
AG2	10,923	0,0045	1,446	1,682
Stage 1	6,555	0,0039	0,211	0,410
Stage 2	6,042	0,0029	0,146	0,214
Stage 3a	8,936	0,0020	0,077	0,079
Stage 3b	5,849	0,0020	0,033	0,034
Stage 4	5,849	0,0020	0,033	0,034
Stage 4 SCR	5,849	0,0020	0,033	0,034
Stage 5	3,286	0,0020	0,001	0,010

Table 189: Emission factors for diesel engines 56 - 80 kW.

Year	NO_x	NH_3	NMVOC	PM
		[g/kwh]		
AG1	11,992	0,0060	1,894	2,184
AG2	10,923	0,0045	1,446	1,682
Stage 1	6,555	0,0039	0,211	0,410
Stage 2	5,639	0,0029	0,146	0,214
Stage 3a	6,885	0,0020	0,077	0,079
Stage 3b	4,347	0,0020	0,033	0,034
Stage 4	2,254	0,0020	0,027	0,027
Stage 4 SCR	2,254	0,0020	0,027	0,027
Stage 5	1,013	0,0020	0,001	0,010

Table 190: Emission factors for diesel engines 80 - 130 kW.

Year	NO_x	NH_3	NMVOC	PM
		[g/kwh]		
AG1	10,193	0,0030	1,578	1,623
AG2	12,392	0,0024	1,183	0,885
Stage 1	6,555	0,0020	0,210	0,226
Stage 2	4,833	0,0014	0,146	0,162
Stage 3a	5,860	0,0010	0,077	0,079
Stage 3b	4,347	0,0010	0,033	0,034
Stage 4	2,254	0,0010	0,027	0,027
Stage 4 SCR	2,254	0,0010	0,027	0,027
Stage 5	1,013	0,0010	0,001	0,010

Table 191: Emission factors for diesel engines >130 kW.

Year	NO_x	NH_3	NMVOC	PM
	[g/kwh]			
AG1	10,193	0,0030	1,578	1,623
AG2	12,392	0,0024	1,183	0,885
Stage 1	6,555	0,0020	0,210	0,226
Stage 2	4,833	0,0014	0,146	0,162
Stage 3a	5,860	0,0010	0,077	0,079
Stage 3b	2,635	0,0010	0,033	0,034
Stage 4	2,254	0,0010	0,027	0,027
Stage 4 SCR	2,254	0,0010	0,027	0,027
Stage 5	1,013	0,0010	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

From the submission 2019 onwards non-exhaust emissions from road resuspension are not reported respectively included in the reported PM figures any more. This is now consistent with the reporting of PM non-exhaust emissions in *1.A.3.b Road Transport*.

Regarding non-exhaust emissions, the EMEP/EEA 2016 Guidebook 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 Guidebook 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).

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: 1990–2018.

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	151.2
1992	4,127	59.5	882.1	149.0	0.32	150.2
1993	4,340	59.5	883.3	148.7	0.32	149.6
1994	4,555	50.4	897.2	146.4	0.31	145.4
1995	4,821	18.6	921.3	142.3	0.31	138.3
1996	6,008	18.6	956.6	136.2	0.30	127.7
1997	5,663	18.6	984.0	132.0	0.29	119.9
1998	6,660	18.6	1,004.3	128.6	0.28	114.2
1999	6,353	16.3	1,018.4	126.3	0.28	109.8
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	121.0	0.27	102.2
2003	7,241	16.3	962.3	108.8	0.26	92.1
2004	7,965	2.4	861.6	90.5	0.25	77.4
2005	11,017	2.4	736.8	67.7	0.23	60.5
2006	13,683	2.4	637.0	50.6	0.21	46.0
2007	14,826	0.5	590.2	40.6	0.19	37.1
2008	16,351	0.5	572.8	34.0	0.18	31.2
2009	15,988	0.5	562.0	30.3	0.17	27.5
2010	15,334	0.5	556.4	28.5	0.17	25.6
2011	15,412	0.5	558.7	26.8	0.16	23.6
2012	15,971	0.5	544.4	24.3	0.15	20.7
2013	16,063	0.5	513.3	21.6	0.15	17.8
2014	15,737	0.5	489.4	19.9	0.14	15.9
2015	15,337	0.5	466.8	18.3	0.14	14.2
2016	15,439	0.5	435.3	16.2	0.14	12.1
2017	16,205	0.5	392.6	13.9	0.13	9.8
2018	17,353	0.5	355.2	11.8	0.13	7.8

Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Category-specific Recalculations

No recalculations have been made in this year's submission.

Category-specific Planned Improvements

A new study is planned to be commissioned in 2020. Parameters such as operating times, vehicle stock (focus e-vehicles) and emission factors for the off road sector will be updated.

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: 1990–2018.

Year	Liquid fuels [TJ]	Solid fuels [TJ]

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	2,035	4.6
2011	1,710	4.6
2012	1,760	4.9
2013	1,621	4.9
2014	1,695	4.9
2015	1,520	4.84
2016	1,576	4.87
2017	1,638	4.93
2018	1,304	4.68
1990–2018	-44%	-93%

Emission Factors

Emission factors were taken from (HAUSBERGER 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: 1990–2018.

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	255.0
1992	2,165.2	113.0	768.8	152.7	0.3	255.1
1993	2,110.6	109.1	771.9	152.0	0.3	255.2
1994	2,129.4	107.9	778.7	151.1	0.3	252.5
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	264.2
1997	1,787.8	57.6	800.8	147.4	0.3	258.3
1998	1,761.1	54.3	808.3	146.3	0.3	257.1
1999	1,818.3	52.4	816.3	145.1	0.3	251.8
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	2,143.2	28.5	820.6	123.7	0.2	207.2
2007	2,131.0	28.3	799.7	115.9	0.2	196.6
2008	2,127.4	27.7	779.1	107.9	0.2	185.5
2009	2,084.6	29.1	760.8	100.1	0.2	176.0
2010	2,039.3	27.8	739.8	91.8	0.2	165.9
2011	1,714.8	28.6	718.3	83.8	0.2	168.9
2012	1,764.6	28.7	696.4	79.5	0.2	159.6
2013	1,626.0	29.2	663.4	72.1	0.2	156.3
2014	1,700.1	29.0	632.5	64.6	0.2	141.1
2015	1,525.0	29.6	611.4	61.2	0.2	147.0
2016	1,581.2	29.3	599.8	60.4	0.2	142.9
2017	1,642.5	29.2	576.4	56.8	0.2	135.2
2018	1,308.4	30.2	564.0	55.4	0.2	158.2

Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Category-specific Recalculations

The adjustment of the CH4 emission factors to the EMEP/EEA Guidebook 2019 led to a slight change of the NMVOC emissions over the whole time series

Adjustment of energy quantities to the energy balance from 2005 onwards.

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 and 2010-2011) will be analyzed together with Statistik Austria in 2020 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 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 (STATISTIK AUSTRIA 2019a). Additionally, fuel consumption for working boats is taken into account in the national fuel consumption of navigation.

Emissions are calculated bottom-up with the model GEORG. 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. 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 190. Activities include liquid fuels (diesel, gasoline and biofuels).

Emission Factors

Emission factors were taken from (HAUSBERGER 2006). 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: 1990–2018.

Year	Activities	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	863	52.4	673.9	687.2	0.2	152.2
1991	780	51.6	661.1	742.5	0.2	150.9
1992	763	51.4	661.3	753.9	0.2	149.5
1993	769	51.5	664.8	747.4	0.2	148.8
1994	922	52.7	689.2	641.1	0.2	151.6
1995	1,016	44.6	704.6	585.8	0.2	152.0
1996	1,037	21.2	713.4	567.2	0.2	150.7
1997	1,029	21.2	719.8	560.9	0.2	148.9
1998	1,108	21.4	732.9	522.1	0.2	148.4
1999	1,085	21.3	739.4	520.7	0.2	146.0
2000	1,172	21.5	753.3	484.1	0.2	145.2
2001	1,218	21.6	765.1	463.3	0.2	143.4
2002	1,336	21.7	778.8	424.7	0.2	139.2
2003	1,095	21.4	772.4	477.6	0.2	131.2
2004	1,314	21.2	794.5	406.7	0.2	127.7
2005	1,290	21.2	793.7	394.7	0.2	119.1
2006	1,145	21.0	786.2	410.1	0.2	109.2
2007	1,216	20.9	781.8	376.5	0.2	97.2
2008	1,116	20.7	758.3	381.0	0.2	86.0
2009	966	20.3	731.5	401.4	0.2	74.3
2010	1,116	20.7	725.7	346.4	0.2	69.0
2011	1,009	20.5	702.6	352.7	0.2	61.7
2012	1,035	20.6	693.4	329.8	0.2	58.9
2013	1,098	20.8	687.1	302.0	0.2	56.6
2014	1,021	20.6	673.9	301.2	0.2	53.7
2015	867	20.2	653.2	319.7	0.2	50.3
2016	927	20.4	648.9	292.1	0.2	48.1
2017	949	20.5	635.2	275.5	0.2	45.2
2018	730	19.7	608.3	314.3	0.2	43.0

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 harbors 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[110], an underestimation of emissions can be excluded.

Category-specific Recalculations

The adjustment of the CH4 emission factors to the EMEP/EEAGuidebook 2019 led to a slight change of the NMVOC emissions over the whole time series

Category-specific Planned Improvements

A new study is planned to be commissioned in 2020. Parameters such as operating times, vehicle stock (focus e-vehicles) and emission factors for the off road sector will be updated.

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).*

[110] GHG emissions from fuel export are included in 1.A.3.b and are presented separately in Table 66 (Chapter 3.2.12.2)

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 191. 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). However, for mobile machinery in households and gardening the previous set of EFs of diesel engines (prior to the update 2017) has been taken as shown in the IIR 2017. EFs of petrol engines have not been updated by the mentioned update. 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: 1990–2018.

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1990	1,916	29.5	419.2	2,379.6	0.2	70.2
1991	1,920	29.5	420.8	2,382.2	0.2	69.2
1992	1,937	29.6	424.5	2,373.4	0.2	68.7
1993	1,948	29.7	427.8	2,366.8	0.2	68.0
1994	1,937	25.5	433.4	2,337.6	0.2	65.9
1995	1,944	11.1	450.5	2,248.9	0.2	63.6
1996	1,923	11.1	460.6	2,189.3	0.1	60.5
1997	1,905	11.1	469.6	2,124.8	0.1	58.2
1998	1,889	11.1	478.9	2,056.5	0.1	55.9
1999	1,885	10.0	487.7	1,990.6	0.1	53.6
2000	1,885	10.0	497.4	1,928.3	0.1	51.4
2001	1,887	10.0	506.4	1,880.0	0.1	49.2
2002	1,885	10.0	509.4	1,846.0	0.1	46.2
2003	1,879	10.0	506.4	1,833.0	0.1	42.7
2004	1,867	2.4	499.2	1,758.4	0.1	39.3
2005	1,844	2.4	490.0	1,625.7	0.1	36.2
2006	1,820	2.4	480.2	1,494.7	0.1	33.2
2007	1,797	0.5	466.0	1,355.4	0.1	30.4
2008	1,767	0.5	449.6	1,216.9	0.1	27.8
2009	1,744	0.5	429.9	1,078.9	0.1	25.2
2010	1,727	0.5	406.7	955.5	0.1	22.7
2011	1,718	0.5	381.5	856.4	0.1	20.4
2012	1,712	0.5	355.8	784.6	0.1	18.2
2013	1,715	0.5	330.2	753.8	0.1	16.0
2014	1,729	0.5	305.5	743.6	0.1	14.0
2015	1,737	0.5	282.8	740.9	0.1	12.3
2016	1,739	0.5	262.2	744.2	0.1	10.8
2017	1,747	0.5	241.4	743.0	0.1	9.5
2018	1,751	0.5	222.2	742.4	0	8.5

Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Category-specific recalculations

The adjustment of the CH4 emission factors to the EMEP/EEA Guidebook 2019led to a slight change of the NMVOC emissions over the whole time series.

Category-specific Planned Improvements

A new study is planned to be commissioned in 2020. Parameters such as operating times, vehicle stock (focus e-vehicles) and emission factors for the off road sector will be updated.

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).* For the submission 2018 the growth indicator "grain harvest" was re-analysed. A comprehensive analysis of key figures in agriculture (STATISTIK AUSTRIA 2019c) has shown that production data and developments in agricultural areas often counteract each other. A pure usage of production data for the calibration of the annual operating hours, as well as the direct allocation of the decrease in area to operating hours did not appear to be sufficient any more. Following improvements have been implemented in the model GEORG of the Graz University of Techanology:

- Fixed tractor operating hours are following the decrease in agricultural area (data available for base year 2005 with 90 fixed operating hours per tractor per year).
- Variable tractor operating hours are still calibrated with the growth indicator "grain harvest" (data available for base year 2005 with 70 variable operating hours per tractor per year).
- From 2005, a slight increase in efficiency of tractor usage in relation to area and production of around 0.5 % per year was assumed.

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 192. 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: 1990–2018.

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]	[t/PJ]				
1990	10,377	57.9	907.7	380.2	0.4	198.4
1991	10,339	58.2	915.1	332.2	0.5	196.6
1992	10,429	58.2	917.5	338.0	0.5	194.9
1993	10,480	58.2	920.9	336.0	0.5	192.9
1994	10,569	49.2	921.1	353.8	0.5	189.8
1995	10,115	18.3	922.2	350.2	0.4	185.4
1996	10,520	18.3	923.7	349.7	0.4	180.9

Year	Activity	IEF SO_2	IEF NO_x	IEF NMVOC	IEF NH_3	IEF $PM_{2.5}$
	[TJ]			[t/PJ]		
1997	11,047	18.3	927.2	331.7	0.4	176.3
1998	10,847	18.3	928.8	322.7	0.4	172.2
1999	10,950	16.0	930.4	316.7	0.4	168.7
2000	10,621	16.0	931.1	309.6	0.4	165.7
2001	10,947	16.0	932.4	302.8	0.4	163.1
2002	10,900	16.0	916.7	309.1	0.4	157.3
2003	10,472	16.0	888.6	327.3	0.4	149.5
2004	10,775	2.4	865.3	299.8	0.4	141.2
2005	11,451	2.4	842.6	268.7	0.4	133.1
2006	11,370	2.4	819.0	269.4	0.4	126.3
2007	11,312	0.5	795.9	262.5	0.4	118.6
2008	12,252	0.5	782.3	231.2	0.3	110.2
2009	11,219	0.5	771.7	196.3	0.3	101.8
2010	10,926	0.5	756.5	186.9	0.3	94.3
2011	11,845	0.5	744.9	166.1	0.3	86.6
2012	10,936	0.5	731.6	156.7	0.3	79.7
2013	10,587	0.5	711.1	144.7	0.3	72.8
2014	11,698	0.5	690.1	125.5	0.3	65.9
2015	10,826	0.5	665.7	124.6	0.3	60.8
2016	11,642	0.5	641.2	110.3	0.2	54.8
2017	10,805	0.5	614.8	112.6	0.2	50.7
2018	10,898	0.5	588.7	111.5	0.2	46.7

Emission factors for heavy metals and POPs are presented in chapter 3.2.8.

Category-specific recalculations

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The adjustment of the CH4 emission factors to the EMEP/EEA Guidebook 2019 led to a slight change of the NMVOC emissions over the whole time series.

Category-specific Planned Improvements

A new study is planned to be commissioned in 2020. Parameters such as operating times, vehicle stock (focus e-vehicles) and emission factors for the off road sector will be updated.

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 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: 1990–2018.

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
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
1990–2018	49%	-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/KUDRNA 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 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 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

In this year's submission, Pb emissions from Tyre and Break wear are reported for the first time. Pb emissios were integrated in themodel NEMO using the mean values of the emission factors contained in the EMEP/EEA air pollutant emission inventory guidebook 2019.

The result contains shares of lead emissions for road traffic according to the guidebook for the 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.[111]

PAH emission factors

For the 2016 submission the emission factors for *1.A.3.b Road Transport* were updated in the model NEMO for the four PAHs relevant for the UNECE POPs protocol:

- indeno(1,2,3-cd)pyrene
- benzo(k)fluoranthene
- benzo(b)fluoranthene
- benzo(a)pyrene

According to the EMEP/EEA Guidebook 2013 (EEA 2013) specific exhaust emission factors were taken for each vehicle category and emission class given in [µg/km]. The non-exhaust emission factors (abrasion and suspension) were also taken from (EEA 2013) and implemented in the model NEMO as ratio factors of TSP non-exhaust (from tires and brake) in ppm (mass related). These emission factors are calculated in NEMO according to the Tier 2 methodology (HAUSBERGER et al. 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 (UBA BERLIN 1998), (SCHEIDL 1996) and (ORTHOFER & VESSELY 1990) as well as measurements of emissions of a tractor engine by FTU (FTU 2000) were applied. For diesel fuelled mobile off-road sources the HDV emission factor was taken; for gasoline driven mobile sources in *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

[111] 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).

Dioxin emissions

Dioxin emission factors are presented in Table 197 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

PCB emissions from *1.A.3.b Road Transport* were calculated and reported for the first time in the current submission. For the calculation of PCB emissions in the model NEMO specific emission factors were taken from (EEA 2013) for each vehicle category and emission class given in [picograms/km]. Due to the low emission factors given in the guidebook, the calculated PCB emissions from *1.A.3.b Road Transport* are a minor source (HAUSBERGER et al. 2015c).

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* were calculated for the first time in the current submission. Since no calculation method or values for these emissions 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 et al. 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): 1990–2018.

Year	Activity	IEF Cd	IEF Hg	IEF Pb
	[TJ]		[kg/PJ]	
1990	1,481	0.02	0.01	1,105.1
1991	1,671	0.02	0.01	1,009.3
1992	1,861	0.02	0.01	933.8
1993	2,051	0.02	0.01	873.1
1994	2,242	0.02	0.01	823.3
1995	2,405	0.02	0.01	0.02
1996	2,577	0.02	0.01	0.02
1997	2,764	0.02	0.01	0.02
1998	2,948	0.02	0.01	0.02
1999	3,018	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

Year	Activity	IEF Cd	IEF Hg	IEF Pb
	[TJ]		[kg/PJ]	
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	4,955	0.02	0.01	0.06

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): 1990–2018.

Year	Activity	IEF Cd	IEF Hg	IEF Pb
	[TJ]		[kg/PJ]	
1990	11,138	0.02	0.01	0.02
1991	12,508	0.02	0.01	0.02
1992	13,543	0.02	0.01	0.02
1993	14,289	0.02	0.01	0.02
1994	14,802	0.02	0.01	0.02
1995	16,638	0.02	0.01	0.02
1996	18,458	0.02	0.01	0.02
1997	19,181	0.02	0.01	0.02
1998	19,814	0.02	0.01	0.02
1999	19,293	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

Year	Activity	IEF Cd	IEF Hg	IEF Pb
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

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: 1990–2018.

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	176,826	0.09	0.01	1,004.63	1.49	0.02	4.65	0.002
1991	196,386	0.09	0.01	749.19	1.50	0.02	4.20	0.002
1992	196,215	0.09	0.01	520.73	1.53	0.02	3.67	0.002
1993	198,243	0.09	0.01	336.49	1.56	0.02	3.16	0.002
1994	199,009	0.09	0.01	201.73	1.62	0.01	2.75	0.002
1995	202,791	0.09	0.01	15.59	1.67	0.01	2.36	0.002
1996	224,095	0.09	0.01	14.58	1.64	0.01	1.92	0.002
1997	210,964	0.09	0.01	15.83	1.66	0.01	1.69	0.003
1998	237,523	0.09	0.01	14.51	1.58	0.01	1.45	0.002
1999	229,403	0.09	0.01	15.47	1.53	0.01	1.27	0.003
2000	241,747	0.09	0.01	15.05	1.44	0.01	1.11	0.003
2001	259,856	0.09	0.01	14.27	1.36	0.01	1.00	0.003
2002	288,170	0.08	0.01	13.24	1.29	0.00	0.91	0.003
2003	311,792	0.08	0.01	12.57	1.23	0.00	0.84	0.003
2004	318,769	0.08	0.01	12.50	1.19	0.00	0.78	0.003
2005	325,692	0.08	0.01	12.30	1.15	0.00	0.80	0.003
2006	313,467	0.08	0.01	13.03	1.16	0.00	0.85	0.003
2007	317,097	0.08	0.01	13.03	1.12	0.00	0.84	0.003
2008	299,955	0.08	0.01	13.43	1.09	0.00	0.90	0.003
2009	295,039	0.08	0.01	13.48	1.06	0.00	0.99	0.003
2010	306,694	0.08	0.01	13.17	1.04	0.00	1.00	0.003

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]
2011	296,496	0.08	0.01	13.89	1.03	0.00	0.99	0.002
2012	296,250	0.08	0.01	13.87	1.01	0.01	1.01	0.002
2013	309,917	0.08	0.01	13.40	1.01	0.01	1.00	0.002
2014	302,483	0.08	0.01	14.11	1.01	0.01	1.01	0.002
2015	309,533	0.08	0.01	14.13	1.00	0.01	1.03	0.002
2016	319,311	0.08	0.01	14.14	0.99	0.00	0.98	0.002
2017	327,189	0.08	0.01	14.11	0.99	0.00	0.94	0.001
2018	329,567	0.09	0.01	14.59	0.99	0.00	0.94	0.001

Category-specific Recalculations

The implementation of Pb emissions from Tyre and Break wear lead to an increase in Pb emissions 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 1990–2018.

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	2,143.2	0.03	0.04	0.3	6.6	0.01	1.6	0.0010
2007	2,131.0	0.03	0.03	0.3	6.6	0.01	1.6	0.0010
2008	2,127.4	0.03	0.03	0.2	6.5	0.01	1.6	0.0010
2009	2,084.6	0.04	0.04	0.3	6.6	0.01	1.7	0.0010
2010	2,039.3	0.03	0.03	0.2	6.5	0.01	1.7	0.0010
2011	1,714.8	0.03	0.04	0.3	6.5	0.01	1.7	0.0011
2012	1,764.6	0.03	0.04	0.3	6.5	0.01	1.7	0.0011

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]
2013	1,626.0	0.04	0.04	0.3	6.6	0.01	1.7	0.0011
2014	1,700.1	0.03	0.04	0.3	6.5	0.01	1.8	0.0011
2015	1,525.0	0.04	0.04	0.3	6.6	0.01	1.8	0.0010
2016	1,581.2	0.04	0.04	0.29	6.6	0.01	1.8	0.0010
2017	1,642.5	0.04	0.04	0.29	6.6	0.01	1.7	0.0010
2018	1,308.4	0.04	0.04	0.34	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 1990–2018.

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	863	0.02	0.01	291.82	6.24	0.01	2.25	0.005
1991	780	0.02	0.01	264.90	6.23	0.01	2.37	0.005
1992	763	0.02	0.01	211.88	6.22	0.01	2.39	0.006
1993	769	0.02	0.01	151.98	6.23	0.01	2.38	0.006
1994	922	0.02	0.01	78.18	6.26	0.01	2.16	0.005
1995	1,016	0.02	0.01	0.03	6.27	0.01	2.06	0.004
1996	1,037	0.02	0.01	0.03	6.27	0.01	2.03	0.004
1997	1,029	0.02	0.01	0.03	6.27	0.01	2.04	0.004
1998	1,108	0.02	0.01	0.03	6.28	0.01	1.96	0.004
1999	1,085	0.02	0.01	0.03	6.28	0.01	1.98	0.004
2000	1,172	0.02	0.01	0.03	6.29	0.01	1.91	0.004
2001	1,218	0.02	0.01	0.03	6.29	0.01	1.87	0.003
2002	1,336	0.02	0.01	0.03	6.30	0.01	1.80	0.003
2003	1,095	0.02	0.01	0.03	6.28	0.01	1.95	0.004
2004	1,314	0.02	0.01	0.03	6.31	0.01	1.80	0.003
2005	1,290	0.02	0.01	0.03	6.30	0.01	1.80	0.003
2006	1,145	0.02	0.01	0.03	6.29	0.01	1.88	0.003
2007	1,216	0.02	0.01	0.03	6.30	0.01	1.83	0.003
2008	1,116	0.02	0.01	0.03	6.29	0.01	1.90	0.003
2009	966	0.02	0.01	0.03	6.27	0.01	2.02	0.003
2010	1,116	0.02	0.01	0.03	6.29	0.01	1.88	0.003
2011	1,009	0.02	0.01	0.03	6.28	0.01	1.95	0.003
2012	1,035	0.02	0.01	0.03	6.29	0.01	1.92	0.003
2013	1,098	0.02	0.01	0.03	6.30	0.01	1.86	0.002
2014	1,021	0.02	0.01	0.03	6.29	0.01	1.91	0.003
2015	867	0.02	0.01	0.03	6.27	0.01	2.05	0.003
2016	927	0.02	0.01	0.03	6.28	0.01	1.97	0.002
2017	949	0.02	0.01	0.03	6.29	0.01	1.94	0.002
2018	730	0.02	0.01	0.03	6.25	0.01	2.18	0.003

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 transfor-mation[(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	NANE	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. 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. 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	2 504	2 403	1 577	870
1995	1 484	1 743	2 354	1 271	27
2000	1 847	1 381	2 436	1 249	NO
2001	2 039	1 630	2 320	1 206	NO
2002	1 943	1 561	2 590	1 412	NO
2003	2 412	1 655	2 481	1 152	NO

Year	Activity [kt]			Activity [kt]	
	Storage of solid fuels			Mining activities	
2004	2 424	1 215	2 443	235	NO
2005	2 146	1 272	2 684	6	NO
2006	2 341	753	2 700	7	NO
2007	2 385	95	2 711	NO	NO
2008	2 195	88	2 836	NO	NO
2009	1 527	84	2 111	NO	NO
2010	1 902	82	2 555	NO	NO
2011	2 045	88	2 568	NO	NO
2012	1 698	88	2 521	NO	NO
2013	1 694	84	2 626	NO	NO
2014	1 341	93	2 534	NO	NO
2015	1 916	94	2 343	NO	NO
2016	1 715	79	2 260	NO	NO
2017	1 611	76	2 530	NO	NO
2018	1 472	80	2 083	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[112]	Refinery dispatch station		Oil refining	
	Activity [1 000m^3]	IEF [g/t] NMVOC	Gasoline [kt]	IEF [g/t] NMVOC	Crude oil refined [kt]
1990	7 993	1 109	2 554	472	7 952

[112] Refinery crude oil throughput

Year	Transport of crude oil[112]	Refinery dispatch station		Oil refining	
	Activity [1 000m³]	IEF [g/t] NMVOC	Gasoline [kt]	IEF [g/t] NMVOC	Crude oil refined [kt]
1995	8 721	916	2 402	174	8 619
2000	8 720	811	1 980	168	8 240
2001	8 855	296	1 998	62	8 799
2002	9 020	281	2 142	62	8 947
2003	9 309	269	2 223	62	8 819
2004	8 930	262	2 133	59	8 442
2005	9 000	205	2 073	59	8 743
2006	8 810	221	1 992	60	8 472
2007	9 090	228	1 966	60	8 496
2008	9 380	183	1 835	58	8 710
2009	8 930	186	1 842	57	8 286
2010	8 300	171	1 821	55	7 719
2011	8 900	181	1 756	50	8 170
2012	9 200	173	1 715	47	8 349
2013	9 300	169	1 665	40	8 584
2014	9 300	183	1 624	48	8 435
2015	9 500	161	1 640	44	8 853
2016	8 900	139	1 638	50	8 184
2017	9 000	157	1 619	58	8 064
2018	9 800	128	1 658	42	8 970

Year	Transport and depots		Service stations	
	IEF [g/t] NMVOC	Gasoline [kt]	IEF [g/t] NMVOC	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
2009	151	1 842	270	1 842
2010	119	1 972	270	1 821
2011	112	1 886	270	1 756
2012	134	1 853	270	1 715
2013	134	1 798	270	1 665

Year	Transport and depots		Service stations	
	IEF [g/t] NMVOC	Gasoline [kt]	IEF [g/t] NMVOC	Petrol [kt]
2014	151	1 730	270	1 624
2015	143	1 725	270	1 640
2016	146	1 723	270	1 638
2017	125	1 744	270	1 619
2018	127	1 794	270	1 658

Between 1990 and 2018 NMVOC emissions from the transport of crude oil increased by 23% 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%, 91% and 76% respectively) between 1990 and 2018 due to installation of gas recovery units.

NMVOC emissions from oil refining and gas extraction also showed a notable decrease of 90% and 66% respectively between 1990 and 2018. 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 2013–2018 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	
	IEF [g/1 000 m^3] SO_2	Raw gas Throughput [1 000 m^3]	IEF [g/1000m^3] NMVOC	Gas production [1000m^3]	IEF [g/km] NMVOC	Distribution mains [km]
1990	8 061.59	248 090	849	1 288 000	2 043	11 672
1995	3 771.84	405 638	676	1 482 000	1 248	17 778

Year	First treatment desulfuration		Gas extraction		Gas distribution	
	IEF [g/1 000 m³] SO_2	Raw gas Throughput [1 000 m³]	IEF [g/1000m³] NMVOC	Gas production [1000m³]	IEF [g/km] NMVOC	Distribution mains [km]
2000	120.00	358 357	525	1 805 000	864	24 099
2001	120.00	393 492	485	1 954 000	829	25 042
2002	120.00	347 513	468	2 014 000	833	24 216
2003	120.00	408 198	465	2 030 000	797	25 699
2004	120.00	373 099	472	1 963 000	744	26 158
2005	120.00	338 349	557	1 637 000	724	26 958
2006	120.00	402 990	501	1 819 000	713	27 413
2007	120.00	444 029	284	1 848 000	696	27 945
2008	120.00	372 406	289	1 531 000	682	28 348
2009	120.00	466 628	300	1 670 000	673	28 533
2010	120.00	397 132	288	1 816 000	662	28 733
2011	120.00	375 168	295	1 684 000	659	29 023
2012	120.00	375 420	270	1 807 000	650	29 260
2013	116.11	335 874	319	1 467 000	634	29 469
2014	117.08	307 475	397	1 247 000	625	29 826
2015	139.73	279 102	383	1 166 000	617	30 067
2016	128.15	179 474	352	1 253 000	608	30 215
2017	142.38	252 837	235	1 742 000	597	30 507
2018	96.79	237 622	379	969 000	597	30 089

3.3.5 NFR 1.B.2.d Other fugitive emissions from energy production – Methodological issues

In this category, NH3- and Hg-emissions from energy production from geothermal energy are considered.

NH3- 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 NH3/MWh electricity produced and 0.44g Hg/MWh electricity produced).

Table 216: Activity data for fugitive NH3- and Hg- emissions from NFR category 1.B.2.d

year	geothermal energy extraction [GWh]
1990	NO
1995	NO
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

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 2005–2017 are due to a revision of the energy balance by Statistik Austria. This revision leads to an increase of 0.003 kt TSP emissions, 0.001 kt PM_{10} emissions and 0.0004 kt $PM_{2.5}$ emissions in 2017

Recalculations of NH_3- and Hg-emissions for the years 2005-2017 are due to the new estimation of fugitive emissions from energy production in geothermal energy (subcategory 1.B.2.d) and lead to an increase of 0.0005kt NH_3 and 0.0001kt Hg in 2017.

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 2018.

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 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	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	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

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 T PM_{10},	LA, TA
2.C.3	Aluminium production	DIOX,	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.h	Printing	NMVOC	LA, TA
2.G	Other product manufacture and use	Cd	LA, TA

NFR Category	Source Categories	Key Categories	
		Pollutant	KS-Assessment
2.H	Other Processes	NMVOC	LA, TA
2 I	Wood Processing	TSP	LA, TA

TA = Trend Assessment 2018

LA = Level Assessment (if not further specified – for the years 1990 and 2018)

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 2016 (EEA 2016). Further information on the uncertainty assessment of activity data can be found in Austria`s National Inventory Report (UMWELTBUNDESAMT 2020a). 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 2016 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
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

NRF sector	Pollutant	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty (%)
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	5.0	30.0	30.4
2.G	SO_2	20.0	125.0	126.6
2.G	NO_x	20.0	125.0	126.6
2.G	NMVOC	20.0	125.0	126.6
2.G	$PM_{2.5}$	20.0	125.0	126.6
2.G	NH_3	20.0	40.0	44.7
2.H	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	BGBI 1994/498 Verordnung für Anlagen zur Glaserzeugung
2.C.1	BGBl. II Nr. 264/2014 Gießerei-Verordnung 2014
2.C.1	BGBI II 1997/160 Verordnung für Anlagen zur Erzeugung von Eisen und Stahl BGBl. II 2007/290 Änderung der Verordnung über die Begrenzung der Emission von luftverunreinigenden Stoffen aus Anlagen zur Erzeugung von Eisen und Stahl
2.C.1	BGBl. II Nr. 160/1997 Begrenzung der Emission von luftverunreinigenden Stoffen
2.C.1	BGBl. III Nr. 141/2004 Protokoll zu dem Übereinkommen von 1979 über weiträumige grenzüberschreitende Luftverunreinigung betreffend Schwermetalle samt Anhängen und Erklärungen (in Anhang 2 angeführt)
2.D.3	BGBl. I Nr. 111/2002 VOC-Anlagen-Verordnung
2.A/2.B/2.C/2.D	BGBI II 1997/331 Feuerungsanlagen-Verordnung
2.C 2/2.C 3/2.C 5	BGBl. II Nr. 86/2008 Begrenzung der Emission von luftverunreinigenden Stoffen aus Anlagen zur Erzeugung von Nichteisenmetallen und Refraktärmetallen – NER-V
2.A/2.B/2.C/2.D	BGBL I 115/1997 Immissionsschutzgesetz – Luft, IG-L
2.A/2.B/2.C/2.D	BGBI I 127/2013 Emissionsschutzgesetz für Kesselanlagen – EG-K 2013

4.1.6 Planned Improvements

2.A.5.b Construction and demolition

The methodology to calculate the particulate matter emissions from construction and demolition based on the EMEP/EEA Guidebook 2019 will be compared to the country-specific methodology in future submissions.

2.D.3.cAsphalt roofing

This subsector has been updated during the evaluation of the solvents model: all of the Austrian production sites have installed off-gas treatment systems and in the past years, emissions have been negligible. Therefore the notation key has been changed to NE. The time series will be revised, when data on the insertion of the abatement technologies are fully investigated. The investigation is planned for the next submission.

2.D.3.bRoad paving with asphalt

$PM_{2.5}$ will be estimated, when data on plants and abatement technologies in place are fully investigated. The investigation is planned for the next submission.

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[113] 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[114].

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.

[113] Association of German Engineers – VDI Verein Deutscher Ingenieure

[114] http://www.air.sk/tno/cepmeip/

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
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	2018
Magnesite	1 179 162	783 497	725 832	693 754	757 063	702 504	808 239
Sand	2 517 296	3 033 907	3 692 910	3 660 228	2 001 407	2 169 684	2 278 274
Gravel	14 264 676	17 192 140	20 978 974	25 361 797	28 304 033	27 550 482	26 800 600
Silicates	1 484 527	810 520	1 991 018	2 580 295	2 593 863	2 017 977	2 155 109
Dolomite	1 879 837	8 789 688	7 152 245	6 291 413	3 914 859	3 963 986	4 346 730
Limestone	15 371 451	19 079 581	23 823 529	22 643 754	21 189 887	21 059 817	21 076 927
Basaltic rocks	3 673 535	4 202 244	4 933 202	3 166 281	3 234 408	3 543 675	3 513 876

Activity data [t]	1990	1995	2000	2005	2010	2015	2018
Iron ore	2 310 710	2 116 099	1 859 449	2 047 950	2 068 853	2 783 327	2 803 536
Tungsten ore	191 306	411 417	416 456	472 964	429 748	535 762	544 390
Gypsum, Anhydride	751 645	958 430	946 044	911 162	872 273	715 195	836 862
Lime, quick, slacked	512 610	522 934	654 437	788 328	764 845	772 225	734 579
Cement	3 693 539	2 929 973	3 052 974	3 221 167	3 097 043	3 256 561	3 551 969
Cement & Lime milling	2 450000	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	58 133
Wheat flour	259 123	287 461	291 482	324 160	451 086	516 638	381 911
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	124 971
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	1 145 577
Activity data [m²]	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2018**
Total area under construction (for sub-category „Construction and demolition“	10 142 004	11 060 799	11 788 151	11 941 513	13 504 469	13 804 436	15 275 921

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

No recalculations have been made for this year's submission.

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 44) depicts the process of ammonia synthesis, the main production lines (ammonia, urea, melamine, nitric acid, fertiliser 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 2020a).

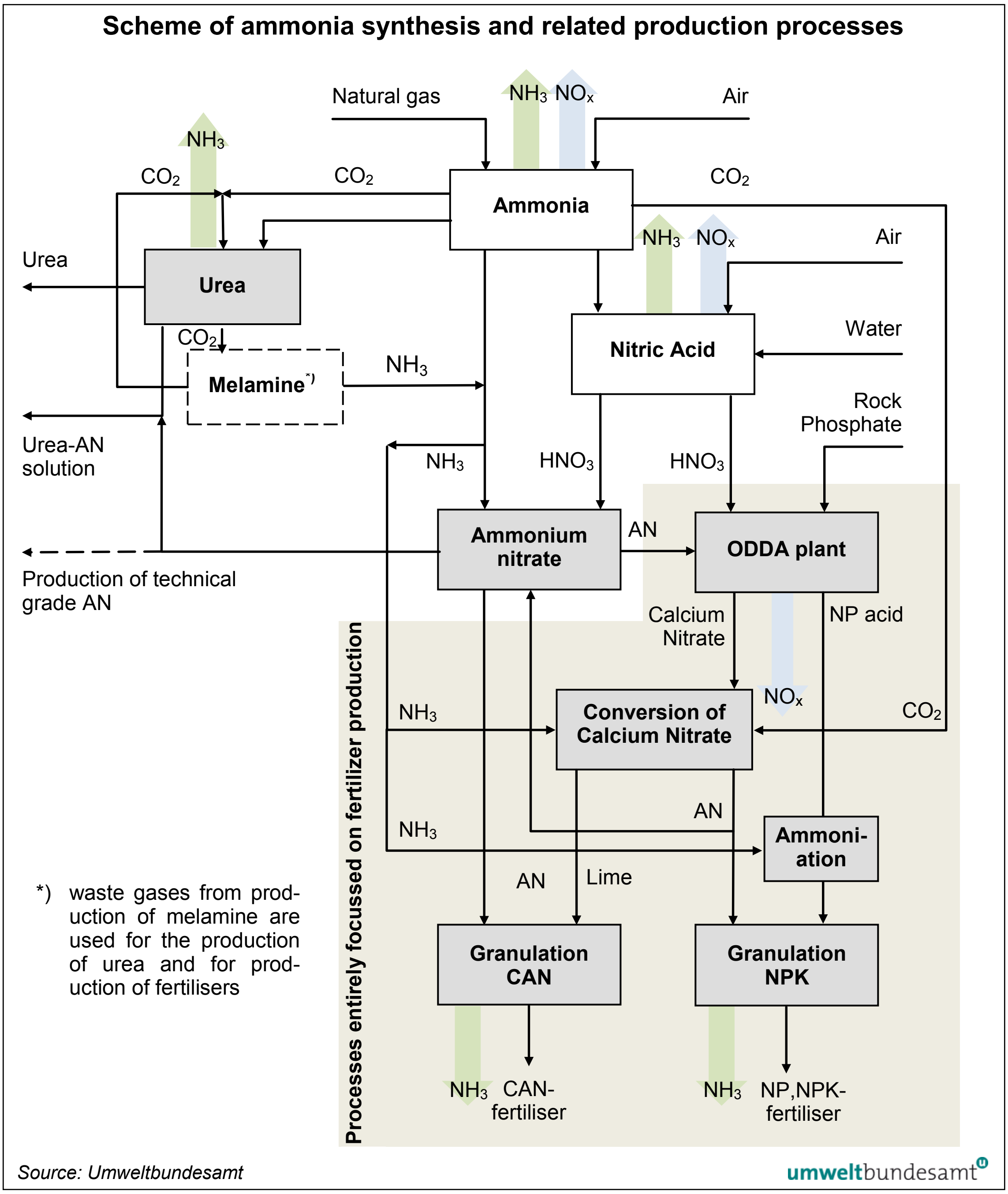

Figure 44: Scheme of ammonia synthesis and related production processes.

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
2018	171.2	422.6	12.4	30.6	64.8	160.0

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
2018	51.1	118.9	4.6	10.7

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;

- PAH emissions from graphite production;
- 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
2018	0,40	31,69	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

Year	NH_3 emission [t]	NH_3 IEF [g/t]	CO emission [t]	CO IEF [g/t]
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
2018	36.8	104.6	3.3	3.3

Fertilizer production

For fertilizer production activity, data from 1990 to 1994 were taken from national production statistics[115] (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.

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
2018	53.9	67.6	24.7	31.0

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

[115] 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.

Year	Cd [kg]	Hg [kg]	Pb [kg]	TSP [t]	PM_{10} [t]	$PM_{2.5}$ [t]
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
2018	0.50	0.07	0.62	348	204	107

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
2018	405 103	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
2018	NA	NA	NO	NO

4.3.3 Category-specific Recalculations

2 B.10.a Other chemical industry

Due to a transcription error NMVOC emissions of one plant have been revised for the whole time series (+ 0.008 kt NMVOC in 2017)

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[116]), (HÜBNER 2001b[117]). 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.

Table 232: Activity data (Pig Iron) and emissions from blast furnace charging.

	1990	1995	2000	2005	2010	2015	2018
Activity [t]	3 444 000	3 888 000	4 320 000	5 457 755	5 643 855	5 794 527	5 262 843
Emissions [kg]							

[116] according to EUROPEAN COMMISSION IPPC BUREAU (2000); MAGISTRAT DER LANDESHAUPTSTADT LINZ (1995)

[117] according to HÜBNER (2000); EUROPEAN COMMISSION IPPC BUREAU (2000); UMWELTBUNDESAMT BERLIN (1998)

Cd	342	86	98	124	129	132	120
Hg	218	281	236	298	308	316	287
Pb	26 307	2 118	2 557	3 230	3 340	3 429	3 115
PAH	341	142	139	176	182	186	169
BAP	92	38	38	47	49	50	46
BBF	104	43	42	54	55	57	52
BKF	75	31	30	38	40	41	37
IND	71	29	29	36	38	39	35
Emissions [g]							
DIOX	33	10	12	2	2	1	1
HCB	7 241	2 261	2 657	3 357	3 472	3 564	3 237
PCB	8 610	9 720	10 800	13 644	14 110	14 486	13 157
Emissions [t]							
TSP	6 209	4 113	4 174	2 268	849	718	665
PM10	4 346	2 879	2 922	1 587	595	503	466
PM2.5	1 863	1 234	1 252	680	255	215	200

Following a recommendation from the last CLRTAP Review, coke input in the sinter plant, coke oven output and blast furnace chowpers, are presented in Table 233.

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[116]), 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[117]) and, for PCB, with emission factors from the EMEP/EEA Emission Inventory Guidebook 2016 (EEA 2016).

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	2018
Activity [t]	3 921 341	4 538 355	5 183 461	6 407 738	6 570 357	7 020 178	6 176 020
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 1990–2018.

	1990	1995	2000	2005	2010	2015	2018
Activity [t]	370 107	453 645	540 539	622 485	637 383	667 000	720 900
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[116])

(6) (HÜBNER 2001b[117])

(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 1990–2018.

	1990	1995	2000	2005	2010	2015	2018
Activity [t]	196 844	176 486	191 420	196 017	167 854	165 193	170 074
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.

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 1990–2018.

	1990	1995	2000	2005	2010	2015	2018
Activity [t]	46 316	59 834	92 695	109 927	121 426	140 749	150 559
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 1990–2018.

	1990	1995	2000	2005	2010	2015	2018
Activity [t]	8 525	10 384	13 214	18 456	16 577	12 814	12 853
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

In this year's submission estimates for the PAH fractions BAP, BBF, BKF, IND category 2.C.1 has been included.

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 2018, 28% of total NMVOC emissions in Austria (30.13 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 1990–2018 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	16.30	0.01	NE	45.79	13.26	0.44	12.79	12.65	13.20
1995	81.28	20.36	0.01	NE	26.72	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	56.90	18.62	0.01	NE	15.91	6.49	0.27	4.50	4.94	6.16
2002	55.99	18.00	0.01	NE	14.96	6.38	0.25	4.18	6.16	6.04
2003	55.39	17.70	0.02	NE	13.23	5.42	0.37	5.46	7.93	5.26
2004	46.64	14.91	0.02	NE	9.94	3.87	0.41	5.59	8.06	3.85
2005	54.22	17.47	0.02	NE	10.29	3.75	0.56	7.51	10.81	3.81
2006	60.15	19.67	0.02	NE	10.14	3.39	0.71	9.33	13.42	3.48
2007	58.84	19.69	0.02	NE	8.77	2.60	0.76	9.97	14.37	2.66
2008	55.65	19.23	0.02	NE	7.29	1.81	0.77	10.12	14.64	1.76
2009	44.71	16.24	0.02	NE	6.05	1.50	0.57	7.70	11.18	1.45
2010	43.41	16.62	0.02	NE	6.08	1.51	0.50	7.01	10.23	1.45
2011	42.48	17.21	0.02	NE	6.17	1.54	0.42	6.34	9.31	1.46
2012	40.52	17.45	0.02	NE	6.14	1.53	0.34	5.49	8.12	1.43
2013	35.64	16.39	0.02	NE	5.65	1.41	0.23	4.26	6.38	1.31

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**					
2014	33.44	16.52	0.02	NE	5.57	1.39	0.14	3.37	5.14	1.27
2015	29.94	16.00	0.02	NE	5.28	1.32	0.05	2.36	3.72	1.19
2016	28.93	15.46	0.02	NE	5.10	1.28	0.05	2.28	3.59	1.15
2017	30.46	16.27	0.02	NE	5.37	1.35	0.05	2.40	3.79	1.21
2018	30.13	16.10	0.02	NE	5.31	1.33	0.05	2.38	3.74	1.20
Trend 1990– 2018	***-73,67%***	***-1,23%***	***273.29%***		***-88.40%***	***-89.97%***	***-89.12%***	***-81.42%***	***-70.41%***	***-90.91%***
Share in National Total										
1990	**35.46%**	**6.08%**	**0.00%**	**-**	**13.71%**	**3.97%**	**0.13%**	**3.83%**	**3.79%**	**3.95%**
2018	**28.10%**	**15.01%**	**0.02%**	**-**	**4.95%**	**1.24%**	**0.04%**	**2.22%**	**3.49%**	**1.12%**

NMVOC emissions in this sector decreased by 74% between 1990 and 2018, 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)[118] (repealed by Solvent Ordinance 1995)
- Solvent Ordinance 1995[119] (repealed by Solvent Ordinance 2005)
- Paint finishing systems Ordinance (1995)[120] (repealed by VOC Installations Ordinance)

In the subsequent years the legislation was adapted to be in line with European legislation:

- VOC Installations Ordinance (2002)[121], implementation of "Solvent Emission Directive"[122]
- VOC Ordinance 2005[123] – implementation of "Paints Directive"[124]

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118 Verordnung des Bundesministers für Umwelt, Jugend und Familie über Verbote und Beschränkungen von organischen Lösungsmitteln (**Lösungsmittelverordnung**), BGBl. Nr. 492/1991

119 Verordnung des Bundesministers für Umwelt über Verbote und Beschränkungen von organischen Lösungsmitteln (**Lösungsmittelverordnung 1995 – LMVO 1995**), BGBl 872/1995

120 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

121 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

122 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

123 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) [125] – implementation of "Industrial Emissions Directive" 2010/75/EC[126]

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

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 inquires in solvent consuming sectors, and after 2000, information from company solvent balances in solvent consuming sectors.

The model used for the calculation of NMVOC emissions from solvents use was established for the year 2000. It is based on a top-down and bottom-up approach: top-down data is based on statistical data and their average solvent contents, bottom-up data used for the allocation of the different amounts to the respective SNAP categories is based on data and information from solvent using industry, scaled up (if needed) using employee numbers or expert judgements. Furthermore additional investigations as e.g. for domestic solvent use, were used. The model was finalized in 2003. Since then, statistical allocations was changed a few times, solvent contents were regulated by different legislations (e.g. Eco Paint Directive, etc.), especially the Solvent Emissions or VOC directive (and the subsequent Industrial Emissions Directive), which demands minimum abatement techniques from different industrial sectors. In order to take these changes into account, the following main revisions have been introduced in the years 2016-2019:

1. Statistical data used for the calculation of the Top Down Sum, i.e. the overall amount of solvents placed on the market, has been reviewed: changes in statistical data were taken into account, some redundant posts were deleted, some new ones taken into account, some "non-solvent" uses were updated (these are substances that are not emitted during or after use, as they are used as a reagent for synthesis).
2. Solvent contents for products, especially for the domestic use, were reviewed, and solvent contents and emission factors from the German UBA, based on data directly from producers were taken into account The German and Austrian markets are very much alike, thus this approach is the most feasible.
3. Bottom-up data was completely reviewed, based on solvent balances reported by industry: solvent balances were collected for those companies that are required to report their solvent

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[124] 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

[125] 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

[126] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

use as well as solvent emissions in the course of the VOC Installations Ordinance (2002). They were then allocated to their respective SNAP category. For those categories, where not all installations were covered by the reporting obligation (because their solvent consumption does not exceed the defined threshold), the number of employees working in these companies was investigated, and emissions were scaled to the total number of employees for that sector taken from statistics..

Together with the institute that elaborated the former model, these data and the information at hand were incorporated for 2015 to be consistent to the data and the model for 2002. Data in between was interpolated.
For a more detailed description of the model update please refer to the IIR 2019, chapter 4.5.2.1.

Due to the intensity of preparation and details needed, updates of the bottom up data are planned every 5 years, this means that solvent balances will be collected in 2021 for the year 2020, using this information AD allocation will be revised and EFs will be updated; Furthermore the top-down sum (changes in statistical allocation etc) will be reviewed. For the years in between only the top down sum will be updated; allocation of the activity data as well as the emission factors from the year 2015 will be used.

Top down data:

Data from national import/export and production statistics provide a balance for substances used as solvents and solvents contained in products:

Solvent Balance per Substance$_i$ = *(Substance*$_i$ *Import – Substance*$_i$ *Export + Substance*$_i$ *Production)*

From the Solvent Balance per Substance (or substance group, respectively) the non-solvent use of substances (i.e. where the substance is used as a reagent) is subtracted:

Solvent Use per Substance$_i$ = *Solvent Balance per Substance*$_i$ – *Non Solvent Use of Substance*$_i$

"Non solvent use" of a substance is any use of a substance where it is not emitted, i.e. substances (or a certain share of the substances) used as a reagent in a chemical processes,

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 accounted for in this equation, as the amount of solvents used for their production are already accounted for in the above mentioned balance based on substance (groups):

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 Use per Substance*$_i$ + $\sum p$ *Solvents in Product*$_p$

Bottom up data

For 1990–2002:

Extensive inquiries concerning solvent applications were made in several studies in the 90ies (WINDSPERGER et al. 2002a/2002b/2004/2008): for a reference year (2000) and several other years (1980, 1990, 1995, 2003) and the amount of solvents consumed in the different sub categories was estimated.

In a first step an extensive survey on the use of solvents in the year 2000 was carried out in 1 300 Austrian companies (WINDSPERGER et al. 2002b). In this survey data about 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 were 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 used per industrial branch were extrapolated using the number of employees (the values of "solvent use per employee" of the sample was multiplied by total employment of the relevant branches taken from national employment statistics (STATISTIK AUSTRIA 2000 & 1998) and using information from (KSV1870 INFORMATION 2000).

For three years (1980, 1990, 1995) the values for solvent use were extrapolated using the factor "solvent use per employee" of the year 2000 and the number of employees of the respective year 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).

In a second step a survey in 1 800 households was conducted (WINDSPERGER et al. 2002a) for estimating the domestic solvent use (37 categories in 5 main groups: cosmetic, do-it-yourself, household cleaning, car, fauna and flora). Also, solvent use in the context of moonlighting besides commercial work and do-it-yourself was calculated.

The comparison of top down and bottom up approach helped to identify several additional applications that contribute to a large extent to the total amount of solvents used. Thus in a third step the quantities of solvents used in these applications such as windscreens wiper fluids, anti-freeze, hospitals, de-icing agents of aeroplanes, tourism, cement- respectively pulp industry, were estimated in surveys.

The outcome of these three steps was the total stock of solvents used for each application in the year 2000 (at SNAP level 3) (WINDSPERGER et al. 2002a). To achieve a time series the development of the economic and technical situation in relation to the year 2000 was considered. It was distinguished between "general aspects" and "specific aspects". The information about these defined aspects 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. On the basis of this information calculation factors were estimated. With these factors and the data for solvent use and emission of 2000 data for the years 1980, 1990 and 1995 was estimated. For the years in between data was linearly interpolated.

For 2003 onwards:

In 2015–2018, for the 2015 new data and methods were applied, and data from 2003-2015 was interpolated. Mainly data available from reports under directive 1999/13/EC (VOC Solvents Directive)[127] were implemented into the model:

An extensive research was based on solvent balances for the year 2015 of those companies that were obliged to report their use of solvents as well as emissions under directive 1999/13/EC (VOC Solvents Directive). The companies were then allocated to the different SNAPs, and the number of employees was surveyed. The total number of employees of the whole sector was derived from the national statistic on performance and structures (Österreichische Leistungs- und Strukturstatistik), which was then adjusted to the part of the sector in question (based on expert judgement). With the proportion of the employees of the companies to the total number of the sector, activity data as well as emissions were calculated for each SNAP. In some cases, for those sectors where discrepancies between smaller and bigger enterprises were too big, a form factor was introduced to reflect a plausible relation.

Two exceptions from that approach were taken for the following sectors:

- Domestic use: the amount of products on the Austrian market were taken into account, information on solvent content and emission factors from German UBA were obtained and used. Activity data is the amount of solvents in products, which were combined with the respective emission factor for each type of product (which led to a combined EF of 74% for Domestic Solvent Use (Other), and 95% for Domestic Use of Pharmaceuticals). Emission factors were also interpolated between the old and new approach, with the help of IIÖ.
- Paints used in construction, as well as domestic use: statistical data was combined with information on the average solvent content of paints derived from studies on the Ecopaint directive. Activity data reflects the solvent content of paints and not the amount of paints used, an emission factor of 95% is applied.

Top down / bottom up combination

[127] VOC-Anlagen-Verordnung (VAV), BGBl. II Nr. 301/2002 vom 26.7.2002

Data from the top down approach (for the reference year 2000, up to 2002 as well as 2015) were compared with data from the /bottom up approach. As there where large discrepancies the sub sectors were further investigated and identified additional sources added to the bottom up approach, additional identified non-solvent uses subtracted from the top down approach. As a deviation of 10-20% remained, the bottom up data was adjusted to finally fit the (higher) top down sum.

The following graph depicts the logic behind the calculation of NMVOC emissions in Austria:

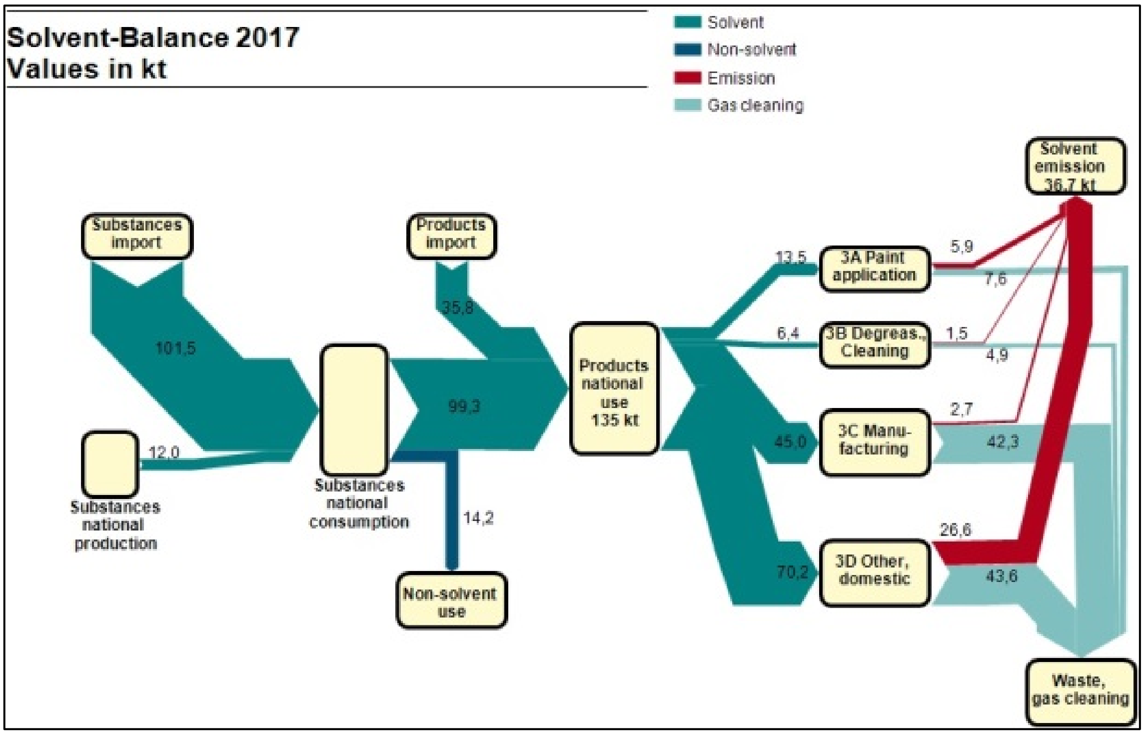

Figure 45: Sankey diagram of the calculation of solvent emissions in Austria (WINDSPERGER et al. 2018).

4.5.2.2 Activity data

Activity data have been updated since the last submission. 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] 1990–2018.

	2.D.3	2.D.3.a	2.D.3.d	2.D.3.e	2.D.3.f	2.D.3.g	2.D.3.h	2.D.3.i
Year					t Solvent			
1990	137 924	23 361	50 131	15 467	459	18 585	14729	15 192
1995	130 088	25 296	50 371	13 564	426	12 465	13 474	14 492
2000	112 872	21 896	35 517	11 940	340	23 798	8 242	11 140
2001	112 709	21 698	35 281	12 210	340	24 073	7 960	11 148
2002	114 039	21 112	34 638	12 342	337	24 023	10 557	11 031
2003	113 487	20 896	30 772	10 936	545	26 156	14 503	9 680

	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**			
2004	97 164	17 719	23 063	8 168	645	24 633	15 798	7139
2005	115 698	20 894	23 558	8 306	980	31 994	22 830	7 135
2006	132 473	23 691	22 512	7 887	1 364	39 676	30 735	6 609
2007	134 842	23 877	18 379	6 378	1 634	43 479	35 954	5 141
2008	133 910	23 477	13 755	4 698	1 867	46 245	40 336	3 532
2009	113 829	19 957	11 692	3 993	1 587	39 310	34 287	3 002
2010	117 341	20 572	12 053	4 116	1 636	40 523	35 345	3 095
2011	122 370	21 454	12 569	4 293	1 706	42 260	36 860	3 228
2012	124 912	21 900	12 830	4 382	1 741	43 138	37 626	3 295
2013	118 181	20 720	12 139	4 146	1 648	40 813	35 598	3 117
2014	119 891	21 029	12 321	4208	1 672	41 367	36 131	3 164
2015	116 913	20 507	12 014	4 103	1 631	40 339	35 233	3 085
2016	112 960	19814	11 608	3 965	1 576	38 975	34 042	2 981
2017	118 940	20 863	12 223	4 174	1 659	41 039	35 844	3 139
2018	117 643	20 635	12 090	4 129	1 641	40 591	35 453	3 105

Also emission factors have been updated since the last submission. They were evaluated taking into account information from actual solvent balances from companies in the respective sector. EFs for 2015 are based on this evaluation, and were interpolated to 2002, taking into account information from each economic sector, expert judgements and legal obligations (as well as BATs).

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 1990–2018.

	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	0.90	0.65	0.52	0.85	0.47	0.66	0.65
2001	0.89	0.64	0.50	0.80	0.44	0.62	0.64
2002	0.89	0.63	0.49	0.74	0.41	0.58	0.63
2003	0.89	0.61	0.47	0.69	0.43	0.55	0.62
2004	0.88	0.60	0.45	0.63	0.40	0.51	0.61

	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			
2005	0.88	0.58	0.43	0.58	0.38	0.47	0.60
2006	0.87	0.57	0.41	0.52	0.35	0.44	0.59
2007	0.87	0.56	0.40	0.47	0.32	0.40	0.59
2008	0.87	0.54	0.38	0.41	0.29	0.36	0.51
2009	0.86	0.53	0.36	0.36	0.26	0.33	0.50
2010	0.86	0.51	0.34	0.30	0.23	0.29	0.49
2011	0.86	0.50	0.33	0.25	0.20	0.25	0.47
2012	0.85	0.48	0.31	0.19	0.17	0.22	0.46
2013	0.85	0.47	0.29	0.14	0.14	0.18	0.45
2014	0.85	0.46	0.27	0.08	0.13	0.14	0.44
2015	0.84	0.44	0.25	0.03	0.09	0.11	0.43
2016	0.84	0.44	0.25	0.03	0.09	0.11	0.43
2017	0.84	0.44	0.25	0.03	0.09	0.11	0.43
2018	0.84	0.44	0.25	0.03	0.09	0.11	0.43

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 2016 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
2017	1 353 548	20.3
2018	1 503 348	22.6

2.D.3.c Asphalt roofing

This subsector has been investigated during the evaluation of the solvents model. 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, ,so for the current submission the notation key of this category has been changed to NE.

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
Activity	Amount of fireworks placed on market	Inhabitants (Smokers)
Method	EMEP/EEA 2016 default emission factors used.	
Emission factor	EMEP/EEA 2016 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 sold in Austria was used. In 2018, more accurate data on cigarettes, loose tobacco and cigars became available from the Ministry of Finance. Thus, the time series was adapted according to the new information. 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 1990–2018.

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

Table 245: Emissions from SNAP 604_X6B Tobacco Use from 1990–2018

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

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]
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
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

4.5.5 Category-specific Recalculations

NFR 2.D.3.a Solvent Use

Following in depth QC activities time series inconsistencies in the solvents model were removed: (i) the reporting categories of the import/export statistics for various ethers had changed over time and were now considered consistently and (ii) for antifreeze fluids, of which not all reported in the category are relevant for VOC emission, the same assumption as used in the years before was applied. This led to a decrease of NMVOC emissions of 6.25 kt in 2017.

2.D.3.Domestic Solvent Use, Hg emissions

Due to the omission of the EF for Hg from the EMEP EEA GB 2019, this source is no longer reported.

NFR 2.G Tobacco Use and emissions from firework use:

More detailed information became available from the Austrian Ministry of Finance, based on the amount of cigarettes, as well as loose tobacco products and cigars taxed in Austria fromz onwards. The trend was then extrapolated back to 1990. This led to an increase of emissions of NOx, CO, NMVOC, NH_3, TSP, PM10, PM2.5, Cd, Ni, Zn, Cu, Dixon and PAHs.

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 246.

[128] according to MEISTERHOFER (1986)

Table 246: POP emissions and activity data from smokehouses 1990–2018:

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
⇣	⇣	⇣	⇣	⇣	⇣	⇣	⇣	⇣
2018	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 has been included.

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

Gaseous emissions from chipboard production are reported under category 2.H.1.

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 247: 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	**Produced off-site**
		wood chips-industry-logs	wood chips-industry-byproduct
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 248: 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	51 666	113.12	45.25	18.10
2010	97 256	212.94	85.18	34.07
2015	102 319	224.03	89.61	35.84
2018	97 248	212.92	85.17	34.07

4.7.3 Category-specific Recalculations

NFR 2.I Wood processing

Due to recalculations of the energy balances, reported particular matter emissions since 2005 have changed. (-0.001 kt PM2.5 for 2017).

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% - 4%).

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) (BMNT 2000–2019): 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 238 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 249: 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 fertilisers 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	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	✓	NO
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 239.

Table 250: 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, TA
3.B.3	Manure Management (Swine)	NH_3	LA, 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, TA
3.D.a.2	Organic fertilizers	NMVOC	LA, TA
3.D.c	On-farm storage, handling and transport of agricultural products	TSP	LA, TA
3.D.c	On-farm storage, handling and transport of agricultural products	PM_{10}	LA, TA

LA = Level Assessment (if not further specified – for the years 1990 and 2018)

TA = Trend Assessment 1990–2018

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 240 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 251: Summary of methodologies used in Austria's agriculture inventory.

NFR category		Methodology used
3.B Manure Management	3.B.1 Cattle	T3 (NH_3), T2 (NO_x, NMVOC), T1 PM)
	3.B.2 Sheep	T2 (NH_3, NO_x, NMVOC), T1 (PM)
	3.B.3 Swine	T3 (NH_3), T2 (NO_x, NMVOC), T1 PM)
	3.B.4 Other Livestock	T2 (NH_3, NO_x, NMVOC), T1 (PM)
3.D Agricultural Soils	3.D.a.1 Inorganic N fertilizers	T3 (NH_3), T1 (NO_x)
	3.D.a.2.a Animal manure applied to soils	T3 (NH_3), T2 (NMVOC), T1 (NO_x)
	3.D.a.2.b Sewage sludge applied to soils	T1
	3.D.a.2.c Other organic fertilisers applied to soils (including compost)	T1
	3.D.a.3 Urine and dung deposited by grazing animals	T3 (NH_3), T2 (NMVOC)

NFR category		Methodology used
	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.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 252: 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)
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 242 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 253: 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 (BMNT 2000–2019),
   - ✓ 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) is presented in Chapter 1.6.

5.2.6 Planned Improvements

It is planned to evaluate the national N excretion values on the basis of a new scientific study. The project will be carried out by the University of Natural Resources and Applied Life Science (BOKU) and will start in spring 2020.

5.3 NFR 3.B Manure Management

The Austrian sectorial inventory model follows the N-flow concept (AMON & HÖRTENHUBER 2014, AMON & HÖRTENHUBER 2019). In the current submission Austria included the recommendations under the NEC Review 2019 as well as implemented the new EMEP/EEA GB 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 2019b) 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 243 and Table 244 presents applied animal data. Background information listed below:

From 1990 onwards: The continuous decline of dairy cattle numbers is connected with the increasing milk yield per cow: For the production of milk according to Austria's milk quota every year a smaller number of cows is needed.

1991: A minimum counting threshold for poultry was introduced. Farms with less than 11 poultry were not considered any more. However, the contribution of these small farms is negligible, both with respect to the total poultry number and to the trend.
The increase of the soliped population between 1990 and 1991 is caused by a better data collection from riding clubs and horse breeding farms.

1993: New characteristics for swine and cattle categories were introduced in accordance with Austria's entry into the European Economic Area and the EU guidelines for farm animal population categories. In 1993 part of the "Young cattle < 1 yr" category was included in the "Young cattle 1–2 yr" category. This shift is considered to be insignificant: no inconsistency in the emission trend of "Non-Dairy Cattle" category was recorded.
In the same year "Young swine < 50 kg" were shifted to "Fattening pigs > 50 kg" (before 1993 the limits were 6 months and not 50 kg which led to the shift) causing distinct inconsistencies in time series. Following a recommendation of the Centralized Review 2003, the age class split for swine categories of the years 1990–1992 was adjusted using the split from 1993.

1993: For the first time other animals e.g. deer (but not wild living animals) were counted. Following the recommendations of the Centralized Review 2004, to ensure consistency and completeness animal number of 1993 was used for the years 1990 to 1992.

1995: The financial support of suckling cow husbandry increased significantly in 1995 when Austria became a Member State of the European Union. The husbandry of suckling cows is used for the production of veal and beef; the milk yield of the cow is only provided for the suckling calves. Especially in mountainous regions with unfavourable farming conditions, suckling cow husbandry allows an extensive and economic reasonable utilisation of the pastures. Suckling cow husbandry contributes to the conservation of the traditional Austrian alpine landscape.

1996–1998: The market situation affected a decrease in veal and beef production, resulting in a declining suckling cow husbandry. Farmers partly used their former suckling cows for milk production. Thus, dairy cow numbers slightly increased at this time. Reasons are manifold: Changing market prices, BSE epidemic in Europe and change of consumer behaviour, milk quota etc.

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

[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).

very rapidly. Market prices change due to changes in costumer behaviour, saturation of swine production, epidemics etc.

Table 254: Domestic livestock population and its trend 1990–2018 (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
Trend 90–18	***-41.1%***	***-17.8%***	***326.4%***	***-33.2%***	***-26.1%***	***-21.5%***	***-9.2%***

The FAO agricultural data base (FAOSTAT) provides worldwide harmonized data (FAO AGR. STATISTICAL SYSTEM 2001). In the case of Austria, these data come from the national statistical system (Statistik Austria). However, there are inconsistencies between these two data sets. Analysis shows that there is often a time gap of one year between the two data sets. FAOSTAT data are seemingly based on the official Statistik Austria data but there is an annual attribution error. In the Austrian inventory Statistik Austria data is used, they are the best available.

Table 255: Domestic livestock population and its trend 1990–2018 (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
Trend 90–18	***-24.7%***	***-21.4%***	***-39.1%***	***-31.9%***	***-31.9%***	***-31.9%***	***31.1%***	***145.1%***	***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 2018d)

[4] share of litter 8–20 kg within young swine category < 20 kg (47%, STATISTIK AUSTRIA 2018d)

Swine numbers decreased in 2018 compared to the previous year. For sheep and goats a rise in livestock numbers could be observed in 2018.

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 2018d). This approach was accepted under the NEC Review 2018 and applied for all inventory years.

Horse numbers for 2015, 2016, 2017 and 2018 are provided by the Ministry of Agriculture and are published in (BMNT 2000–2019, 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 256: Domestic livestock population and its trend 1990–2018 (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
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
Trend 90–18	***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 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 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 the values of 2017 have been used. Information on anaerobic digestion is based on data published by the Austrian Energy Regulator (E-CONTROL 2019). 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 257: Share of N in manure management systems 1990 (cattle and swine).

Animal category	**Manure Management Systems 1990**					
	Buildings – tied systems		**Buildings – loose housing systems**		**Excreted outside the buildings**	
	liquid slurry [%]	**solid manure [%]**	**liquid slurry [%]**	**solid manure [%]**	**yards [%]**	**pasture [%]**
Dairy cows	23.6	50.4	11.0	3.4	0.9	10.7
Suckling cows	12.3	58.7	6.0	11.3	1.1	10.7
Cattle < 1 year	11.3	53.3	6.8	23.0	0.8	4.8
Breeding heifers 1–2 years	17.5	39.5	9.4	6.7	0.8	26.2
Fattening heifers, bulls & oxen, 1–2 years	30.4	37.3	18.2	12.8	0.8	0.6
(other) cattle > 2 years	20.6	44.9	9.2	6.6	1.0	17.8
Breeding sows plus litter	--	--	69.2	29.7	1.2	--
Fattening pigs	--	--	71.3	28.2	0.6	--

For yards the values for the year 1990 were estimated to be the half of the values from 2005 (PÖLLINGER 2008).

Table 258: 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 259: 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	18.7
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 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[130] 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 260: 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*

Table 261: 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).

[130] Österreichisches Kuratorium für Landtechnik und Landentwicklung

Manure storage – cattle and swine

Table 251 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.

Table 262: 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 the same shares as for 2017 have been used.

Table 263: 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	11.4	11.5	13.5	8.3	8.2	16.3	5.1	3.7

	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
aerated								
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 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 253 and Table 254 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 264: Austria specific N excretion values of dairy cows for the period 1990–2018.

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			

[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 500kg has been assumed for the years from 2004 onwards.

Table 265: 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)] (2018)	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 (2018)	27.7
Young & fattening pigs (1990)	9.0
Young & fattening pigs (2018)	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 266: 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 a*nd *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 256 provides NH_3 emission factors for the housings of cattle and swine (EIDGENÖSSISCHE FORSCHUNGSANSTALT 1997 and DÖHLER et al. 2002).

Table 267: Emission factors for NH_3 emissions from animal housing.

Manure management system	Emission factor [kg NH_3-N (kg N excreted)$^{-1}$]

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 268: 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 243, Table 244 and Table 245)*
$Nex_{(T)}$	=	*N excretion of animals of type T in the country [kg N animal^{-1} yr^{-1}] (see Table 253, Table 254 and Table 262)*
$MMS_{(T)}$	=	*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 269: 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 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 259 provides NH_3 emission factors for the storage of cattle and swine manures (EIDGENÖSSISCHE FORSCHUNGSANSTALT 1997).

Table 270: 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 260 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[131] group and published in (REIDY et al. 2008, 2009).

Table 271: 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).

[131] European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

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: No

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.

Table 272: 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 250.

5.3.3.2 Animal excretion – non-key livestock categories

Country specific N excretion values are presented in the following table:

Table 273: 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 263 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 274: 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 2018*

**) *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 261, the non-key livestock categories are all 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 275: 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 estimating NH_3-N losses and NH_3 emissions from digesters reported under waste sector (see Table 265) is the N in the manure when entering the biogas facilities, taking into account all N-losses during animal housing before. The remaining N (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 276: N amounts digested in biogas facilities

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
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	1 284 870	9 360 074	10 644 944

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 5.3.3.3 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 255). 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

From submission 2019 onwards 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 255). 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 2019b) (please refer to Table 243, Table 244 and Table 245). 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 2018d). 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 2016. 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 2020 – Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol" (UMWELTBUNDESAMT 2020a).

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 266 provides the resulting country-specific emission factors for the different cattle categories for 2018.

Table 277: Country-specific NMVOC emission factors of cattle for 2018.

Livestock category	3.B	3.B	3.D.a.2.a	3.D.a.3
	EF silage feeding [kg NMVOC head^{-1} yr^{-1}]	EF housing incl. storage [kg NMVOC head^{-1} yr^{-1}]	EF application [kg NMVOC head^{-1} yr^{-1}]	EF grazing [kg NMVOC head^{-1} yr^{-1}]
Dairy cows	14.00	5.47	7.25	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 2020 – Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol" (UMWELTBUNDESAMT 2020a).

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 2020). Table 267 provides an overview of NMVOC emission factors and parameters used in the calculations.

Table 278: NMVOC emission factors and fractions used for livestock categories other than cattle for 2017

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	0.44	-
Young & fattening pigs	0.001703	0.17	0.46	-
Sheep	0.001614	1.13	2.26	0.00002349
Goats	0.001614	1.13	2.09	0.00002349
Horses	0.001614	1.37	1.82	0.00002349
Laying hens	0.005684	0.20	0.44	-
Broilers	0.009147	0.40	0.99	-
Turkeys	0.005684	0.51	0.38	-
Other poultry	0.005684	0.39	0.57	-
Other animals	0.001614	1.13	2.19	0.00002349

Livestock other than cattle is not fed with silage in Austria.

5.3.8 Category-specific Recalculations

Update of activity data

Animal livestock

Livestock numbers of poultry and other animals (mainly deer) have been revised as new data has become available based on the final results of the farm structure survey 2016 (STATISTIK AUSTRIA 1990-2019). To avoid jumps in the time series, the years 2014 and 2015 have been interpolated. As currently no updated data is available for the respective livestock categories, the values of 2016 have been used for the years 2017 and 2018.

Manure Management (3.B) – NH_3

The main reason for revised NH_3 emissions from manure management is the implementation of the new EMEP/EEA Guidebook 2019 in Austria's air emission inventory. The 2019 version of the Guidebook provides updated NH_3 emission factors for housing and storage for the livestock categories layers, broilers, sheep and other animals. Furthermore, the calculation method, which is based on the fraction of TAN that is immobilised in organic matter (f_{imm}) when the manure is managed as a litter-based solid and the litter is straw, has been revised. According to (EEA 2019), this immobilisation greatly reduces the potential NH_3-N emission during storage and after application.

The improved calculations resulted in lower NH_3 emissions from manure management for the whole time series (– 1.4 kt NH_3 in 2017)

Biological treatment of waste (5.B.2) – NH_3

NH_3 emissions from anaerobic digestion at biogas facilities are calculated in sector *3 Agriculture* but reported under sector *5 Waste*. The Tier 1 methodology of the EMEP/EEA Guidebook is applied. In the EMEP/EEA GB 2019 the NH_3-N EF was changed from 0.0286 kg of NH_3-N to 0.0275 kg of NH_3-N, leading to a downward revision across the whole time series (– 0.02 kt NH_3 in 2017).

Manure Management (3.B) – NO_x

NO_x emissions are calculated using a mass-flow approach based on the concept of a flow of TAN through the manure management system according to the EMEP/EEA GB 2019. Although there were no changes in the methodology for NO_x between the Guidebook versions 2016 and 2019, the revisions in the ammonia inventory had an impact on NO_x and resulted in lower emissions for the whole time series (– 0.01 kt NO_x in 2017).

Manure Management (3.B) – NMVOC

The NMVOC emission calculations according to the 2019 EMEP/EEA Tier 2 methodology are strongly linked to the compilation of the ammonia emissions inventory. Therefore, although there were no changes in the methodology for NMVOC between the Guidebook versions 2016 and 2019, the revisions to the ammonia inventory also had an impact on NMVOC emissions. The improved calculations resulted in recalculations for the whole time series (+ 0.09 kt NMVOC in 2017).

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 2019b) provides national data of annual livestock numbers on a very detailed level (please refer to Table 243, Table 244 and Table 245).

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 268 the applied emission factors are listed.

Table 279: 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

Reasons for the recalculated emissions from 2014 to 2017 are the updated activity data of poultry and other animals.

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). 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)

5.5.2 Inorganic N-fertilizers (NFR 3.D.a.1)

Key Category: NH_3

Activity Data

Austria estimates emissions from different types of mineral fertilisers 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 fertiliser statistics are annually published in the so-called "Green Reports" (BMNT 2000–2019).

Detailed historical data for different mineral fertiliser 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 fertilisers are available. A consistent time series of fertiliser types other than urea has been generated by linear interpolation and adjustment to annual total mineral fertiliser 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 269 provides national N fertiliser data from 1990 to 2018.

Table 280: N usage of different types of mineral fertilizers (arithmetic average of two years) in Austria 1990–2018.

Year	Calcium ammonium nitrate (CAN)	N solutions (Urea AN)	Ammonium sulphate (AS)	other straight N compounds and equivalent to calcium nitrate	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

Year	Calcium ammonium nitrate (CAN)	N solutions (Urea AN)	Ammonium sulphate (AS)	other straight N compounds and equivalent to calcium nitrate	Calcium nitrate (CN)	NPK mixtures	Other	Urea
				[t N/year]				
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

Data sources:Annual fertilizer statistics compiled by AMA (Agrarmarkt Austria, www.ama.at) and annually published in the "Green Reports" (BMNT, www.gruenerbericht.at)

Urea data 1995 to 2014: Raiffeisen Ware Austria, sales company (http://www.rwa.at) & BMNT (2013 & 2014)

Fertiliser 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 2019): 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).

In Austria, full time-series data for the different mineral fertiliser types is shown in Table 269. 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 2016, table 3.2) have been calculated. The resulting emission factors, adjusted to Austrian conditions, are indicated in the following table.

Table 281: NH_3 emission factors for the different types of mineral fertilisers in Austria

Mineral fertiliser	Emission factors (EMEP/EEA GB 2016)	Emission factors (EMEP/EEA GB 2016)	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
Other straight N compounds	10	19	13
NPK mixtures	50	91	64
Urea	155	164	158
Other	-	-	50(*)

(*) *For other fertilisers the 2016 EMEP/EEA default Tier 1 EF has been 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 (NFR 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 (NFR 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 are 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 2020 – Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol" (UMWELTBUNDESAMT 2020a).

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*
$Frac_{LS-bc}$	=	*Fraction of nitrogen left for spreading produced as liquid slurry in a liquid waste management system (broadcast spreading)*
$Frac_{LS-bs}$	=	*Fraction of nitrogen left for spreading produced as liquid slurry in a liquid waste management system (band spreading)*
CF_{bs}	=	*Correction factor band spreading*
$F_{TAN\ SS}$	=	*Fraction of total ammoniacal nitrogen (TAN) in animal waste produced in a solid waste management system including N input from straw*
$F_{TAN\ LS}$	=	*Fraction of total ammoniacal nitrogen (TAN) in animal waste produced as slurry in a liquid waste management system including N input from straw*
$EF\text{-}NH_3\text{-}N_{spread\ SS}$	=	*NH_3-N Emission factor of animal waste from a solid manure system (farmyard manure) spread on agricultural soils (broadcast spreading)*
$EF\text{-}NH_3\text{-}N_{spread\ LS}$	=	*NH_3-N Emission factor of animal waste from a liquid slurry waste management system spread on agricultural soils (broadcast spreading)*

Application technologies – cattle and swine

Since inventory revision 2008 the agriculture inventory considers band spreading application of liquid manure. Table 271 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 the same values as for 2017 have been used.

Table 282: 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 283: 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 273 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 the same values as for 2017 have been used.

Table 284: 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 263. 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 274) has been implemented to Austria´s ammonia inventory (AMON & HÖRTENHUBER 2019) for the first time. 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. Abatement factors have been taken from (UNECE 2015); the abatement factor for humid conditions (timing) before application has been taken from (REIDY & MENZI 2007). For 2018 the same values as for 2017 have been used.

Table 285: 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	37%	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 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 (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 286: Amount of sewage sludge (dry matter) produced in Austria, 1990–2018.

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
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

Year	Total [t dm]	agriculturally applied [t dm]	agriculturally applied [%]
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

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).

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 275)*

5.5.3.3 Other organic fertilizers applied to soils (NFR 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). 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 287: 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

Year	Digestates (livestock manures) [kg N year^{-1}]	Digestates (veg. part) [kg N year^{-1}]	N from compost [kg N year^{-1}]
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
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	2 068 188	9 360 074	1 631 028

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 294 (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 288: Amount of compost (dry matter) produced in Austria, 1990–2018.

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

Year	Total amount of compost [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied compost N [t N]
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
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

5.5.4 Urine and dung deposited by grazing animals (NFR 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 246 to Table 248. 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 254.

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)

In submission 2019 NMVOC emissions from category 3.D.a.3 Urine and dung deposited by grazing animals were reported for the first time. 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 2016, 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 1990–2019) and (STATISTIK AUSTRIA 2018e). 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 2018e) 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 2020, chapters *6.3.2 Cropland (Category 4.B)* and *6.4.2 Grassland (Category 4.C)* (UMWELTBUNDESAMT 2020a).

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 289: Agricultural land use data 1990–2018 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	1 423 377	271 068	85 070	45 552	1 021 687	1 713 391	449 508
1992	1 414 742	245 728	69 114	49 919	1 049 981	1 711 865	443 325
1993	1 398 526	240 971	73 701	59 090	1 024 764	1 710 340	437 141
1994	1 402 750	240 961	77 021	71 402	1 013 366	1 689 668	430 957
1995	1 404 248	255 910	76 826	89 246	982 266	1 668 997	424 773
1996	1 414 005	247 602	51 222	64 904	1 050 277	1 670 182	418 899
1997	1 397 357	259 832	57 807	54 897	1 024 821	1 671 366	413 025
1998	1 395 643	264 405	59 282	52 086	1 019 870	1 661 034	407 151
1999	1 395 274	260 579	55 901	65 768	1 013 026	1 650 702	401 277
2000	1 377 934	293 806	52 473	51 762	979 893	1 652 301	398 499
2001	1 375 899	287 777	51 219	56 098	980 805	1 653 900	395 720
2002	1 374 930	288 764	47 145	55 383	983 638	1 655 499	392 942
2003	1 375 823	272 001	40 003	44 035	1 019 785	1 657 097	390 163
2004	1 403 797	290 174	45 664	35 284	1 032 675	1 632 873	387 385
2005	1 405 234	288 960	42 847	35 251	1 038 176	1 608 648	384 607
2006	1 389 960	284 577	26 924	42 582	1 035 877	1 581 383	381 828
2007	1 388 741	292 976	46 702	48 509	1 000 554	1 554 118	379 050
2008	1 376 689	296 775	53 171	56 056	970 687	1 539 169	376 271
2009	1 375 326	309 034	48 528	56 933	960 831	1 524 220	373 493
2010	1 372 530	302 852	45 699	53 803	970 176	1 509 271	370 714
2011	1 369 819	304 334	45 943	53 636	965 905	1 493 892	367 997
2012	1 365 214	308 179	48 525	55 821	952 688	1 478 512	365 279
2013	1 364 057	297 286	56 108	58 557	952 106	1 463 133	362 562
2014	1 359 738	304 645	48 241	52 816	954 036	1 434 736	358 957
2015	1 354 301	302 965	39 563	37 529	974 244	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	1 377 942	351 746
2018	1 335 080	292 654	40 725	40 504	961 197	1 377 942	351 746

5.5.6 Use of Pesticides (3.D.f)

Until submission 2019 Austria reported NA for source category 3.D.f Use of pesticides. Following a recommendation of the NEC Review 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.

Activity data

According to Regulation 1185/2009 in Austria the following substances were used in the following years:

- Atrazine: 1990-1995
- Clopyralid: 1990-2018
- Chlorothalonil: 1990-2018
- DCPA, Dacthal, Chlorthaldimethyl: 1995
- Endosulfan: 1990-2006
- Lindane: 1990-1997
- Picloram: 1990-2018
- 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 42 provides the total amount of active substances.

Table 290: 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

Year	Active substances [kg]	Year	Active substances [kg]
2004	19 850.80		

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

Livestock data (3.B, 3.D)

Livestock numbers of poultry and other animals (mainly deer) have been revised as new data has become available based on the final results of the farm structure survey 2016 (STATISTIK AUSTRIA 1990-2019, see Chapter 1.3.8)

Detailed raw material and energy balances (3.D.a.2.c)

In 2019 new information on input materials for Austria's biogas plants became available (E-CONTROL 2019) resulting in slightly revised amounts of digested manure and energy crops.

Methodological changes

NH_3

3.D.a.1 Inorganic N fertilisers

Revised emissions from inorganic N fertilisers are due to the implementation of new information on agriculture practice. Including the rapid incorporation of urea into the soil in Austria's calculations resulted in lower NH_3 emissions from synthetic fertiliser application for the entire time series (– 0.6 kt NH_3 in 2017).

3.D.a.2.a Animal manure applied to soils

NH_3 emissions of animal manure applied on soils have been revised downwards for the entire time series. The main reasons are updated NH_3 emission factors for manure spreading for the livestock categories layers and broilers according to the EMEP/EEA GB 2019, as well as improvements carried out in the manure management sector due to the new Guidebook (e.g. updated NH_3 emission factors and an improved calculation of the immobilised fraction of TAN, see Chapter 6.3.2.1). These changes led to a downward revision of the NH_3 emissions by – 1.3 kt for the year 2017.

3.D.a.3 Urine and dung deposited by grazing animals

According to the EMEP/EEA GB 2019, the default Tier 2 NH_3 EFs for grazing for the livestock categories sheep and other animals have been revised downwards compared to the 2016 GB. This results in lower NH_3 emissions for the whole time series (– 0.06 kt NH_3 in 2017).

NO_x

3.D.a.2.a Animal manure applied to soils

The revisions to the ammonia calculations according to the EMEP/EEA GB 2019 in the manure management sector have led to higher N amounts available for application. As a consequence, NO_x emissions of manure application have been resived upwards for the entire time series (+ 0.1 kt NO_x in 2017).

NMVOC

3.D.a.2.a Animal manure applied to soils

NMVOC emissions from manure application have been estimated based on the 2019 EMEP/EEA Tier 2 methodology which is closely linked to the compilation of the ammonia inventory. Therefore, the revisions to the ammonia inventory also had an impact on the NMVOC emissions and resulted in lower emissions for the entire time series (– 0.3 kt NMVOC in 2017).

HCB

3.D.f. Use of Pesticides

Following a recommendation of the NEC Review 2019 Austria estimated these emissions for the first time.

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 4.3) based on (WINIWARTER et al. 2001) and reported under NFR source category *3.D.d Off-farm storage, handling and transport of bulk agricultural products*.

5.6.1 Methodological Issues

5.6.1.1 Farm-level agricultural operations including storage, handling and transport of agricultural products (3.D.c)

Emissions of particulate matter from field operations are linked with the usage of machines on agricultural soils. They are considered in relationship with the treated areas. In previous submissions Austria calculated its emissions based on a country-specific approach. From submission 2018 onwards, as recommended in the NEC Review 2017 (EC 2017), the EMEP/EEA Tier 1 methodology has been applied.

Activity Data

Data of agricultural land use are taken from (STATISTIK AUSTRIA 1990–2019) and (STATISTIK AUSTRIA 2018e). 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 2018e) 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 2020, chapters *6.3.2 Cropland (Category 4.B)* and *6.4.2 Grassland (Category 4.C)* (UMWELTBUNDESAMT 2020a).

Further details are given in "Austria's National Inventory Report 2020, chapters *6.3 Cropland (Category 4.B)* (UMWELTBUNDESAMT 2020a).

Table 291: Agricultural land use data 1990–2018.

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	1 405	908
1991	1 423	886	2006	1 390	889
1992	1 415	896	2007	1 389	870
1993	1 399	905	2008	1 377	864
1994	1 403	915	2009	1 375	858
1995	1 404	926	2010	1 373	851
1996	1 414	932	2011	1 370	843
1997	1 397	938	2012	1 365	835
1998	1 396	924	2013	1 364	826
1999	1 395	910	2014	1 360	820
2000	1 378	910	2015	1 354	813
2001	1 376	910	2016	1 344	806
2002	1 375	909	2017	1 337	806
2003	1 376	909	2018	1 335	806
2004	1 404	909			

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 4.3) but reported under sector *3.D.d Off-farm storage, handling and transport of agricultural products*.

A simple methodology was applied. Emissions were estimated multiplying the amount of bulk material by an emission factor.

Activity data

Activity data was taken from official Statistik Austria production statistics (see Chapter 4.3, Table 212).

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 4.3, Table 211).

5.6.2 Category-specific Recalculations

No revisions have been carried out.

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 2018), in Austria about 250 ha were burnt in 2018. This value corresponds to about 0.1% of the relevant cereal area in 2018. 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 1990–2019) and (STATISTIK AUSTRIA 2018e). 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 2020, chapters *6.3.2 Cropland (Category 4.B)* and *6.4.2 Grassland (Category 4.C)* (UMWELTBUNDESAMT 2020a).

According to an expert judgement from the *Federal Association of Viniculture* (Bundesweinbauverband 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 292: Activity data for field burning of agricultural residues 1990–2018.

Year	Viniculture Area [ha]	Burnt Residual Wood [t]
1990	58 364	4 377
1991	57 981	4 349
1992	57 599	4 320
1993	57 216	4 291
1994	56 422	4 232
1995	55 627	4 172
1996	54 061	4 055
1997	52 494	3 937
1998	51 854	3 889
1999	51 214	3 841
2000	50 304	3 773
2001	49 393	3 704
2002	48 483	3 636
2003	47 572	3 568
2004	48 846	3 663
2005	50 119	3 759
2006	49 981	3 749
2007	49 842	3 738
2008	47 688	3 577
2009	45 533	3 415
2010	45 480	3 411
2011	45 427	3 407
2012	45 373	3 403
2013	45 320	3 399

Year	Viniculture Area [ha]	Burnt Residual Wood [t]
2014	45 799	3 435
2015	46 277	3 471
2016	46 756	3 507
2017	46 756	3 507
2018	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

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 2020, 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

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 EMEP/EEA Tier 2 emission factors for orchard crops provided in the guidebook chapter 5.C.2 Small-scale waste burning were used for the first time resulting in revised emissions for NO_x, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, Cd, Pb, and PAHs.

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 2018.

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 283 presents the contribution of sector Waste to national total emissions of the different pollutants.

Table 293: Contribution to National Total Emissions from NFR sector 5 Waste in 2018.

Pollutant	Source Category: 5 Waste	Pollutant	Source Category: 5 Waste
SO_2	0.12%	PAH	< 0.01%
NO_x	0.01%	Diox	6.90%
NMVOC	0.05%	HCB	0.18%
NH_3	2.48%	TSP	1.81%
CO	0.60%	PM_{10}	1.65%
Cd	0.16%	$PM_{2.5}$	1.93%
Hg	4.09%		
Pb	0.01%		

The overall emission trend reflects changes in waste management policies as well as waste treatment facilities. According to the Landfill Ordinance[132] 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 2005 due to

[132] 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[133]) and the obligatory pre-treatment of waste[134] since 2004 (with some exemptions until 2009) before deposition (regulated in Austrian Landfill Ordinance[135]).

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 industry: waste separation regarding material, recyclable waste, hazardous waste; more efficient process lines; use of co- and by-product process line; (scap) 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[136]) and to demonstrate that all relevant activity data are taken into account in the inventory.

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[133] Verordnung über die getrennte Sammlung biogener Abfälle (BGBl. Nr. 68/1992)

[134] 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)

[135] 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

[136] In fact non-residual waste also comprises waste from other (industrial) sources.

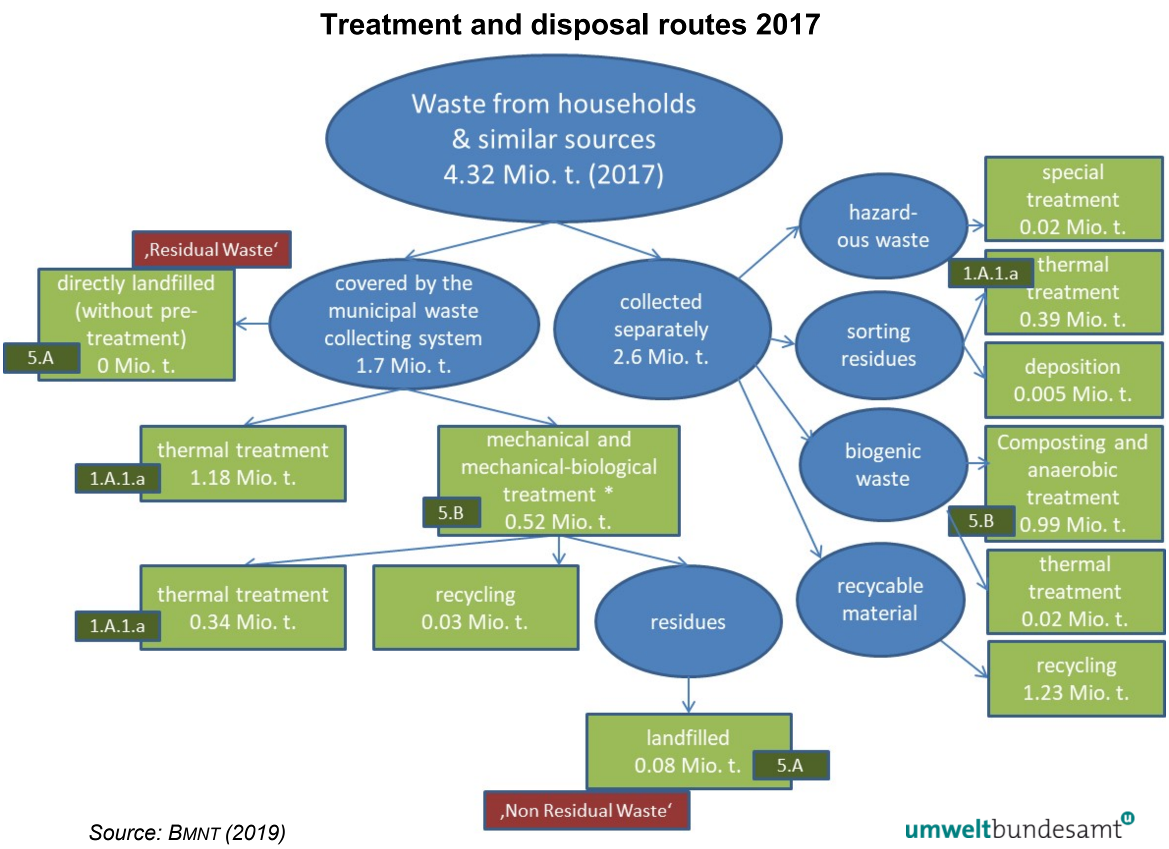

Figure 46: Main streams of treatment and disposal of waste from households and similar sources.

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 284 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 294: 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.

NFR Category	Source Category	Key Category	
		Pollutant	KS-Assessment
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 295: 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 BMLFUW). 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

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[137] 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[138]), 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.

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137 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).

138 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 291).

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[139].

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 286 presents the waste amounts considered 1990–2018.

Table 296: Activity data for "Residual waste" and "Non-Residual Waste" 1990–2018.

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

[139] 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
1990–2018	**-75%**	**-100%**	**-94%**

In 1990, the Austrian Waste Management Law[140] entered into force. As a consequence, from 1990 to 1995, the deposited amount of waste decreased due to recycling activities, reuse and increased capacities for waste combustion, despite a rise in total waste generation. After 1994/1995 waste recycling still increased but was compensated by growing amounts of total waste generated so the amounts of deposited waste did not decrease any further. The amount of deposited waste peaked in 2003 due to the remediation of some contaminated sites and then dropped as from the beginning of 2004 only pre-treated waste was allowed to be deposited. This is due to the implementation of the Landfill Ordinance, which prohibits the disposal of untreated waste and therefore leads to reduced waste volumes as well as decreased carbon content in deposited waste.

However, under certain circumstances there were some exceptions to this pre-treatment-obligation granted to some Austrian provinces.[141] 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[142] is allowed to be deposited any more.

140 Waste Management Act of 2002 , Federal Law Gazette I No 102/2002 as amended by Federal Law Gazette I No 9/2011

141 Regulated in § 76.Abs. 7 AWG 2002

142 as defined at the beginning of this sub-chapter

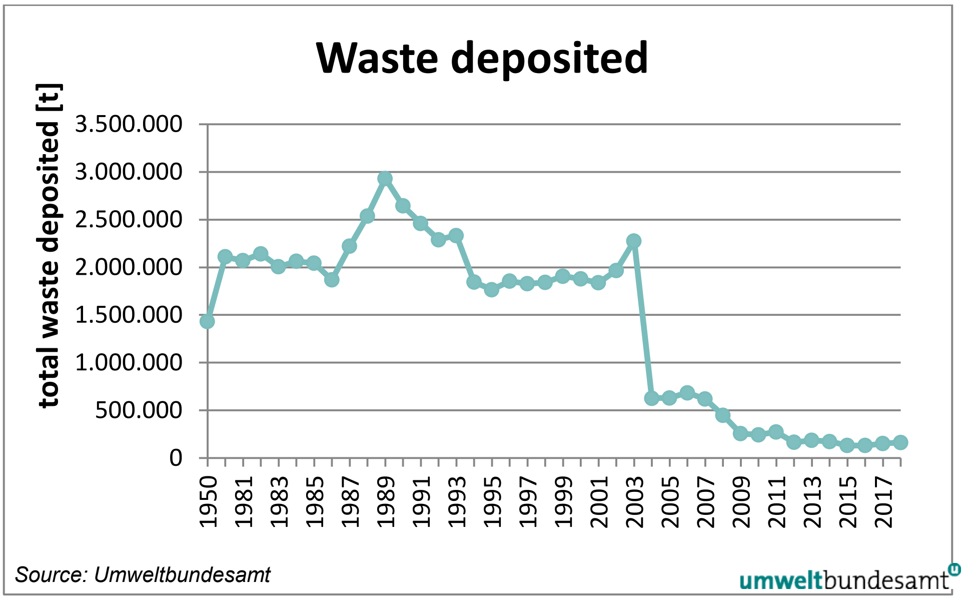


Figure 47: Deposited waste (residual and non-residual waste) 1990–2018.

The quantities of "residual waste" have been taken from the following sources:

- Data for 2008–2018 have been taken from the EDM[143], an electronic database administered by the BMNT. Since the beginning of 2009 landfill operators are obliged to register their data directly and electronically (per upload) at the portal of http://edm.gv.at[145].
- 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[146] (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

[143] Electronic Data Management

[144] According to § 41 (1) Landfill Ordinance, Federal Law Gazette BGBl. Nr 39/2008

[145] According to §41 (1) Landfill Ordinance, Federal Law Gazette BGBl. Nr 39/2008

[146] Data available from the Federal Waste Management Plan (Bundesabfallwirtschaftsplan - BAWP) as well as from the Austrian landfill database.

were taken from the EDM[147] (Electronic Data Management). Only the amounts of waste with biodegradable lots were considered. Table 287 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 297: Considered types of waste (list of waste[148]).

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

[147] 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

[148] 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 288 summarises the parameters used and the corresponding references.

Table 298: Parameters for calculating landfill gas from SWDS.

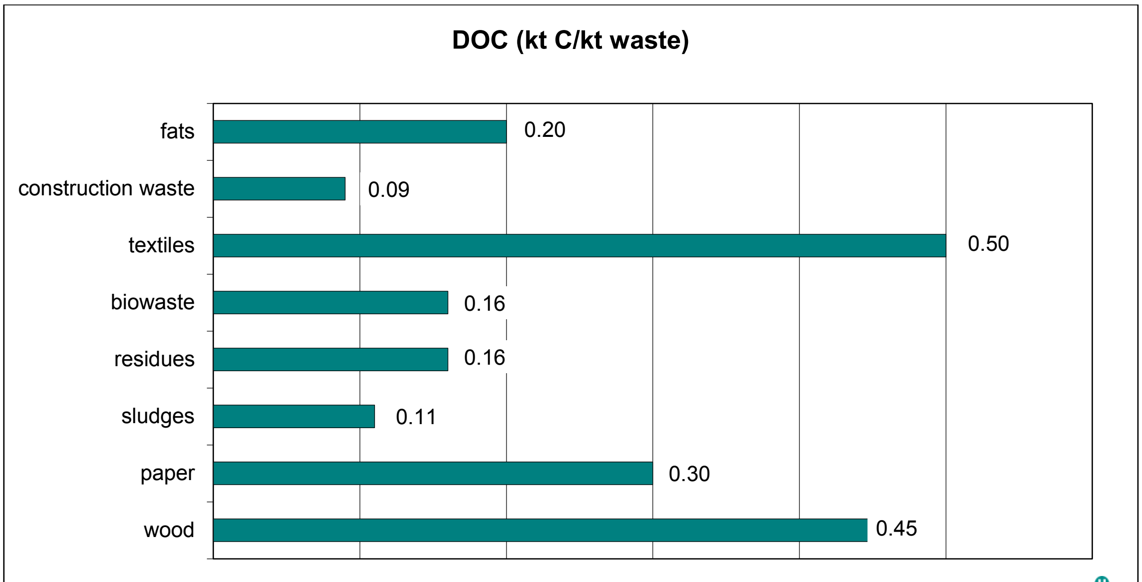
Waste category/ Parameters	residual waste	wood	paper	sludges	Sorting residues/ output MBT[149]/ bulky waste	Bio-waste	textiles	Construction waste	fats
Methane correction factor (MCF)	1 IPCC default for managed SWDS								
Fraction of degradable organic carbon dissimilated (DOC_F)	0.6	0.5	0.55	0.55	0.55	0.55	0.55	0.55	0.77
	national waste expertise (UMWELTBUNDESAMT 2005b)[150]								
DOC (kt C/kt waste)	see Table 290	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)	0.55 as cited in various Austrian and German literature (FLÖGL, W. 2002, ÖWAV 2003, LFU 1992, UMWELTBUNDESAMT (2008a) UMWELTBUNDESAMT (2014b)								
Methane Oxidation in the upper layer (OX)	10% IPCC default								
Landfill gas recovery (R)	see Figure 50 (UMWELTBUNDESAMT 2004b, 2008, 2014b, 2019b)								
Process start (M)	13 Delay time of 6 months, with an average residence time of 6 months (IPCC default)								

[149] MBT: **M**echanical-**b**iological **t**reatment

[150] 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 288. 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.



Source: Umweltbundesamt

Figure 48: 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 2003c). 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 2003c). 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.

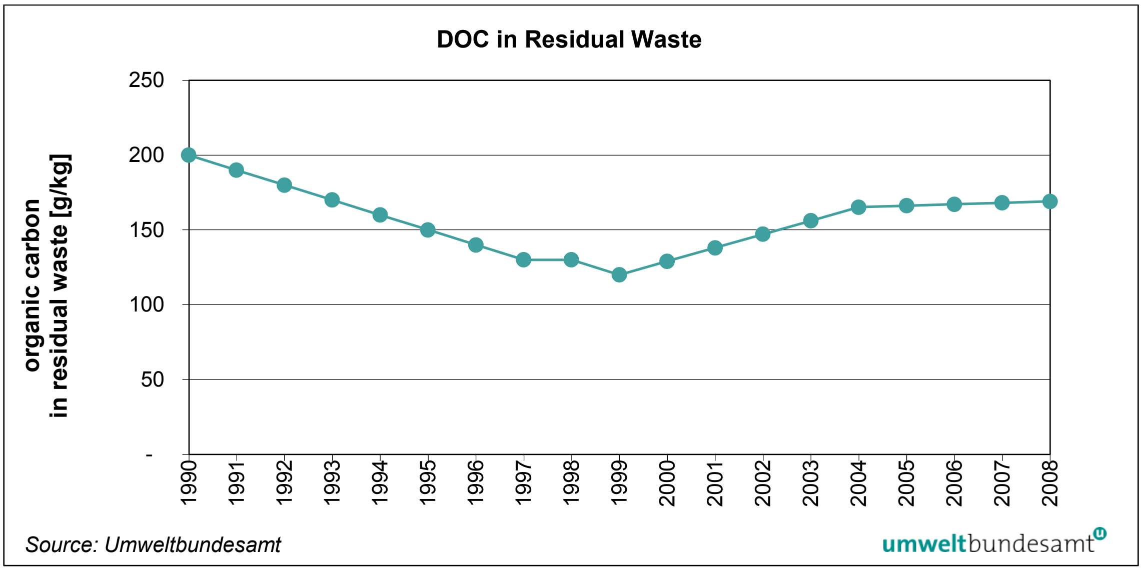


Figure 49: Development of DOC in residual waste.

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 289 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 290). For the years before 1990, the same DOC as in 1990 was used.

Table 299: 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 2003c)*

[2)] *(BMLFUW 2006a)*

[3)] *Annual update (2009) of the Federal Waste Management Plan (BMLFUW 2006a)*

Table 300: 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)]	2009–2018	n.r.**)

[1)] *assumed to be equal to the DOC of 1990*

[2)] *(UMWELTBUNDESAMT 2003c)*

[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 288.

Austria does not apply the bulk DOCf option of the IPCC 2006 GL as detailed information is available on the waste deposited. The composition of the different landfilled waste fractions (waste types) is well known, allowing for adapting the default DOCf (0.5) as provided by the IPCC 2006 GL accordingly (see UMWELTBUNDESAMT 2005b). Higher DOCf values than the IPCC 2006 default (0.5) are applied for most of the waste types (except wood) as the composition data shows a low share of lignin in the waste deposited. The DOCf for fats is set to 0.77 as lignin C is excluded here.

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.a branches from trees and bushes) is treated biologically in composting plants (considered under 5.B.1 composting).

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. Results show that 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[151] – an effect that is due to the extensive capturing of landfill gas which can lead to the dilution of the landfill gas captured.

Compared to 2002 (maximum amount of landfill gas captured), landfill gas recovered decreased by 70% by 2018.

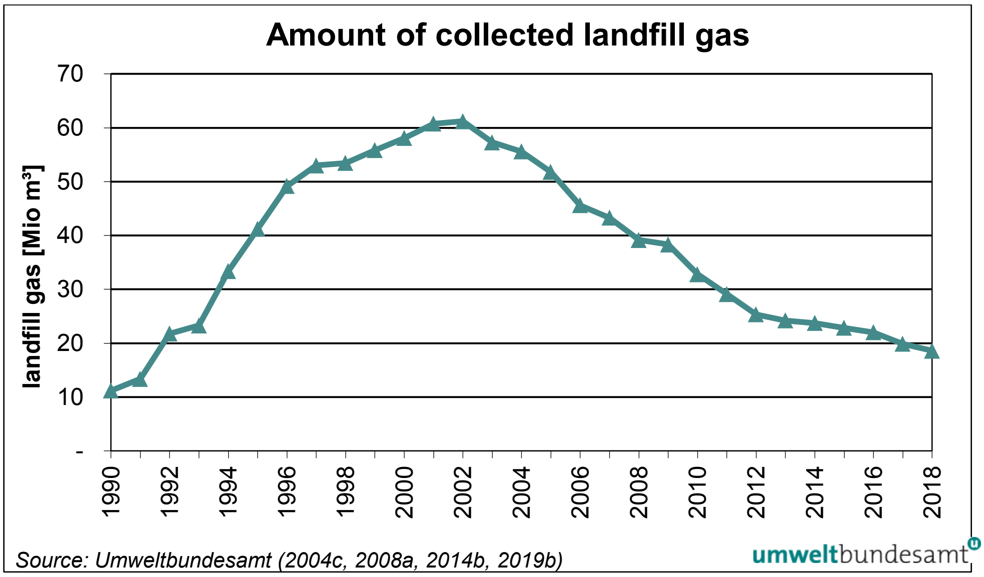


Figure 50: Amount of collected landfill gas 1990 to 2018.

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).[152]

Table 301: Emission factors for CO, NMVOC, NH_3 and heavy metals.

	CO	NMVOC	NH_3	Cd	Hg	Pb
	Vol.%	mg/Nm^3	mg/Nm^3	mg/Nm^3	mg/Nm^3	mg/Nm^3
concentration in landfill gas	2	300	10	0.003	0.00002	0.003

6.3.1.3 Category-specific Recalculations

No recalculations have been made in this years' submission.

[151] a methane concentration of 55% (default) is used for the estimation of the landfill gas **produced** ('F') over the whole time-series.

[152] according to UMWELTBUNDESAMT (2001b)

6.3.2 PM emissions

6.3.2.1 Source Category Description

PM emissions reported here are from waste handling at landfill sites. Only specific waste types are considered such as residues from iron and steel production (slags, dusts), clinker, dust and ashes from thermal waste treatment and combustion plants, as well as some mineral and construction waste.

6.3.2.2 Methodological Issues

PM emissions are calculated by multiplying the waste amounts with the respective emission factors for TSP, PM_{10} and $PM_{2.5}$.

Activity Data and Emission Factors

Activity data has been taken from a database for landfill disposal and – since 2008 – the EDM[153]. 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 302: 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
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

[153] Electronic Data Management

Year	residues from iron and steel production (slags, dusts)	clinker, dust and ashes	mineral waste	construction waste
	[t]	[t]	[t]	[t]
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
1998–2018	**35%**	**225%**	**579%**	**-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 303: Emission factors for PM.

TSP	PM_{10}	$PM_{2.5}$
g/t WASTE	g/t WASTE	g/t WASTE
18.00	8.52	2.68

6.3.2.3 Category-specific Recalculations

Minor recalculations are reported for particulate matter emissions from waste disposal (-2.5 t TSP, -1.2 t PM10, -0.4 t PM2.5 in 2017) caused by the 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%), and stabilised since then. For mechanical treatment plants the amounts of waste treated almost doubled between 1990 and 2007, since then a decrease can be observed.

NH_3 emissions from composting and from mechanical biological treatment only amount to 1 244 t in 2018.

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 294.

Since 2008, the 'Electronic Data Management' (EDM) is the primary data basis[154], 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). 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.

[154] In subcategory *5.A Solid Waste Disposal* waste amounts have been taken from EDM reports already since 2008.

Table 304: 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	BMLFUW 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	

Activity data on agricultural feedstock treated in anaerobic plants is provided within NFR sector 3 Agriculture (please refer to Table 265).

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 305: 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

NH_3 emissions from *5.B.2 anaerobic digestion* were recalculated for the whole time series (-20.9 t in 2017) as the default emission factor for NH_3-N was adapted according to the new EMEP/EEA Guidebook 2019.

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 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 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%[155] in 1990 (about 10 k of incinerations) to 24% in 2004 and to 35% in 2011. The percentage 2012–2017 has been linearly interpolated to 44% in 2017 (about 37k incinerations), following a general trend in Austria which has been reported by market dominating funeral companies of larger cities.

Table 306: 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 -2018	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 297 shows emission factors of main pollutants.

Table 307: 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	-	-

[155] Estimate from (HÜBNER 2001b)

Table 308: 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 309: NFR 5.C. Waste incineration: emission factors for heavy metals and POPs.

Municipal waste	Cd	Hg	Pb	PAH	DIOX	HCB
	[mg/t]				[µg/t]	
1990	71.0	299.0	1 170.0	0.7	250.0	850.0
1991	59.2	263.2	966.0	0.7	250.0	850.0

Industrial Waste	Cd	Hg	Pb	PAH	DIOX	HCB
	[mg/t]				[µg/t]	
1990	510.0	112.0	2 400.0	1.6	160.0	970.0
1991	414.0	99.4	1 922.0	1.6	160.0	970.0

Sludges from waste water treatment	Cd	Hg	Pb	PAH	DIOX	HCB
	[mg/t]				[µg/t]	
1990	235.0	55.0	730.0	1.6	1.5	300.0
1991	191.8	45.8	585.2	1.6	1.5	300.0

Clinical waste	Cd	Hg	Pb	PAH	DIOX	HCB
	[mg/t]				[µg/t]	
1990	4.77	5.76	540.00	0.00	1.08	216.00
1991	3.99	4.82	451.50	0.00	0.68	135.45
1992	3.21	3.87	363.00	0.00	0.36	72.60
1993	2.42	2.93	274.50	0.00	0.14	27.45
1994	1.64	1.98	186.00	0.00	0.00	0.19
1995–2005	0.62	0.71	7.75	0.00	0.00	0.19
2006	0.50	0.58	6.25	0.00	0.00	0.16
2007	0.40	0.46	5.00	0.00	0.00	0.12
2008	0.30	0.35	3.75	0.00	0.00	0.09
2009	0.20	0.23	2.50	0.00	0.00	0.06
2010–2018	0.10	0.12	1.25	0.00	0.00	0.03

Waste oil	Cd	Hg	Pb	PAH	DIOX	HCB
	[mg/t]				[µg/t]	
1990	360.0	30.0	106 300.0	6.7	17.0	17 020.0
1991			87 560.0		0.4	370.0
1992			68 820.0			
1993			50 080.0			
1994			31 340.0			
1995–2018	13.0		60.0			

Table 310: 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 1993–2017
[4] for 1990
[5] for 1991
[6] for 1992–1995
[7] for 2000–2018
[8] EMEP/EEA Guidebook 2019

6.5.3 Category-specific Recalculations

Following a recommendation of the NECD 2019 review, SO_2, Cd, and PCB emissions from *5.C.1.b.v cremation* have been estimated by means of the tier 1 method from the EMEP/EEA Guidebook 2019.

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"[156]), 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)[157] 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 2006C, BMLFUW 2008b, BMLFUW 2010, BMLFUW 2012, BMLFUW 2014a, BMLFUW 2016, BMNT 2018C). For 2018 preliminary data had to be used as information on the connection rate in some federal provinces were missing at the time of inventory compilation (Umweltbundesamt 2020b).

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.

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[156] 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)

[157] (the former Federal Ministry of Sustainability and Tourism (BMNT) respectively former Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)

Table 311: 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	1 093 098 753	20 585 418	1 072 513 335
2018	1 070 896 259	20 467 467	1 050 428 792

In the year 2018[158] 95.3% of the Austrian population is connected to municipal wastewater treatment plants. The remaining wastewater is treated either in septic tanks (2.9%), domestic wastewater handling systems (1.6%), or disposed otherwise ('unspecified disposal routes': 0.2%).

[158] the latest year for which data on connection rate is currently available

6.6.3 Category-specific Recalculations

For NMVOC from category *5.D.1 domestic wastewater* a recalculation for 2017 was carried out (from 16.82 t to 16.09 t) as new data on wastewater volumes became available. This new data was used to replace activity data that had been extrapolated based on population growth.

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) and 2018. For the years were data is missing, a mean value of car fires by 1000 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 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 1990 to 2004 the number of fires were determined based on the mean value of fire accidents per inhabitant 2005-2010 and the population numbers 1990-2004.

Table 312: 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

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 313: 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

Minor recalculations of particulate matter emissions for 2017 from category *5.E other waste* (+4.6 t TSP/PM_{10}/$PM_{2.5}$) were due to activity data becoming available (data on building fires 2017).

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 2017 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[159]. The last In-depth (Stage 3) review of the Austrian Inventory took place in 2017 (UNITED NATIONS 2017); the findings are summarised in Table 319. The next Stage 3 review is currently not scheduled, but will 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 2019 for Austria are summarised and commented in Table 320.

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.

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 7.3.

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.

[159] http://www.ceip.at/ms/ceip_home1/ceip_home/review_process/stage3_review_ae/

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).

7.2.1 Energy (1)

7.2.1.1 Revision of the energy balance

The federal office for national statistics, "Statistik Austria", revised the energy balance for the years 1990 to 2017 with the following main implications for energy consumption as used in the inventory:

- Natural gas gross inland consumption 2014 and 2015 has been revised downwards by -1 and -1.8 TJ. Moreover, natural gas consumption has been shifted to different sectors: For 2005 and 2006, about 1 to 1.2 PJ have been shifted from the power sector (1.A.1.a) to the commercial sector (1.A.4.a). For 2011, about 0.7 PJ have been shifted from the power sector (1.A.1.a) to the commercial sector (1.A.4.a). For 2013, about 1.7 PJ have been shifted from the commercial and residential sector (1.A.4.a and 1.A.4.b) to the industry sector (1.A.2). For 2014, about 1.1 PJ have been shifted from the residential and commercial sector (1.A.4.a and 1.A.4.b) to the industrial sector (1.A.2). For 2016, about 3 PJ have been shifted from petroleum refineries (1A1b) to the residential and industry sector (1.A.4.b, 1.A.2).
- For liquid fuels, gross inland consumption has been revised downwards by - 0.1 to -2.2 PJ for the years 2005 to 2011 (crude oil input into refineries) and by - 1.3 PJ PJ for the year 2017, which does not have an effect on final consumption, because lower fuel imports have been counterbalanced by higher refinery fuel output. For the period 2013 to 2017, between 1.1 and 4.6 PJ of liquid fuels have been shifted from the industry sector (mostly from 1.A.2.e food processing and 1.A.2.g other manufacturing industries) to the residential (1.A.4.b) and commercial (1.A.4.a) sector.
- For solid fuels, mainly the residential sector has been revised for the years since 2005 (+ 1 PJ in 2005 and + 0.2 PJ in 2017).

- For 'biomass', gross inland consumption has been revised upwards for the whole time series 2005 – 2017 (2005: + 7 PJ, 2010: + 15.7 PJ, 2015: 9.4 PJ, 2017: + 14.5 PJ). For the years 2005 to 2016, transformation input to the power sector (1.A.1.a) has been revised downwards (by - 0.4 to - 2.7 PJ) while for 2017 it has been revised upwards by + 3.5 PJ, which explains most of the higher NO_X (+7%) and $PM_{2.5}$ (+6%) emissions in 2017 of category 1.A.1.a. The largest revision to biomass consumption took place in the 1.A.4 stationary combustion subcategories, with increases of + 6.4 PJ in 2005 and + 12.6 PJ in 2017.

7.2.1.1 Stationary combustion 1.A.1.a, 1.A.1.b, 1.A.1.c, 1.A.2.a-1.A.2.g and 1.A.4.a-1.A.4.c

In general, recalculations follow the revisions of the energy balance. Revisions of methodologies are outlined in the following paragraphs:

7.2.1.2 Petroleum refining (1.A.1.b)

Cd emissions from 1.A.1.b refineries have been re-estimated using a method developed by CONCAWE (CONCAWE 2017). This results in higher Cd emissions 1990 but lower Cd emissions 2017.

7.2.1.3 Pulp and paper industry (1.A.2.d)

Based on a new study (Windsperger et al 2020) performed in 2019, NO_x and $PM_{2.5}$ emission factors from hard coal, black liqueur and wood waste used in pulp and paper industries have been revised, resulting in NO_X emissions that are about - 0.8 kt lower and $PM_{2.5}$ emissions that are slightly higher for 2017.

7.2.1.4 Chemicals industry (1.A.2.c)

$NO_{x,}$ SO_2 and PM_{10} emissions from a large waste incineration plant are now based on measured data. This results in NO_x emissions from category 1.A.2.c that are about - 0.1 kt lower, SO_2 emissions that are - 0.3 kt lower and $PM_{2.5}$ emissions that are - 0.2 kt lower for the year 2017.

7.2.1.5 Other sectors (1.A.4.ai, 1.A.4.bi, 1.A.4.ci)

Changes according to a revision of the energy demand model for space heating

The module 'Heating type by technology' was updated with a new approach based on recent market data and expert consultation (on the sale of fuel technology). This information was used for remodelling the heating stock and turnover based on two studies, resulting in a revised consumption by type of heating.

Additionally, the mixed-fuel wood boiler stock was subdivided into two categories (advanced and conventional). Advanced technology is associated with (slightly) lower NO_x, NMVOC and $PM_{2.5}$ emissions than conventional equipment.

7.2.1.6 Road Transport (1.A.3.b)

The domestic activity data (fuel consumption/mileage) has been updated fundamentally with new specific mileage per vehicle category: for the first time, data from periodic roadworthiness testing has been evaluated resulting in new age-related mileage data and improved data accuracy. This affects the categories passenger cars (PC), light-duty vehicles (LDV) and motorcycles (MC).

Update/Improvement of methodology and emission factors

By using the latest version of the emission model "NEMO" from the Graz University of Technology for emission calculations, the following improvements to the model and to the input data were obtained, resulting in emission changes as described below:

- New specific mileage per vehicle category: for the first time, data from periodic roadworthiness testing has been evaluated resulting in new age-related mileage data. This affects the categories PC, LDV and MC. In the case of cars, the analysis of this new data source led to the following findings:
  - Old vehicles are driven more than previously (and generally) assumed and
  - The specific mileage per car for each year of a vehicle's age is lower than previously assumed
  - These facts generally lead to a decrease in the total domestic mileage of passenger cars over the entire time series.
- New and improved emissions factors for all vehicle categories:
  - The most recent version of the emission calculation model NEMO (TU-Graz) includes the recently released emission factor database HBEFA 4.1. All consumption factors were checked or revised within this new software version.

    The implementation of the new HBEFA Version 4.1 resulted in an increase in emission factors for all vehicle categories. Due to dieselgate and the mandatory PEMS measurements for the Euro 6d_temp standard, large amounts of new measurement data have become available. New findings, such as the influence of ambient temperature on the functional efficiency of NO_x exhaust after-treatment systems (such as SCR), new aging conditions of such systems, new improved traffic situations combined with revised dynamic parameters, have led to an increase in the specific emissions for each vehicle category.

According to the bottom-up/top-down methodology applied for the calculation of domestic fuel consumption and fuel export, an increased use of domestic diesel always results in a reduction of the quantities handled in fuel export, and vice versa. As fuel export is mainly associated with truck traffic, the emission reduction or increase is strongly reflected in subsector 1.A.3.b.3 Heavy duty trucks and buses.

7.2.1.7 Coal mining and handling (1.B.1.a)

The recalculations of $PM_{2.5}$ emissions in category 1.B.1.a (Coal Mining and Handling) for the years 2005–2017 are due to a revision of the energy balance by Statistik Austria. This revision has led to an increase by 0.0004 kt $PM_{2.5}$ emissions in 2017.

7.2.1.1 Other fugitive emissions from energy production (Geothermal energy) (1.B.2.d)

Following a recommendation of the NECD 2019 review, NH_3 emissions from category *1.B.2.d Other fugitive emissions from energy production (Geothermal energy)* have been estimated for the first time.

7.2.2 Industrial Processes and Product Use (2)

7.2.2.1 Other chemical industry (2.B.10.a)

Due to a transcription error, the NMVOC emissions of one chemical plant had to be revised for the whole time series (+ 0.008 kt NMVOC in 2017)

7.2.2.2 Iron and Steel Production (2.C.1)

In this year's submission estimates for the PAH fractions BAP, BBF, BKF, IND category 2.C.1 has been included for the first time.

7.2.2.3 Solvent Use (2.D.3)

Following in-depth QC activities, time series inconsistencies in the solvents model were removed: (i) the reporting categories of the import/export statistics for various ethers had changed over time and have now been considered consistently; and (ii) for antifreeze fluids, of which not all reported in the category are relevant for VOC emissions, the same assumption as the one used in the years before has been applied. This has led to a decrease in activity data (Solvents Used), leading to a decrease in emissions.

Hg emissions

Due to the omission of the EF for Hg from the EMEP EEA GB 2019, this source is no longer reported.

7.2.2.4 Other product use (2.G)

More detailed statistical data became available on cigarettes sold in Austria, as well as loose tobacco and cigars taxed in Austria from 1997 onwards. The trend was then extrapolated back to 1990. This led to an increase of emissions of NO_x, CO, NMVOC, NH_3, TSP, PM_{10}, $PM_{2.5}$, Cd, Ni, Zn, Cu, Dixon and PAHs.

7.2.2.5 2.H Other processes (2.H)

In this year's submission an estimate of the PAH fractions BAP, BBF, BKF, IND in Sector 2.H.2 has been included for the first time.

7.2.2.6 Wood processing (2.I)

Due to recalculations of the energy balances, the activity data had to be updated. Thus, particular matter emissions since 2005 have changed (- 0.001 kt $PM_{2.5}$ for 2017).

7.2.3 Agriculture (3)

7.2.3.1 Manure Management (3.B)

Update of activity data

Livestock numbers of poultry and other animals (mainly deer) have been revised as new data has become available based on the final results of the farm structure survey 2016 (STATISTIK AUSTRIA 1990-2019). To avoid jumps in the time series, the years 2014 and 2015 have been interpolated. As currently no updated data is available for the respective livestock categories, the values of 2016 have been used for the years 2017 and 2018.

Manure Management (3.B) – NH_3

The main reason for revised NH_3 emissions from manure management is the implementation of the new EMEP/EEA Guidebook 2019 (EEA 2019) in Austria's air emission inventory. The 2019 version of the Guidebook provides updated NH_3 emission factors for housing and storage for the livestock categories layers, broilers, sheep and other animals. Furthermore, the calculation method, which is based on the fraction of TAN that is immobilised in organic matter (f_{imm}) when the manure is managed as a litter-based solid and the litter is straw, has been revised. According to (EEA 2019), this immobilisation greatly reduces the potential NH_3-N emission during storage and after application.

The improved calculations resulted in lower NH_3 emissions from manure management for the whole time series (– 1.4 kt NH_3 in 2017)

Biological treatment of waste (5.B.2) – NH_3

NH_3 emissions from anaerobic digestion at biogas facilities are calculated in sector *3 Agriculture* but reported under sector *5 Waste*. The Tier 1 methodology of the EMEP/EEA Guidebook is applied. In the EMEP/EEA GB 2019 the NH_3-N EF was changed from 0.0286 kg of NH_3-N to 0.0275 kg of NH_3-N, leading to a downward revision across the whole time series (– 0.02 kt NH_3 in 2017).

Manure Management (3.B) – NO_x

NO_x emissions are calculated using a mass-flow approach based on the concept of a flow of TAN through the manure management system according to the EMEP/EEA GB 2019. Although there were no changes in the methodology for NO_x between the Guidebook versions 2016 and 2019, the revisions in the ammonia inventory had an impact on NO_x and resulted in lower emissions for the whole time series (– 0.01 kt NO_x in 2017).

Manure Management (3.B) – NMVOC

The NMVOC emission calculations according to the 2019 EMEP/EEA Tier 2 methodology are strongly linked to the compilation of the ammonia emissions inventory. Therefore, although there were no changes in the methodology for NMVOC between the Guidebook versions 2016 and 2019, the revisions to the ammonia inventory also had an impact on NMVOC emissions. The improved calculations resulted in recalculations for the whole time series (+ 0.09 kt NMVOC in 2017).

Manure Management (3.B) - Particle Emissions

Reasons for the recalculated emissions from 2014 to 2017 are the updated activity data of poultry and other animals.

7.2.3.2 Agricultural Soils (3.D)

Update of activity data

Livestock numbers of poultry and other animals (mainly deer) have been revised as new data has become available based on the final results of the farm structure survey 2016 (STATISTIK AUSTRIA 1990-2019, see Chapter 1.3.8)

Detailed raw material and energy balances (3.D.a.2.c)

In 2019 new information on input materials for Austria's biogas plants became available (E-CONTROL 2019) resulting in slightly revised amounts of digested manure and energy crops.

Methodological changes

Agricultural Soils (3.D) *NH_3*

3.D.a.1 Inorganic N fertilisers

Revised emissions from inorganic N fertilisers are due to the implementation of new information on agriculture practice. Including the rapid incorporation of urea into the soil in Austria's calculations resulted in lower NH_3 emissions from synthetic fertiliser application for the entire time series (– 0.6 kt NH_3 in 2017).

3.D.a.2.a Animal manure applied to soils

NH_3 emissions of animal manure applied on soils have been revised downwards for the entire time series. The main reasons are updated NH_3 emission factors for manure spreading for the livestock categories layers and broilers according to the EMEP/EEA GB 2019, as well as improvements carried out in the manure management sector due to the new Guidebook (e.g. updated NH_3 emission factors and an improved calculation of the immobilised fraction of TAN, see Chapter 6.3.2.1). These changes led to a downward revision of the NH_3 emissions by – 1.3 kt for the year 2017.

3.D.a.3 Urine and dung deposited by grazing animals

According to the EMEP/EEA GB 2019, the default Tier 2 NH_3 EFs for grazing for the livestock categories sheep and other animals have been revised downwards compared to the 2016 GB. This results in lower NH_3 emissions for the whole time series (– 0.06 kt NH_3 in 2017).

Agricultural Soils (3.D) *NO_x*

3.D.a.2.a Animal manure applied to soils

The revisions to the ammonia calculations according to the EMEP/EEA GB 2019 in the manure management sector have led to higher N amounts available for application. As a consequence, NO_x emissions of manure application have been resived upwards for the entire time series (+ 0.1 kt NO_x in 2017).

Agricultural Soils (3.D) HCB

3.D.f. Use of Pesticides

Following a recommendation of the NEC Review 2019 Austria estimated these emissions for the first time.

Agricultural Soils (3.D) NMVOC

3.D.a.2.a Animal manure applied to soils

NMVOC emissions from manure application have been estimated based on the 2019 EMEP/EEA Tier 2 methodology which is closely linked to the compilation of the ammonia inventory. Therefore, the revisions to the ammonia inventory also had an impact on the NMVOC emissions and resulted in lower emissions for the entire time series (– 0.3 kt NMVOC in 2017).

7.2.3.3 Field burning of agricultural residues (3.F) – NO_x, SO_2, NMVOC, PM

The EMEP/EEA Tier 2 emission factors for orchard crops provided in the guidebook chapter 5.C.2 Small-scale waste burning were used for the first time resulting in revised emissions for NO_x, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, Cd, Pb, and PAHs.

7.2.4 Waste (5)

7.2.4.1 Waste disposal on land (5.A)

Minor recalculations of particulate matter emissions from waste disposal (- 2.5 t TSP, - 1.2 t PM_{10}, - 0.4 t $PM_{2.5}$ in 2017) were caused by the correction of a transcription error.

7.2.4.2 Biological Treatment (5.B)

NH_3 emissions from anaerobic digestion at biogas facilities (5.B.2) are calculated in sector *3 Agriculture* but reported under sector *5 Waste*. The Tier 1 methodology of the EMEP/EEA Guidebook is applied. In the new EMEP/EEA GB 2019 the NH_3-N EF was changed from 0.0286 kg of NH_3-N to 0.0275 kg of NH_3-N, leading to a downward revision across the whole time series (– 0.02 kt NH_3 in 2017).

7.2.4.3 Incineration and open burning of waste (5.C)

Following a recommendation from the NECD 2019 review, SO_2 emissions from 5.C.1.b.v cremation have been estimated the first time.

7.2.4.4 Wastewater (5.D)

For NMVOC from category *5.D.1 domestic wastewater* a recalculation for 2017 was carried out (from 16.82 t to 16.09 t) as new data on wastewater volumes became available. This new data was used to replace activity data that had previously been extrapolated based on population growth.

7.2.4.5 Other waste (5.E)

Minor recalculations of particulate matter emissions for 2017 from category *5.E other waste* (+4.6 t TSP/PM_{10}/$PM_{2.5}$) were made as activity data became available for this years' submission (data on building fires 2017).

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7.3 Recalculations per Pollutant

The following tables present the changes in emissions[160] for all relevant pollutants compared to the previous submission (IIR 2019). Detailed explanations are provided in the sectoral chapters.

Table 314: Recalculation difference of SO_2 emissions [kt] with respect to submission 2019.

		1990			2017			Absolute Diff.	
SO_2 emissions [kt]		**Δ%**	**Subm. 2019**	**Subm. 2020**	**Δ%**	**Subm. 2019**	**Subm. 2020**	**1990**	**2017**
1.A.1	Energy Industries	*0.0%*	14.06	14.07	*3.4%*	1.29	1.33	0.01	0.04
1.A.2	Manufacturing Industries & Construction	*-0.4%*	17.90	17.83	*-2.9%*	9.25	8.98	-0.07	-0.27
1.A.3	Transport	*0.0%*	5.13	5.13	*1.0%*	0.30	0.30	0.00	0.00
1.A.4	Other Sectors	*0.0%*	32.66	32.66	*18.6%*	1.35	1.60	0.00	0.25
1.A.5	Other	=	0.01	0.01	=	0.02	0.02	-	-
1.B	Fugitive Emissions	=	2.00	2.00	=	0.04	0.04	-	-
2	Industrial Processes and Product Use	=	1.93	1.93	=	0.57	0.57	-	-
3	Agriculture	*10.8%*	0.00	0.01	*39.7%*	0.00	0.00	0.00	0.00
5	Waste	*0.0%*	0.07	0.07	*43.6%*	0.01	0.01	0.00	0.00
	Total Emissions	***-0.1%***	**73.76**	**73.70**	***0.3%***	**12.81**	**12.84**	**-0.07**	**0.03**

Table 315: Recalculation difference of NO_x emissions [kt] with respect to submission 2019.

		1990			2017			Absolute Diff.	
NO_x emissions [kt]		**Δ%**	**Subm. 2019**	**Subm. 2020**	**Δ%**	**Subm. 2019**	**Subm. 2020**	**1990**	**2017**
1.A.1	Energy Industries	*0.2%*	17.78	17.82	*5.4%*	11.15	11.76	0.04	0.61
1.A.2	Manufacturing Industries & Construction	*0.0%*	33.03	33.03	*-4.0%*	27.91	26.79	0.00	-1.12
1.A.3	Transport	*-2.2%*	122.76	120.02	*23.4%*	74.23	91.57	-2.74	17.34
1.A.4	Other Sectors	*1.8%*	29.32	29.85	*1.5%*	19.97	20.26	0.52	0.29
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	*0.0%*	4.27	4.27	*0.5%*	0.47	0.47	0.00	0.00
3	Agriculture	*0.5%*	11.99	12.05	*1.0%*	10.88	10.99	0.06	0.11
5	Waste	=	0.10	0.10	=	0.02	0.02	-	-
	Total Emissions	***-1.0%***	**219.33**	**217.22**	***11.9%***	**144.71**	**161.95**	**-2.11**	**17.24**

[160] 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 316: Recalculation difference of NMVOC emissions [kt] with respect to submission 2019.

		1990			2017			Absolute Diff.	
NMVOC emissions [kt]		**Δ%**	**Subm. 2019**	**Subm. 2020**	**Δ%**	**Subm. 2019**	**Subm. 2020**	**1990**	**2017**
1.A.1	Energy Industries	*-4.7%*	0.33	0.32	*-12.7%*	0.39	0.34	-0.02	-0.05
1.A.2	Manufacturing Industries & Construction	*0.0%*	1.68	1.68	*0.0%*	1.13	1.13	0.00	-0.00
1.A.3	Transport	*10.5%*	88.48	97.78	*-33.4%*	8.95	5.96	9.31	-2.99
1.A.4	Other Sectors	*2.1%*	46.86	47.85	*0.1%*	29.63	29.67	0.99	0.04
1.A.5	Other	*0.0%*	0.01	0.01	*0.1%*	0.02	0.02	0.00	0.00
1.B	Fugitive Emissions	=	15.49	15.49	=	2.29	2.29	-	-
2	Industrial Processes and Product Use	*0.0%*	118.53	118.54	*-15.5%*	40.19	33.96	0.01	-6.24
3	Agriculture	*-1.3%*	52.87	52.19	*-0.6%*	37.53	37.31	-0.68	-0.22
5	Waste	=	0.16	0.16	*-1.2%*	0.06	0.06	-	-0.00
	Total Emissions	***3.0%***	**324.40**	**334.02**	***-7.9%***	**120.19**	**110.73**	**9.61**	**-9.46**

Table 317: Recalculation difference of NH_3 emissions [kt] with respect to submission 2019.

		1990			2017			Absolute Diff.	
NH_3 emissions [kt]		**Δ%**	**Subm. 2019**	**Subm. 2020**	**Δ%**	**Subm. 2019**	**Subm. 2020**	**1990**	**2017**
1.A.1	Energy Industries	*1.2%*	0.19	0.20	*3.2%*	0.44	0.46	0.00	0.01
1.A.2	Manufacturing Industries & Construction	*0.0%*	0.33	0.33	*-3.2%*	0.39	0.38	0.00	-0.01
1.A.3	Transport	*-27.2%*	1.10	0.80	*-13.0%*	1.29	1.12	-0.30	-0.17
1.A.4	Other Sectors	*0.0%*	0.63	0.63	*12.2%*	0.57	0.64	-0.00	0.07
1.A.5	Other	=	0.00	0.00	=	0.00	0.00	-	-
1.B	Fugitive Emissions	=	IE	IE	*NEW*	IE	0.00	IE	0.00
2	Industrial Processes and Product Use	*0.8%*	0.34	0.34	*3.1%*	0.16	0.17	0.00	0.01
3	Agriculture	*-5.1%*	62.23	59.06	*-5.1%*	64.62	61.30	-3.16	-3.32
5	Waste	*-0.1%*	0.37	0.37	*-1.3%*	1.62	1.60	-0.00	-0.02
	Total Emissions	***-5.3%***	**65.19**	**61.73**	***-5.0%***	**69.09**	**65.67**	**-3.46**	**-3.43**

Table 318: Recalculation difference of CO emissions [kt] with respect to submission 2019.

		1990			2017			Absolute Diff.	
CO emissions [kt]		**Δ%**	**Subm. 2019**	**Subm. 2020**	**Δ%**	**Subm. 2019**	**Subm. 2020**	**1990**	**2017**
1.A.1	Energy Industries	*0.6%*	6.07	6.10	*-2.9%*	4.72	4.59	0.03	-0.14
1.A.2	Manufacturing Industries & Construction	*-0.1%*	231.55	231.22	*-0.8%*	163.08	161.82	-0.33	-1.25
1.A.3	Transport	*9.2%*	491.97	537.13	*-9.8%*	79.50	71.69	45.16	-7.81
1.A.4	Other Sectors	*6.0%*	401.90	426.00	*3.7%*	263.39	273.03	24.10	9.64
1.A.5	Other	=	0.22	0.22	=	0.30	0.30	-	-
1.B	Fugitive Emissions	=	IE	IE	=	IE	IE	-	-
2	Industrial Processes and Product Use	*0.1%*	37.16	37.19	*0.5%*	14.08	14.14	0.03	0.07
3	Agriculture	*2.0%*	1.20	1.23	*5.6%*	0.34	0.35	0.02	0.02
5	Waste	=	10.31	10.31	=	3.15	3.15	-	-
	Total Emissions	***5.8%***	**1 180.39**	**1 249.41**	***0.1%***	**528.55**	**529.08**	**69.02**	**0.53**

Table 319: Recalculation difference of Cd emissions [t] with respect to submission 2019.

		1990			2017			Absolute Diff.	
Cd emissions [t]		**Δ%**	**Subm. 2019**	**Subm. 2020**	**Δ%**	**Subm. 2019**	**Subm. 2020**	**1990**	**2017**
1.A.1	Energy Industries	*19.8%*	0.27	0.33	*-10.0%*	0.32	0.28	0.05	-0.03
1.A.2	Manufacturing Industries & Construction	*0.6%*	0.31	0.31	*7.4%*	0.20	0.21	0.00	0.01
1.A.3	Transport	*-73.2%*	0.06	0.02	*-74.7%*	0.11	0.03	-0.04	-0.08
1.A.4	Other Sectors	*-4.0%*	0.42	0.40	*18.8%*	0.27	0.32	-0.02	0.05
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	*0.5%*	0.63	0.63	*2.0%*	0.32	0.33	0.00	0.01
3	Agriculture	*-8.4%*	0.01	0.01	*-27.6%*	0.00	0.00	-0.00	-0.00
5	Waste	*0.1%*	0.06	0.06	*10.9%*	0.00	0.00	0.00	0.00
	Total Emissions	***-0.2%***	**1.76**	**1.75**	***-3.5%***	**1.22**	**1.18**	**-0.00**	**-0.04**

Table 320: Recalculation difference of Hg emissions [t] with respect to submission 2019.

		1990			2017			Absolute Diff.	
Hg emissions [t]		**Δ%**	**Subm. 2019**	**Subm. 2020**	**Δ%**	**Subm. 2019**	**Subm. 2020**	**1990**	**2017**
1.A.1	Energy Industries	*0.3%*	0.35	0.35	*1.7%*	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	*0.2%*	0.00	0.00	-	0.00
1.A.4	Other Sectors	*0.0%*	0.43	0.43	*17.0%*	0.15	0.18	0.00	0.03
1.A.5	Other	=	0.00	0.00	*0.0%*	0.00	0.00	-	0.00
1.B	Fugitive Emissions	=	NA	NA	*NEW*	NA	0.00	NA	0.00
2	Industrial Processes and Product Use	*-7.5%*	0.58	0.53	*-12.0%*	0.41	0.36	-0.04	-0.05
3	Agriculture	=	0.00	0.00	=	0.00	0.00	-	-
5	Waste	=	0.05	0.05	*0.1%*	0.04	0.04	-	0.00
	Total Emissions	***-1.9%***	**2.21**	**2.17**	***-2.1%***	**1.05**	**1.03**	**-0.04**	**-0.02**

Table 321: Recalculation difference of Pb emissions [t] with respect to submission 2019.

		1990			2017			Absolute Diff.	
Pb emissions [t]		**Δ%**	**Subm. 2019**	**Subm. 2020**	**Δ%**	**Subm. 2019**	**Subm. 2020**	**1990**	**2017**
1.A.1	Energy Industries	*1.6%*	1.44	1.47	*2.1%*	2.38	2.43	0.02	0.05
1.A.2	Manufacturing Industries & Construction	*0.0%*	5.59	5.59	*-5.7%*	2.30	2.17	-0.00	-0.13
1.A.3	Transport	*10.2%*	162.93	179.54	*38619.7%*	0.01	4.62	16.61	4.60
1.A.4	Other Sectors	*-1.8%*	7.52	7.38	*18.6%*	1.90	2.25	-0.14	0.35
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	=	9.07	9.07	-	-
3	Agriculture	*-49.2%*	0.01	0.00	*-53.9%*	0.01	0.00	-0.00	-0.00
5	Waste	=	1.02	1.02	*0.6%*	0.00	0.00	-	0.00
	Total Emissions	***7.6%***	**215.93**	**232.41**	**31.1%**	**15.66**	**20.54**	**16.49**	**4.87**

Table 322: Recalculation difference of PAH emissions [t] with respect to submission 2019.

PAH emissions [t]		1990			2017			Absolute Diff.	
		Δ%	Subm. 2019	Subm. 2020	Δ%	Subm. 2019	Subm. 2020	1990	2017
1.A.1	Energy Industries	*1.8%*	0.01	0.01	*2.6%*	0.03	0.03	0.00	0.00
1.A.2	Manufacturing Industries & Construction	*0.0%*	0.06	0.06	*-2.7%*	0.22	0.22	0.00	-0.01
1.A.3	Transport	*1.7%*	0.29	0.29	*-2.3%*	0.35	0.34	0.00	-0.01
1.A.4	Other Sectors	*-7.6%*	12.39	11.45	*-5.6%*	6.91	6.52	-0.94	-0.39
1.A.5	Other	*0.0%*	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	*0.0%*	7.14	7.14	*0.1%*	0.25	0.25	0.00	0.00
3	Agriculture	*-67.2%*	0.25	0.08	*-44.4%*	0.08	0.04	-0.17	-0.03
5	Waste	=	0.00	0.00	=	0.00	0.00	-	-
	Total Emissions	***-5.5%***	**20.13**	**19.03**	***-5.5%***	**7.83**	**7.39**	**-1.10**	**-0.43**

Table 323: Recalculation difference of Dioxin/Furan (PCDD/F) emissions [g] with respect to submission 2019.

Dioxin/Furan emissions [g]		1990			2017			Absolute Diff.	
		Δ%	Subm. 2019	Subm. 2020	Δ%	Subm. 2019	Subm. 2020	1990	2017
1.A.1	Energy Industries	*0.0%*	12.13	12.14	*2.2%*	1.38	1.41	0.00	0.03
1.A.2	Manufacturing Industries & Construction	*0.0%*	1.68	1.68	*-4.9%*	3.94	3.75	0.00	-0.19
1.A.3	Transport	*8.6%*	3.83	4.16	*-4.9%*	1.65	1.57	0.33	-0.08
1.A.4	Other Sectors	*4.1%*	42.13	43.87	*-13.8%*	24.18	20.84	1.73	-3.34
1.A.5	Other	*0.0%*	0.00	0.00	*-1.2%*	0.00	0.00	-	-0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	-	-
2	Industrial Processes and Product Use	*0.0%*	42.85	42.85	*0.0%*	6.78	6.78	0.00	0.00
3	Agriculture	=	0.18	0.18	=	0.06	0.06	-	-
5	Waste	=	20.29	20.29	*1.7%*	2.74	2.78	-	0.05
	Total Emissions	***1.7%***	**123.10**	**125.17**	***-8.7%***	**40.73**	**37.18**	**2.07**	**-3.54**

Table 324: Recalculation difference of HCB emissions [kg] with respect to submission 2019.

HCB emissions [kg]		1990			2017			Absolute Diff.	
		Δ%	Subm. 2019	Subm. 2020	Δ%	Subm. 2019	Subm. 2020	1990	2017
1.A.1	Energy Industries	*0.3%*	0.27	0.28	*1.6%*	0.50	0.51	0.00	0.01
1.A.2	Manufacturing Industries & Construction	*0.0%*	0.29	0.29	*-4.2%*	0.64	0.61	0.00	-0.03
1.A.3	Transport	*8.6%*	0.77	0.83	*-4.9%*	0.33	0.31	0.07	-0.02
1.A.4	Other Sectors	*-1.7%*	54.40	53.49	*-7.9%*	32.60	30.03	-0.91	-2.57
1.A.5	Other	*0.0%*	0.00	0.00	*-1.2%*	0.00	0.00	-	-0.00
1.B	Fugitive Emissions	=	NA	NA	=	NA	NA	-	-
2	Industrial Processes and Product Use	=	20.07	20.07	=	6.07	6.07	-	-
3	Agriculture	*27489.4%*	0.04	10.15	*15441.6%*	0.01	1.81	10.12	1.79
5	Waste	=	0.39	0.39	=	0.06	0.06	-	-
	Total Emissions	***12.2%***	**76.23**	**85.50**	***-2.0%***	**40.21**	**39.40**	**9.27**	**-0.81**

Table 325: Recalculation difference of TSP emissions [kt] with respect to submission 2019.

		1990			2017			Absolute Diff.	
TSP emissions [kt]		**Δ%**	**Subm. 2019**	**Subm. 2020**	**Δ%**	**Subm. 2019**	**Subm. 2020**	**1990**	**2017**
1.A.1	Energy Industries	*2.5%*	1.03	1.06	*4.7%*	1.22	1.28	0.03	0.06
1.A.2	Manufacturing Industries & Construction	*-3.7%*	2.46	2.37	*-22.6%*	1.43	1.11	-0.09	-0.32
1.A.3	Transport	*5.2%*	8.69	9.15	*1.8%*	6.73	6.85	0.45	0.12
1.A.4	Other Sectors	*1.7%*	14.90	15.16	*-3.2%*	9.04	8.75	0.26	-0.29
1.A.5	Other	=	0.02	0.02	=	0.02	0.02	-	-
1.B	Fugitive Emissions	=	0.85	0.85	*0.7%*	0.43	0.44	-	0.00
2	Industrial Processes and Product Use	*0.1%*	19.29	19.31	*0.2%*	15.94	15.96	0.02	0.03
3	Agriculture	*-0.9%*	4.99	4.95	*-0.2%*	4.56	4.55	-0.04	-0.01
5	Waste	=	0.35	0.35	*0.3%*	0.73	0.73	-	0.00
	Total Emissions	***1.2%***	**52.59**	**53.21**	***-1.0%***	**40.10**	**39.69**	**0.62**	**-0.41**

Table 326: Recalculation difference of PM_{10} emissions [kt] with respect to submission 2019.

		1990			2017			Absolute Diff.	
PM_{10} emissions [kt]		**Δ%**	**Subm. 2019**	**Subm. 2020**	**Δ%**	**Subm. 2019**	**Subm. 2020**	**1990**	**2017**
1.A.1	Energy Industries	*2.4%*	0.98	1.00	*4.6%*	1.11	1.17	0.02	0.05
1.A.2	Manufacturing Industries & Construction	*-3.7%*	2.27	2.18	*-22.3%*	1.30	1.01	-0.08	-0.29
1.A.3	Transport	*6.9%*	6.93	7.41	*4.2%*	4.39	4.58	0.48	0.19
1.A.4	Other Sectors	*2.2%*	13.91	14.21	*-3.7%*	8.52	8.20	0.30	-0.32
1.A.5	Other	=	0.02	0.02	=	0.02	0.02	-	-
1.B	Fugitive Emissions	=	0.40	0.40	*0.7%*	0.20	0.21	-	0.00
2	Industrial Processes and Product Use	*0.2%*	11.15	11.16	*0.4%*	7.99	8.02	0.02	0.03
3	Agriculture	*-1.0%*	4.28	4.24	*-0.6%*	3.93	3.90	-0.04	-0.02
5	Waste	=	0.28	0.28	*0.7%*	0.47	0.48	-	0.00
	Total Emissions	***1.7%***	**40.21**	**40.90**	***-1.3%***	**27.94**	**27.58**	**0.69**	**-0.36**

Table 327: Recalculation difference of $PM_{2.5}$ emissions [kt] with respect to submission 2019.

		1990			2017			Absolute Diff.	
$PM_{2.5}$ emissions [kt]		**Δ%**	**Subm. 2019**	**Subm. 2020**	**Δ%**	**Subm. 2019**	**Subm. 2020**	**1990**	**2017**
1.A.1	Energy Industries	*2.3%*	0.83	0.85	*4.5%*	0.94	0.99	0.02	0.04
1.A.2	Manufacturing Industries & Construction	*-3.5%*	1.97	1.90	*-21.8%*	1.11	0.87	-0.07	-0.24
1.A.3	Transport	*8.2%*	5.98	6.48	*8.1%*	2.98	3.22	0.49	0.24
1.A.4	Other Sectors	*3.0%*	13.02	13.41	*-4.4%*	8.13	7.77	0.39	-0.36
1.A.5	Other	=	0.02	0.02	=	0.02	0.02	-	-
1.B	Fugitive Emissions	=	0.11	0.11	*0.7%*	0.06	0.07	-	0.00
2	Industrial Processes and Product Use	*0.4%*	3.81	3.82	*1.8%*	1.75	1.78	0.02	0.03
3	Agriculture	*-11.2%*	0.41	0.36	*-10.9%*	0.31	0.28	-0.05	-0.03
5	Waste	=	0.23	0.23	*1.3%*	0.31	0.32	-	0.00
	Total Emissions	***3.0%***	**26.37**	**27.17**	***-2.0%***	**15.61**	**15.30**	**0.80**	**-0.31**

7.4 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 320. The improvements made in response to the review process under the NEC Directive 2019 are indicated in Table 321.

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 328: 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
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

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
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
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 3.1.6

Finding CLRTAP Review 2017	Reference	Improvement made	Chapter
Energy (mobile)			
1.A.3.b.iv – $PM_{2.5}$: For category 1.A.3.b.iv, $PM_{2.5}$ emissions are indicated as "IE" and the ERT asked where these emissions are included. The Party answered that $PM_{2.5}$ emissions from mopeds and motorcycles should be reported as "NE" and not as "IE" as there are no CS measurements for $PM_{2.5}$ exhaust emissions of 2-wheelers in Austria and the Guidebook suggests no calculation method for estimating those emissions according to Tier 3 (EMEP/EEA Update Dec. 2016 p.57). Austria will consider implementing the suggested Tier 2 default $PM_{2.5}$ emission factors for mopeds and motorcycles in the emission model NEMO for the next submission. Although the contribution of this source is under the 2% threshold compared to national total, it is recommended that the Party calculates and reports these emissions in the next submission.	Para 57	The suggested Tier 2 (EMEP/EEA 2016) default $PM_{2.5}$ EFs for mopeds and motorcycles have been implemented in the emission model NEMO since submission 2018.	Chapter 3.2.6
1.A.3.b.vi, 1.A.3.b.vii – PMs, HMs: Emissions from category 1.A.3.b.vi are reported as "NA" and the ERT asked the Party to explain the reason. The ERT also noted that "PM emissions from tyre and brake wear are included in road abrasion"; nevertheless, the ERT wants to encourage Austria to provide separate estimates for both sub-categories in future submissions. In any case, the notation key "IE" should be used instead of "NA", since the emissions from 1.A.3.b.vi are included in 1.A.3.b.vii. Austria answered that emissions from 1.A.3.b.vi tyre and break wear are definitely included in 1.A.3.b.vii automobile road abrasion. Hence, the notation key indeed should be "IE" instead of "NA". The Party will discuss if the emissions model NEMO can provide $PM_{2.5}$ non-exhaust emissions for tyre/break wear and road abrasion separately. The ERT welcomes this plan.	Para 58	The separate reporting of $PM_{2.5}$ non-exhaust emissions from tyre/break wear and road abrasion has been implemented in the emission model NEMO since submission 2018.	NFR tables, Chapter 3.2.6
1.A.3.b.vi, 1.A.3.b.vii – PMs, HMs: Following up on a relevant question from previous Stage 3 review report (2010, Transport, Category issue 5), the ERT wants to encourage Austria to provide estimates for "Additional HMs" for the categories 1.A.3.b.vi, 1.A.3.b.vii, although these are not mandatory to report.	Para 59	Austria has included this issue in it's sectoral improvement plan, but considers this as "not of high priority" due to the non-mandatory reporting obligation	-

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 2016 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 2016 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 particular 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.	Chapter 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 2016 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	From submission 2018 onwards Austria applies the notation key "NA" instead of "NO" for source category *3.D.f.*	NFR tables
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 329: Improvements made in response to the NEC Review in 2019.

Finding NEC Review 2019	Reference	Improvement made	Chapter
National Total			
0A National Total - National Total for the Entire Territory - Based on Fuel Sold/Fuel Used, BaP, PAHs, 1990-2017: For National Total and the 4 PAH species and all years the TERT noted that Austria does not estimate emissions. To the question on the issue Austria responded that they will put this on the improvement list.	AT-0A-2019-0001	This improvement will be finished by the next submission.	Chapter 2.4.1.1
0B National Total for Compliance Assessment, NOX, NH3, 2010-2017: The TERT noted that there is a lack of clarity regarding the calculation of National Totals (rows 141 and 143). In response to the TERT's request for clarification, the Member state responded: "Austria's "NATIONAL TOTAL FOR COMPLIANCE" (row 144) for the years 2010 to 2017 is based on 'fuel used'. For the years 1990-2009 the "NATIONAL TOTAL FOR COMPLIANCE" (row 144) is reported as 'NR' because there is no compliance for those years under the NEC-Directive. For Austria's comparison with the national emission ceilings from 2010 onwards (Austria's Total for Compliance) both emissions from fuel export (sector Transport) and emissions from approved adjustments have to be subtracted from the National Total based on fuel sold. Austria calculated emission amounts as follows (e.g. for 2017 and NOX emissions): Sum of emissions from all categories excluding emissions from sector Transport 1A3 (rows 14 to 24 and 39 to 140; resulting in 70.48 kt NOX) plus emissions from sector Transport 'Fuel used' (row 152; 61.00 kt NOX) plus 'Adjustments' (row 143) -37.38 NOX = 94.10 kt NOX. For NH3 the same formula is applied. Pursuant to the provisions of the NEC Directive Austria adjusted annual national emission inventories only for those years where national emission reduction commitments would be exceeded without adjustment application."	AT-0B-2019-0001	The new ANNEX I tables in NFR-19 format contain formulae that make the calculation of the national compliance total transparent	NFR Tables 2.5
Energy (stationary)			
1A1b Petroleum Refining, Cd, 2016, 2017: For category 1A1b Petroleum Refining for the pollutant Cd and years 2016 and 2017, the IEF ratios are outliers when compared to other Member States. The TERT notes that reported emissions are higher (>4 times higher) than when a reference value is calculated using Tier 1 EFs from the 2016 EMEP/EEA Guidebook. In response to a question raised during the review, Austria agreed that their national emission factors were much higher and thus Austria might be over-estimating this source. Austria stated that this issue will be investigated and revised in the next submission.	AT-1A1b-2019-0002	Cd emissions from 1A1b refineries have been re-estimated using a method developed by CONCAWE. This results in higher Cd emissions 1990 but lower Cd emissions 2017.	Chapter 3.1.3.2

Finding NEC Review 2019	Reference	Improvement made	Chapter
1A3b Road Transport, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000-2017: Austria has the option to use road transport emissions estimated by fuel used for compliance purposes. The TERT noted that there is a lack of transparency regarding whether only road transport or other transport and/or mobile machinery are estimated on a fuel used basis for compliance purposes. The TERT recognise that this is partly due to the format of the Annex I reporting template. In response to a question raised during the review, Austria explained that road transport by fuel used is used for compliance purposes, and all other sources are calculated on a fuel sold basis.	AT-1A3b-2019-0001	A clear explanation is now included.	Chapter 3.2.6
1A3bvi Road Transport: Automobile Tyre and Brake Wear, Pb, 1998-2017: For Pb emissions from 1A3bvi Road Transport: Automobile Tyre and Brake Wear the TERT noted that emissions are reported as 'NA' in the 2019 submission. However, default emission factors are provided in the 2016 EMEP/EEA Guidebook and therefore emission estimates should have been provided for completeness. In response to a question raised during the review, Austria agreed with the finding and provided revised estimates for 1990, 2005, 2016 and 2017 and stated that the emissions will be included in the next submission. The TERT agreed with the revised estimate provided by Austria.	AT-1A3bvi-2019-0001	The inclusion of Pb emissions from Tyre and Break wear lead to an increase in Pb emissions over the entire time series.	Chapter 3.2.6
1A3c Railways, NO_X, NMVOC, SO_2, NH_3, $PM_{2.5}$, 2004, 2005, 2010, 2011: For 1A3c Railways, all pollutants and years 2004-2005 and 2010-2011, the TERT noted that there are large changes in the activity data between 2004 - 2005 and 2010 - 2011 for this sector. This causes large changes in the pollutant emissions during these years. In response to a question raised during the review Austria agreed with the finding but stated that as this is not a key category, it was not of high priority to resolve the issue. The TERT noted that the issue is below the threshold of significance for a technical correction.	AT-1A3c-2019-0001	This item is included in the improvement plan and dicussed in the planned improvements.	Chapter 3.2.7.2
Energy (mobile)			
1A3dii National Navigation (Shipping), NO_X, 2008: For 1A3dii National Navigation, NO_X, 2008, the TERT noted that significant recalculations had occurred between the 2018 and 2019 inventory submissions for this year, but that no reasons for the change were provided in the IIR. In response to a question raised during the review, Austria identified that the emission estimates were in fact incorrect for this year and that this would be corrected in future submissions. The TERT noted that the issue is below the threshold of significance for a technical correction and related to a non-mandatory year.	AT-1A3dii-2019-0002	The mistake is corrected.	NFR Tables
Fugitive Emissions			

Finding NEC Review 2019	Reference	Improvement made	Chapter
1B2d Other Fugitive Emissions from Energy Production, Geothermal Energy Extraction, NH3, Hg, As, 1990-2017: For category 1B2d Other Fugitive Emissions from Energy Production, pollutants NH_3, Hg and As for all years the TERT noted that the notation key 'NE' is used. In response to a question raised during the review, Austria explained that they are in contact with the Austrian Association of Gas and District Heating Supply Companies to clarify whether emissions from geothermal energy are occurring in Austria.	AT-1B2d-2019-0001	Recalculations of NH3- and Hg-emissions for the years 2005-2017 are due to the new estimation of fugitive emissions from energy production in geothermal energy (subcategory 1.B.2.d) and lead to an increase of 0.0005kt NH3 and 0.0001kt Hg in 2017	Chapter 3.3.5
Agricultural Soils			
3Da2a Animal Manure Applied to Soils, NH_3, 2000-2010: For 3Da2a Animal manure applied to soils and NH_3 the TERT noted that there is a lack of transparency regarding recalculations. This does not relate to an over- or under-estimate of emissions.	AT-3Da2a-2019-0001	Improvements of the methodological description have been implemented in the IIR.	Chapter 5.5.3.1
3Df Use of Pesticides, HCB, 1990, 2005, 2016, 2017: For category 3Df Use of Pesticides, pollutant HCB for years 1990, 2005, 2015, 2016 and 2017 the TERT noted that Austria reports 'NA'. In response to a question raised during the review, Austria indicated that due to the fact that the latest update of the guidebook version was published in October 2018 this issue could not be considered in the current submission. However, Austria will include it in its improvement plan and explained that there is a need for further investigation on the use of the relevant pesticides and possible impurities or by-products in Austria.	AT-3Df-2019-0001	Emssions are estimated and the category is described in the IIR.	NFR Tables Chapter 5.5.6
Waste			
5C1bv Cremation, SO_2, Cd, PCBs, BaP, 1990-2017: For 5C1bv Cremation the TERT noted that there may be an under-estimate of emissions because some pollutant emissions (SO_2, Cd, PCBs, BaP that were reviewed this year and BbF, BkF, IndP that were not reviewed this year) are not estimated although EFs are proposed in the 2016 EMEP/EEA Guidebook. Anyway, Austria reports the sum of the 4 PAHs. In response to a question raised during the review Austria indicated that it will consider the updated methodology proposed in the 2016 EMEP/EEA Guidebook in its next submission. The TERT noted that the issue is below the threshold of significance for a technical correction.	AT-5C1bv-2019-0002	SO_2, Cd, and PCB emissions from 5.C.1.b.v cremation have been estimated	NFR Tables Chapter 6.5

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 latest emission projections for the scenario 'with existing measures' for the year 2020, 2025 and 2030 are published in the report 'Austria's National Air Emission Projections 2019 for 2020, 2025 and 2030' (UMWELTBUNDESAMT 2019d). 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 2017 (UMWELTBUNDESAMT 2017b).

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 64% for fuel sold and 55% 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.

Emission reductions for the other pollutants are in the range from 27% to 48%; NH_3 emissions, however, are projected to increase by 14–15% (see Table 321).

*Table 330: 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**.*

Pollutant	Emission inventory 2019				Emission scenario			Type of scenario
[kt]	**1990**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	
NO_x	219.33	237.87	183.14	144.71	126.62	99.29	84.49	fuel sold
		0.0%	*-23.0%*	*-39.2%*	*-46.8%*	*-58.3%*	*-64.5%*	
	204.33	178.66	152.51	131.48	116.74	93.31	80.21	fuel used
		0.0%	*-14.6%*	*-26.4%*	*-34.7%*	*-47.8%*	*-55.1%*	
SO_2	73.76	25.47	15.86	12.81	13.58	13.41	13.31	fuel sold
		0.0%	*-38%*	*-50%*	*-47%*	*-47%*	*-48%*	
	72.98	25.42	15.83	12.78	13.55	13.36	13.27	fuel used
		0.0%	*-38%*	*-50%*	*-47%*	*-47%*	*-48%*	
NMVOC	324.40	156.10	137.17	120.19	120.37	116.00	111.85	fuel sold
		0.0%	*-12%*	*-23%*	*-23%*	*-26%*	*-28%*	
	322.24	152.16	135.55	119.30	119.57	115.27	111.16	fuel used
		0.0%	*-11%*	*-22%*	*-21%*	*-24%*	*-27%*	
NH_3	65.19	62.70	65.70	69.09	69.47	70.51	71.57	fuel sold
		0.0%	*5%*	*10%*	*11%*	*12%*	*14%*	
	65.15	62.17	65.40	68.85	69.22	70.24	71.28	fuel used
		0.0%	*5%*	*11%*	*11%*	*13%*	*15%*	
$PM_{2.5}$	26.37	22.21	19.19	15.61	14.94	13.42	12.16	fuel sold
		0.0%	*-14%*	*-30%*	*-33%*	*-40%*	*-45%*	
	25.87	20.62	18.49	15.38	14.79	13.33	12.09	fuel used
		0.0%	*-10%*	*-25%*	*-28%*	*-35%*	*-41%*	

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 submission 2017 Austria reported data on gridded emissions based on fuel sold and on fuel used as well as LPS data for 2015. The data for previous years (1990, 1995, 2000, 2005 and 2010) was reported in submission 2012[161].

This chapter includes descriptions on input data, methodology and results of the Austrian gridded emissions for 2015 as well as on large point sources (LPS) for 2015, officially submitted in 2017[162].

Therefore, this chapter remains unchanged since IIR 2017.

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. So, 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 14 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 322 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 2016 (EEA 2016).

[161] http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2012_submissions/

[162] http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2017_submissions/

Table 331: GNFR categories and corresponding NFR categories.

GNFR ID	GNFR Name	NFR categories	Note
A_PublicPower	Public Power	1.A.1.a	
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	
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	
D_Fugitive	Fugitive Emissions	1.B.1, 1.B.2	
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	
F_RoadTransport	Road Transport	1.A.3.b	
G_Shipping	Shipping	1.A.3.d.i(ii), 1.A.3.d.ii	
H_Aviation	Aviation	1.A.3.a.i(i), 1.A.3.a.ii(i)	
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	
J_Waste	Waste	5	
K_AgriLivestock	Agriculture – Livestock	3.B	
L_AgriOther	Agriculture – Other	3.D, 3.F, 3.I	
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 10.4. 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 323 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).

It was not possible to create a fully homogenous set of proxy data that always refers to the year 2015, due to lack of data availability. The data sources cover a time frame from 2011 to 2016, e.g. economic activities on municipal level, where the latest data set is from 2011. This information is also included in Table 323.

Table 332: 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)[163]	2011–2016	Cadaster
River network	Danube, Shipping area	BMLFUW[164]	2015	Vector data
Employees in the manufacturing industries sector	Economic activities on municipal level (NACE classification), register census 2011	Statistik Austria[165]	2011	Municipal level; cadaster
Population	Population per municipality	Statistik Austria	2015	Municipal level
Permanent settlement area	Statistical processed data according to Corine Landcover	Statistik Austria	2013	25 m raster
Corine Land cover 2012	Raster data on land cover	Environment Agency Austria[166]	2012	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[167]	2016	Vector data
Traffic census points	Geo-referenced information on traffic census on motorways	ASFINAG[168]	2015	Points, coordinates
Register of buildings and dwellings	Geo-referenced information on dwellings and buildings	Statistik Austria	2016	Address data
Rural- urban typology	Statistical processed data	Statistik Austria	2015	Municipal level
Animal livestock numbers	INVEKOS data base	Agrarmarkt Austria (AMA)[169]	2012	1 km raster
Large Point Sources (LPS)	Geo-referenced information on power plants, large industrial plants	Official data sub-missions 2017 under Regulation (EC) No 166/2006 and Directive 2010/75/EU	2015	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	2015	Municipal level

[163] http://inspire.ec.europa.eu/LMOS/federal-office-metrology-and-surveying-bev

[164] https://www.bmlfuw.gv.at/

[165] https://www.statistik.at/web_de/statistiken/index.html

[166] http://www.eea.europa.eu/data-and-maps/data/external/corine-land-cover-2012

[167] http://www.gip.gv.at/

[168] http://www.asfinag.at/home-en

[169] https://www.ama.at/Intro

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*.

Population and permanent settlement data

Data from population for 2015 is available from national official statistics at municipal level.

The permanent settlement area combines Corine Landcover data and economic statistics and is a data set compiled by Statistik Austria. The latest one is available for 2013 and in a resolution of 25 m.

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.

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 was described above.

Traffic network and traffic census data

The river network as well as the road network builds the 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.

Register of buildings and dwellings

Geo-referenced information on dwellings and buildings (e.g. heating systems, age of buildings 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.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.

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 INVEKOS data base, available as 1 km raster, were used as proxy. The respective animal categories are consistent with those included in the Austrian Air Emission Inventory on NFR level. Another approach 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 for 2015 are reported by Austrian plants according to Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) (Large Combustion Plants – LCP) as well as under Regulation (EC) No 166/2006 on the establishment of a European Pollutant Release and Transfer Register. The required information on emission values, coordinates, stack heights etc. was matched for each relevant NFR sector and aggregated to the respective GNFR sectors to be in line with the CLRTAP reporting obligation (see reporting template Annex VI). For further information please refer to Chapter 9.2.

Waste treatment

Two different data bases have been taken as proxy for GNFR sector *J_Waste*. On the one hand the respective large point sources with activities in the waste sector have been used as proxy data for waste treatment. On the other hand the population in permanent settlement areas was applied for disaggregating the emissions from waste.

9.1.3.2 Austria's allocation of emissions for the EMEP Grid

Method of allocation

Emissions from point sources were directly allocated to the coordinates of the individual emitters. Line based emissions and emissions from area sources were disaggregated from the national total emissions to the described proxy data (see Table 323). 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.

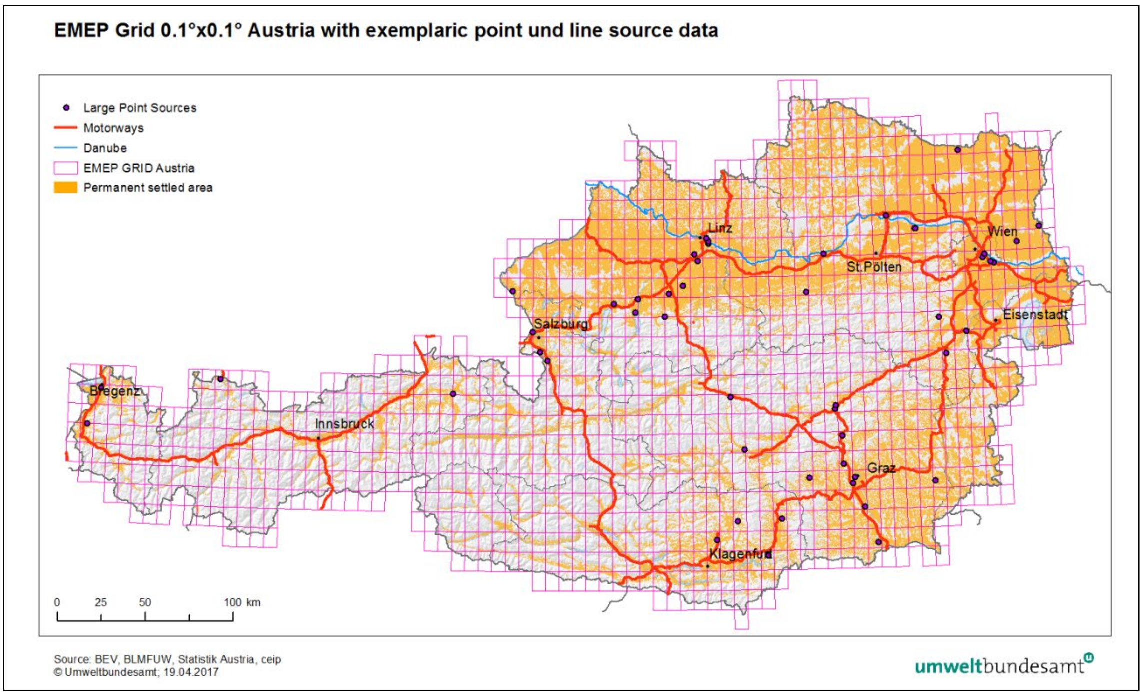

Figure 51: EMEP Grid Austria – example for allocation of the motorway network and waterways (Danube).

A short and simple example of the allocation of the motorway network and waterways (Danube) is illustrated in Figure 51 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 2015

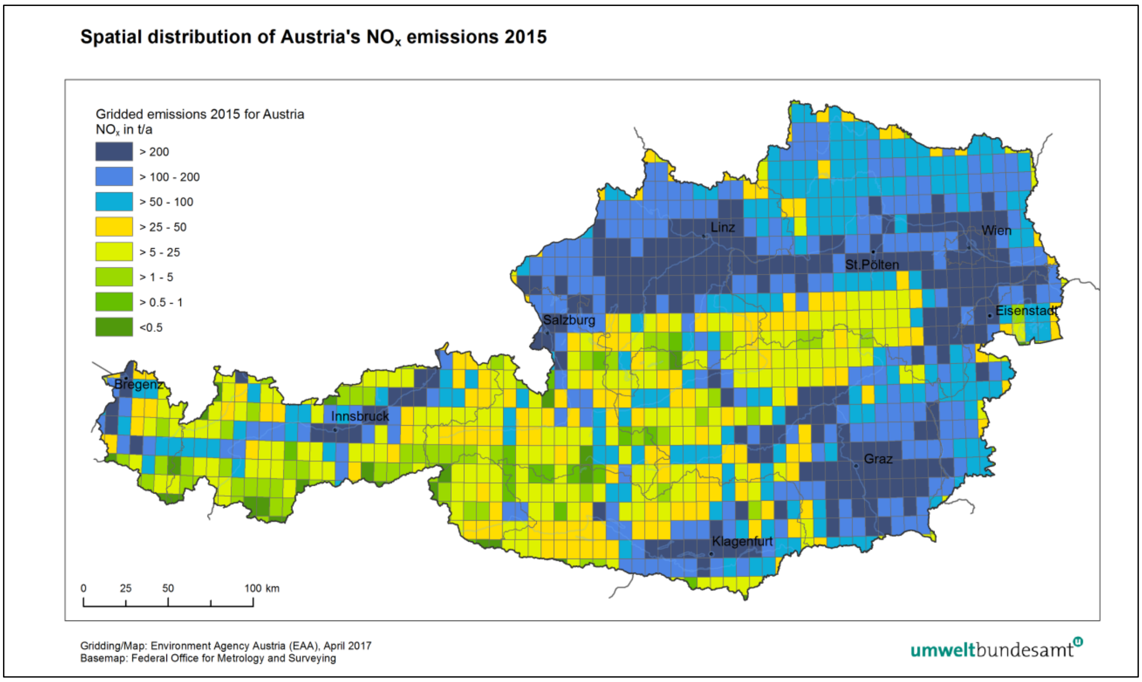

Figure 52: Spatial distribution of Austria´s NO_x emissions 2015 based on fuel sold.

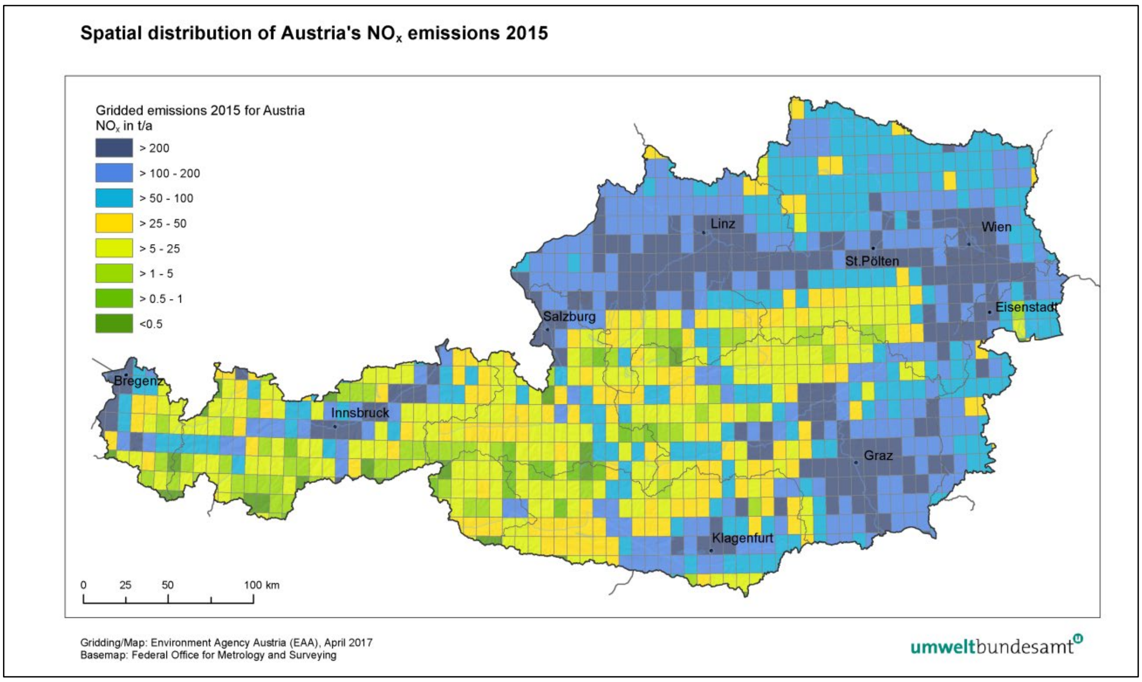

Figure 53: Spatial distribution of Austria´s NO_x emissions 2015 based on fuel used.

9.1.4.2 Spatial distribution of SO_2 emissions in 2015

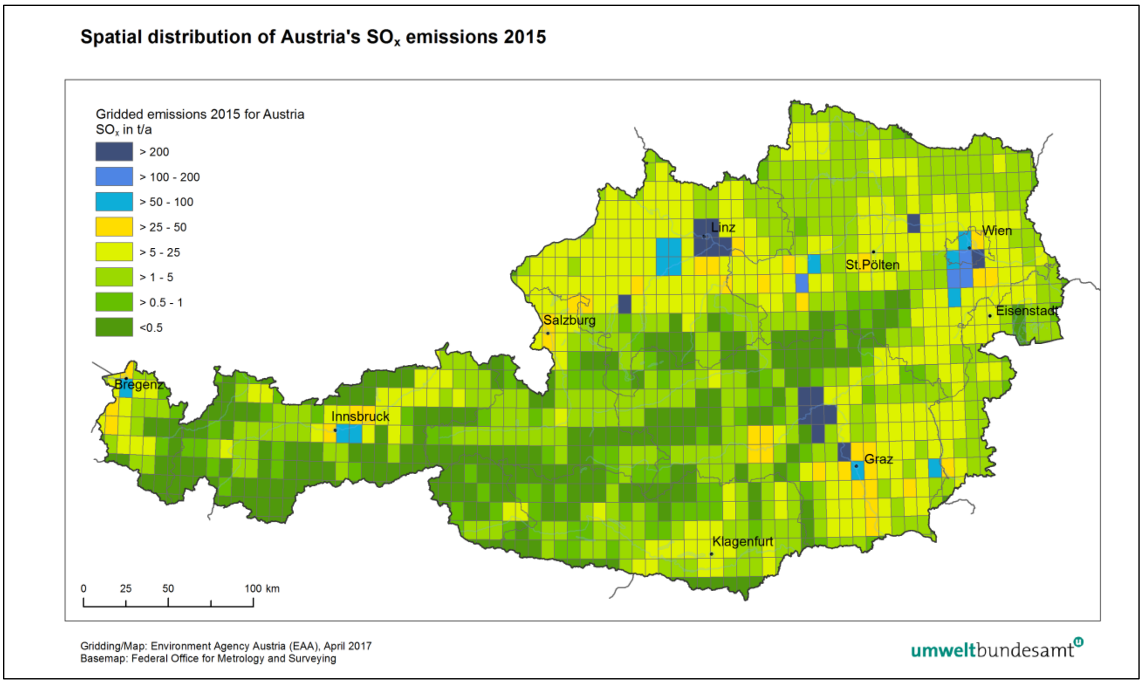

Figure 54: Spatial distribution of Austria´s SO_2 emissions 2015 based on fuel sold.

9.1.4.3 Spatial distribution of NMVOC emissions in 2015

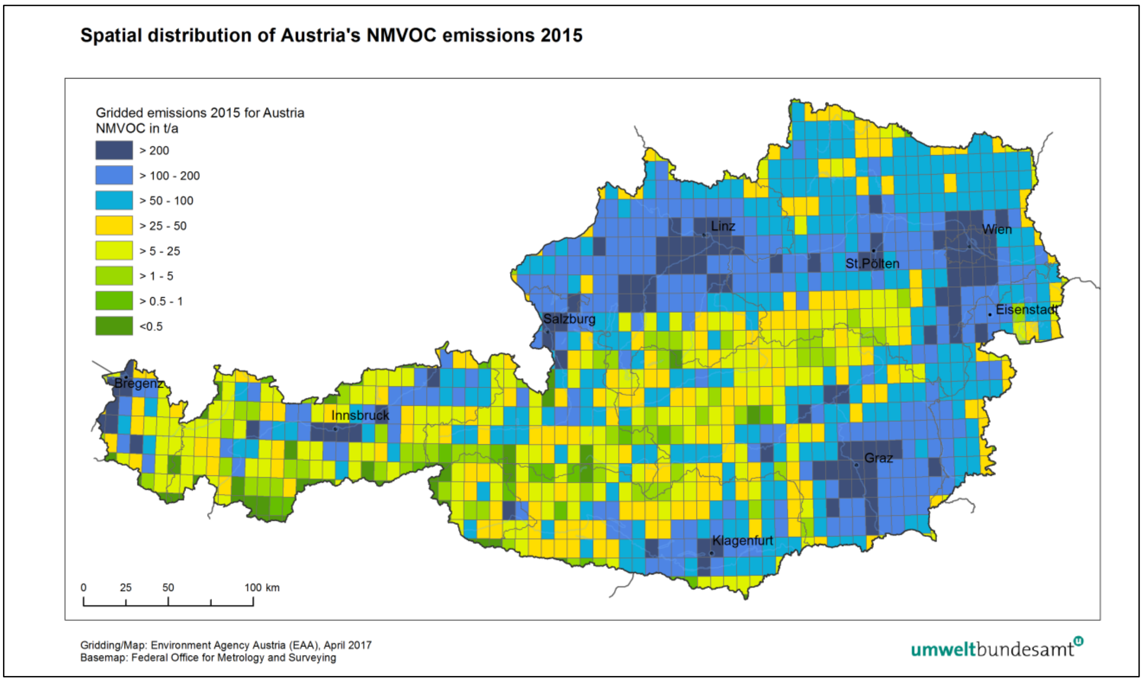

Figure 55: Spatial distribution of Austria´s NMVOC emissions 2015 based on fuel sold.

9.1.4.4 Spatial distribution of NH_3 emissions in 2015

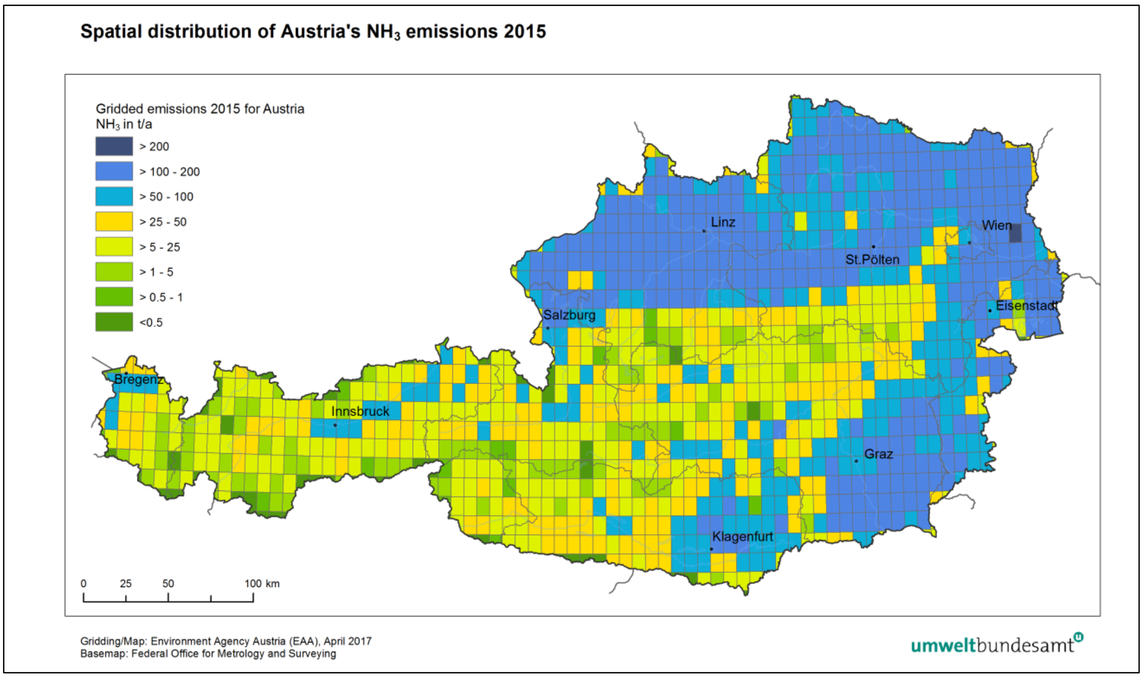

Figure 56: Spatial distribution of Austria´s NH_3 emissions 2015 based on fuel sold.

9.1.4.5 Spatial distribution of $PM_{2.5}$ emissions in 2015

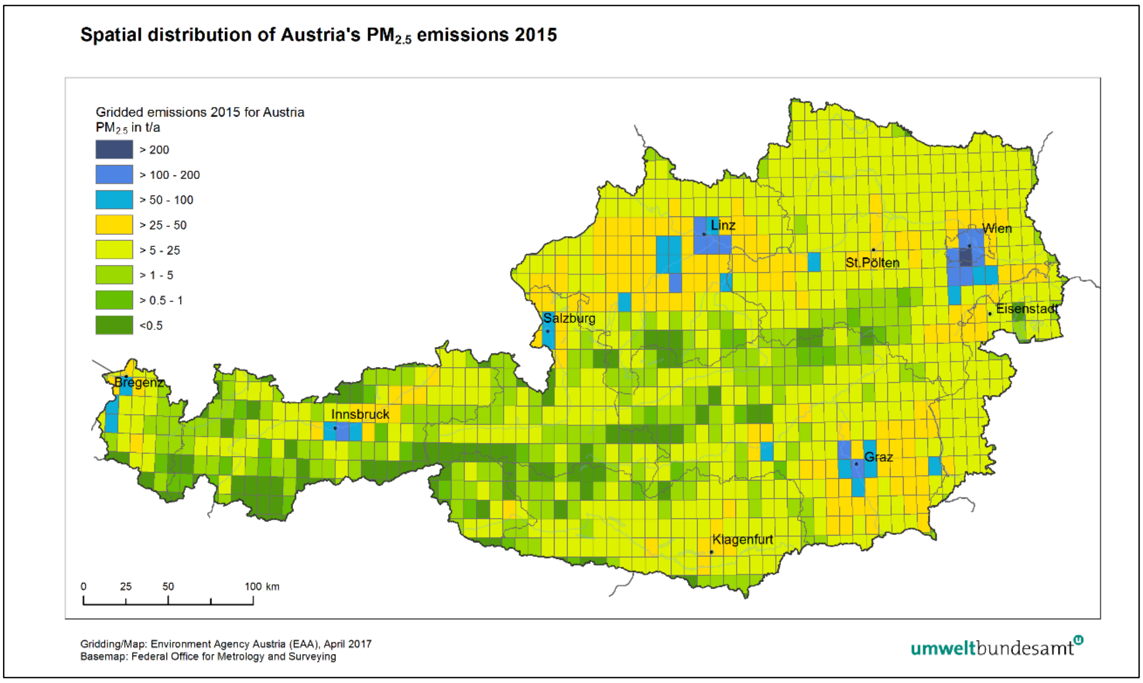

Figure 57: Spatial distribution of Austria´s $PM_{2.5}$ emissions 2015 based on fuel sold.

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. These thresholds have been extracted from the full list of pollutants in Regulation (EC) No. 166/2006 concerning the establishment of a European Pollutant Release and Transfer Register.

Austria reported 55 LPS for the year 2015. The data is distributed to the following GNFR sectors:

- 11 LPS in GNFR sector A_PublicPower
- 35 LPS in GNFR sector B_Industry
- 1 LPS in GNFR sector D_Fugitive
- 5 LPS in GNFR sector E_Solvents
- 3 LPS in GNFR sector I_Offroad

9.2.1 Activity Data

Emission values taken for LPS of 2015 are reported by Austrian plants according to Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) (Large Combustion Plants – LCP) as well as under Regulation (EC) No 166/2006 on the establishment of a European Pollutant Release and Transfer Register. The data for 2015 was taken from Austria´s official submissions on 31st of March 2017.

Emissions from LCPs are available on installation level; E-PRTR data is reported on facility level (one or more installations on the same site operated by the same natural or legal person). So, it was necessary to sum up the respective LCP installations for comparison with the related E-PRTR facility. In case of differences between LCP emissions and E-PRTR emissions the upper emission value was taken. In the following table an overview of the required information and the respective data source is presented.

Table 333: Overview of data sources for LPS (required in ANNEX VI).

Activity data	Data source
LPS	Facility name according to E-PRTR reporting
GNFR	Expert judgement
PRTR Facility ID	PRTR ID according to E-PRTR reporting
Height Class (1-5)	Height Class according to LCP reporting*
Longitude/latitude	Longitude/latitude according to E-PRTR reporting

**If there were more than one height classes available, the upper value was taken.*

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. Finally, the activity data (E-PRTR data and LCP data) was matched for each relevant NFR sector and aggregated as required in ANNEX VI (Template for LPS data for each relevant aggregated Gridding NFR sectors (GNFR)).

PM emissions

Under Directive 2010/75/EU on industrial emissions (IED) $PM_{2.5}$ and PM_{10} emissions are not reported separately, but as total dust emissions. TSP (total suspended particles) was assumed to represent the total dust emissions. $PM_{2.5}$ and PM_{10} emissions were calculated as fractions of TSP in line with the Austrian Air Emission Inventory.

$PM_{2.5}$ emissions are also not reported under the E-PRTR Regulation. However, PM_{10} emissions are submitted under E-PRTR, and so $PM_{2.5}$ could be calculated based on the sectoral composition of TSP and PM_{10} as described before.

9.3 Recalculations

No recalculations for gridded data and LPS have been carried out since last submission in 2012. In 2017 data for 2015 only was reported.

9.4 Planned Improvements

Currently, no improvements are planned.

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11 ABBREVIATIONS

AMA .... Agrarmarkt Austria

ASFINAG .... Autobahnen- und Schnellstraßen-Finanzierungs-Aktiengesellschaft

BAWP .... Bundes-Abfallwirtschaftsplan (Federal Waste Management Plan)

BLI .... Austrian Air Emission Inventory on federal level ("Bundesländer 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] 1990–2018 – 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**	0.26
1991	69.05	67.75	1.30	1.61	0.00	0.06	NO	**70.72**	0.29
1992	52.79	50.79	2.00	1.36	0.00	0.04	NO	**54.19**	0.31
1993	51.66	49.56	2.10	1.11	0.00	0.04	NO	**52.82**	0.33
1994	46.02	44.74	1.28	1.12	0.00	0.05	NO	**47.19**	0.34
1995	45.69	44.16	1.53	1.07	0.01	0.05	NO	**46.81**	0.38
1996	42.89	41.69	1.20	0.99	0.00	0.05	NO	**43.93**	0.43
1997	39.38	39.31	0.07	0.96	0.00	0.05	NO	**40.40**	0.44
1998	34.70	34.66	0.04	0.87	0.00	0.06	NO	**35.63**	0.46
1999	32.87	32.82	0.04	0.81	0.01	0.06	NO	**33.74**	0.45
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	30.40	30.36	0.05	0.71	0.00	0.06	NO	**31.17**	0.40
2004	25.81	25.77	0.04	0.72	0.01	0.06	NO	**26.60**	0.47
2005	25.17	25.13	0.04	0.72	0.00	0.06	NO	**25.95**	0.55
2006	26.01	25.96	0.05	0.73	0.00	0.05	NO	**26.79**	0.58
2007	22.65	22.60	0.05	0.75	0.00	0.04	NO	**23.44**	0.61
2008	19.51	19.47	0.04	0.78	0.00	0.03	NO	**20.33**	0.61
2009	14.07	14.02	0.06	0.70	0.00	0.02	NO	**14.80**	0.53
2010	15.32	15.27	0.05	0.70	0.00	0.01	NO	**16.04**	0.57
2011	14.53	14.49	0.05	0.68	0.00	0.01	NO	**15.23**	0.60
2012	14.20	14.16	0.05	0.65	0.00	0.01	NO	**14.86**	0.57
2013	13.84	13.80	0.04	0.59	0.00	0.01	NO	**14.44**	0.54
2014	13.98	13.94	0.04	0.55	0.00	0.01	NO	**14.54**	0.54
2015	13.40	13.36	0.04	0.57	0.00	0.01	NO	**13.98**	0.58
2016	12.74	12.71	0.02	0.57	0.00	0.01	NO	**13.32**	0.54
2017	12.26	12.22	0.04	0.57	0.00	0.01	NO	**12.84**	0.52
2018	11.18	11.16	0.02	0.57	0.00	0.01	NO	**11.77**	0.59

Table A-2: Emission trends for NO_x [kt] 1990–2018 – 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	200.79	200.79	IE	4.27	12.05	0.10	NO	**217.22**	2.44
1991	210.73	210.73	IE	3.93	11.99	0.09	NO	**226.75**	2.76
1992	199.51	199.51	IE	4.02	11.73	0.06	NO	**215.32**	3.00
1993	193.70	193.70	IE	1.46	11.57	0.05	NO	**206.77**	3.18
1994	185.71	185.71	IE	1.38	11.43	0.05	NO	**198.56**	3.31
1995	185.33	185.33	IE	0.90	11.61	0.05	NO	**197.88**	3.73
1996	203.27	203.27	IE	0.87	11.50	0.05	NO	**215.68**	4.14
1997	189.42	189.42	IE	0.86	11.57	0.05	NO	**201.89**	4.29
1998	201.18	201.18	IE	0.83	11.62	0.05	NO	**213.68**	4.43
1999	193.29	193.29	IE	0.82	11.27	0.05	NO	**205.43**	4.33
2000	199.14	199.14	IE	0.83	11.08	0.05	NO	**211.10**	6.44
2001	209.94	209.94	IE	0.78	11.05	0.05	NO	**221.81**	6.32
2002	217.78	217.78	IE	0.79	11.07	0.05	NO	**229.69**	5.67
2003	229.45	229.45	IE	0.81	10.59	0.05	NO	**240.90**	5.21
2004	229.79	229.79	IE	0.69	10.06	0.05	NO	**240.59**	6.09
2005	235.27	235.27	IE	0.70	10.12	0.05	NO	**246.14**	6.99
2006	225.30	225.30	IE	0.58	10.16	0.04	NO	**236.09**	7.54
2007	217.73	217.73	IE	0.48	10.31	0.04	NO	**228.56**	7.99
2008	203.63	203.63	IE	0.56	10.90	0.03	NO	**215.12**	7.90
2009	189.97	189.97	IE	0.41	10.69	0.02	NO	**201.09**	6.86
2010	191.80	191.80	IE	0.55	9.78	0.02	NO	**202.15**	7.60
2011	183.20	183.20	IE	0.52	10.28	0.02	NO	**194.02**	7.98
2012	177.91	177.91	IE	0.55	10.40	0.02	NO	**188.87**	7.68
2013	177.30	177.30	IE	0.45	10.29	0.02	NO	**188.07**	7.46
2014	168.35	168.35	IE	0.46	10.60	0.02	NO	**179.43**	7.49
2015	164.84	164.84	IE	0.52	10.99	0.02	NO	**176.36**	8.18
2016	158.59	158.59	IE	0.52	11.17	0.02	NO	**170.30**	10.28
2017	150.47	150.47	IE	0.47	10.99	0.02	NO	**161.95**	10.06
2018	139.68	139.68	IE	0.41	10.75	0.02	NO	**150.86**	11.54

Table A-3: Emission trends for NMVOC [kt] 1990–2018 – 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	163.13	147.64	15.49	118.54	52.19	0.16	NO	**334.02**	0.18
1991	164.92	149.80	15.12	112.01	51.21	0.16	NO	**328.31**	0.20
1992	150.76	135.58	15.19	105.25	48.54	0.15	NO	**304.70**	0.22
1993	138.71	124.06	14.65	98.55	47.26	0.15	NO	**284.67**	0.24
1994	123.30	112.18	11.12	91.99	46.79	0.14	NO	**262.22**	0.25
1995	114.91	105.43	9.49	85.28	46.25	0.14	NO	**246.57**	0.29
1996	108.25	99.78	8.46	83.72	45.10	0.13	NO	**237.20**	0.34
1997	96.18	88.22	7.95	82.37	44.33	0.13	NO	**223.01**	0.37
1998	89.40	82.97	6.43	81.06	43.99	0.13	NO	**214.58**	0.40
1999	81.77	76.10	5.67	78.32	43.28	0.12	NO	**203.49**	0.39
2000	75.26	69.57	5.69	62.15	42.27	0.12	NO	**179.79**	0.42
2001	72.20	68.36	3.84	59.96	41.82	0.11	NO	**174.09**	0.41
2002	68.78	64.75	4.03	59.11	40.94	0.11	NO	**168.94**	0.37
2003	66.65	62.70	3.96	58.53	40.44	0.11	NO	**165.74**	0.34
2004	62.76	59.19	3.57	49.80	40.16	0.11	NO	**152.83**	0.40
2005	60.18	56.84	3.34	57.32	39.50	0.11	NO	**157.11**	0.47
2006	56.69	53.34	3.36	63.26	39.19	0.10	NO	**159.25**	0.50
2007	53.70	50.71	2.98	61.94	39.07	0.10	NO	**154.80**	0.53
2008	51.34	48.59	2.75	58.71	38.79	0.10	NO	**148.94**	0.52
2009	48.55	45.97	2.59	47.89	38.98	0.09	NO	**135.51**	0.45
2010	50.05	47.59	2.45	46.70	38.58	0.09	NO	**135.41**	0.49
2011	45.90	43.49	2.41	46.03	37.92	0.08	NO	**129.93**	0.51
2012	45.60	43.20	2.40	44.13	37.61	0.08	NO	**127.42**	0.49
2013	45.04	42.73	2.30	38.87	37.58	0.07	NO	**121.56**	0.46
2014	40.12	37.71	2.42	36.81	37.63	0.07	NO	**114.63**	0.46
2015	40.57	38.25	2.32	33.37	37.43	0.06	NO	**111.44**	0.50
2016	39.92	37.65	2.27	32.33	37.42	0.06	NO	**109.73**	0.23
2017	39.40	37.12	2.29	33.96	37.31	0.06	NO	**110.73**	0.20
2018	36.56	34.39	2.17	33.63	36.97	0.06	NO	**107.22**	0.22

Table A-4: Emission trends for NH_3 [kt] 1990–2018 – 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	1.962	1.962	IE	0.339	59.063	0.367	NO	**61.731**	0.002
1991	2.432	2.432	IE	0.577	59.181	0.382	NO	**62.573**	0.002
1992	2.616	2.616	IE	0.438	57.588	0.434	NO	**61.076**	0.002
1993	2.898	2.898	IE	0.287	58.370	0.515	NO	**62.070**	0.002
1994	3.038	3.038	IE	0.236	58.121	0.622	NO	**62.016**	0.002
1995	3.226	3.226	IE	0.165	59.076	0.642	NO	**63.109**	0.003
1996	3.404	3.404	IE	0.163	58.223	0.668	NO	**62.458**	0.003
1997	3.469	3.469	IE	0.162	58.435	0.666	NO	**62.733**	0.003
1998	3.772	3.772	IE	0.168	58.476	0.697	NO	**63.114**	0.003
1999	3.802	3.802	IE	0.186	57.153	0.767	NO	**61.908**	0.003
2000	3.755	3.755	IE	0.167	55.838	0.822	NO	**60.581**	0.003
2001	3.922	3.922	IE	0.146	55.670	0.922	NO	**60.659**	0.003
2002	4.048	4.048	IE	0.128	54.794	1.018	NO	**59.987**	0.003
2003	4.158	4.158	IE	0.141	54.673	1.099	NO	**60.071**	0.003
2004	4.045	4.045	IE	0.122	54.429	1.346	NO	**59.942**	0.003
2005	4.010	4.005	0.005	0.127	54.292	1.444	NO	**59.873**	0.004
2006	3.935	3.928	0.006	0.136	54.789	1.470	NO	**60.329**	0.004
2007	3.847	3.841	0.005	0.138	56.149	1.515	NO	**61.648**	0.004
2008	3.585	3.582	0.003	0.140	56.051	1.535	NO	**61.311**	0.004
2009	3.388	3.385	0.003	0.148	57.623	1.571	NO	**62.731**	0.004
2010	3.435	3.432	0.003	0.153	57.538	1.565	NO	**62.690**	0.004
2011	3.136	3.134	0.002	0.160	57.273	1.563	NO	**62.132**	0.004
2012	2.999	2.998	0.001	0.153	57.672	1.584	NO	**62.409**	0.004
2013	2.837	2.837	0.001	0.155	57.961	1.532	NO	**62.485**	0.004
2014	2.604	2.603	0.001	0.148	58.896	1.579	NO	**63.227**	0.004
2015	2.640	2.639	0.000	0.140	59.621	1.611	NO	**64.011**	0.004
2016	2.565	2.565	0.000	0.146	60.505	1.598	NO	**64.815**	0.004
2017	2.598	2.598	0.000	0.167	61.300	1.602	NO	**65.666**	0.004
2018	2.537	2.537	0.001	0.135	60.358	1.601	NO	**64.631**	0.005

Table A-5: Emission trends for CO [kt] 1990–2018 – 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	1 200.68	1 200.68	IE	37.19	1.23	10.31	NO	**1 249.41**	0.49
1991	1 212.40	1 212.40	IE	32.45	1.20	10.51	NO	**1 256.55**	0.55
1992	1 152.76	1 152.76	IE	35.31	1.21	10.36	NO	**1 199.64**	0.59
1993	1 089.17	1 089.17	IE	37.01	1.09	10.26	NO	**1 137.53**	0.63
1994	1 022.32	1 022.32	IE	38.14	1.18	9.95	NO	**1 071.60**	0.66
1995	922.40	922.40	IE	34.72	1.17	9.46	NO	**967.74**	0.75
1996	923.30	923.30	IE	29.08	1.12	8.93	NO	**962.42**	0.84
1997	850.10	850.10	IE	28.21	1.19	8.52	NO	**888.02**	0.89
1998	807.43	807.43	IE	25.85	1.16	8.19	NO	**842.63**	0.93
1999	695.34	695.34	IE	21.76	1.19	7.85	NO	**726.15**	0.89
2000	694.43	694.43	IE	18.69	1.05	7.52	NO	**721.69**	0.80
2001	672.11	672.11	IE	14.55	1.17	7.21	NO	**695.04**	0.78
2002	641.37	641.37	IE	14.42	1.10	7.19	NO	**664.09**	0.66
2003	643.89	643.89	IE	14.34	1.05	7.18	NO	**666.46**	0.65
2004	626.14	626.14	IE	14.55	1.63	7.30	NO	**649.61**	0.73
2005	602.20	602.20	IE	14.53	0.98	6.88	NO	**624.59**	0.91
2006	602.26	602.26	IE	14.71	0.91	6.53	NO	**624.41**	0.92
2007	579.25	579.25	IE	14.89	0.93	6.16	NO	**601.23**	0.96
2008	560.39	560.39	IE	14.82	0.90	5.85	NO	**581.96**	0.96
2009	541.18	541.18	IE	13.88	0.84	5.44	NO	**561.34**	0.82
2010	557.23	557.23	IE	14.28	0.80	5.09	NO	**577.39**	0.87
2011	540.45	540.45	IE	14.30	0.59	4.76	NO	**560.10**	0.86
2012	540.67	540.67	IE	14.14	0.43	4.47	NO	**559.71**	0.83
2013	545.35	545.35	IE	14.29	0.39	4.16	NO	**564.19**	0.74
2014	510.15	510.15	IE	14.19	0.44	3.85	NO	**528.63**	0.74
2015	523.38	523.38	IE	14.20	0.38	3.61	NO	**541.56**	0.78
2016	519.98	519.98	IE	14.12	0.38	3.36	NO	**537.84**	1.49
2017	511.43	511.43	IE	14.14	0.35	3.15	NO	**529.08**	1.46
2018	472.56	472.56	IE	14.22	0.35	2.96	NO	**490.09**	1.73

Table A-6: Emission trends for Cd [kg] 1990–2018 – 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	1 052.4	1 052.4	NA	634.1	8.0	60.3	NO	**1 754.8**	0.2
1991	1 058.8	1 058.8	NA	544.5	7.8	49.6	NO	**1 660.7**	0.3
1992	968.9	968.9	NA	400.3	7.8	6.5	NO	**1 383.6**	0.3
1993	897.3	897.3	NA	339.1	6.9	5.8	NO	**1 249.2**	0.3
1994	828.2	828.2	NA	301.9	7.9	5.1	NO	**1 143.1**	0.3
1995	764.3	764.3	NA	278.1	8.2	3.2	NO	**1 053.8**	0.3
1996	782.7	782.7	NA	260.2	7.4	3.1	NO	**1 053.4**	0.4
1997	733.1	733.1	NA	264.2	8.0	3.1	NO	**1 008.4**	0.4
1998	675.6	675.6	NA	267.7	7.9	3.0	NO	**954.3**	0.4
1999	719.9	719.9	NA	277.2	8.4	3.0	NO	**1 008.4**	0.4
2000	685.9	685.9	NA	288.8	7.6	3.0	NO	**985.3**	0.4
2001	706.9	706.9	NA	283.3	8.6	2.9	NO	**1 001.8**	0.4
2002	669.9	669.9	NA	295.0	8.3	2.9	NO	**976.3**	0.4
2003	696.5	696.5	NA	292.6	7.5	2.9	NO	**999.6**	0.3
2004	691.4	691.4	NA	287.6	13.3	3.0	NO	**995.3**	0.4
2005	720.4	720.4	NA	302.9	7.2	2.7	NO	**1 033.2**	0.5
2006	760.6	760.6	NA	311.3	6.3	2.5	NO	**1 080.8**	0.5
2007	772.9	772.9	NA	323.2	6.8	2.7	NO	**1 105.6**	0.5
2008	792.6	792.6	NA	319.8	6.6	2.5	NO	**1 121.5**	0.5
2009	793.1	793.1	NA	259.1	6.2	2.4	NO	**1 060.7**	0.5
2010	865.1	865.1	NA	312.2	5.9	2.4	NO	**1 185.7**	0.5
2011	840.6	840.6	NA	315.4	3.9	2.3	NO	**1 162.3**	0.5
2012	862.3	862.3	NA	312.3	2.3	2.3	NO	**1 179.2**	0.5
2013	869.5	869.5	NA	329.2	2.0	2.1	NO	**1 202.7**	0.5
2014	809.3	809.3	NA	323.6	2.5	2.3	NO	**1 137.7**	0.5
2015	828.8	828.8	NA	314.3	1.8	2.3	NO	**1 147.2**	0.5
2016	825.9	825.9	NA	306.9	1.9	2.1	NO	**1 136.8**	0.6
2017	844.3	844.3	NA	329.8	1.5	2.1	NO	**1 177.7**	0.5
2018	843.7	843.7	NA	286.7	1.5	1.9	NO	**1 133.7**	0.6

Table A-7: Emission trends for Hg [kg] 1990–2018 – 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	1 574.6	1 574.6	NA	534.1	1.6	54.8	NO	**2 165.1**	0.1
1991	1 510.3	1 510.3	NA	498.2	1.6	48.4	NO	**2 058.5**	0.1
1992	1 194.5	1 194.5	NA	440.9	1.6	27.8	NO	**1 664.8**	0.1
1993	967.5	967.5	NA	417.1	1.4	28.0	NO	**1 414.1**	0.1
1994	767.3	767.3	NA	403.8	1.6	27.8	NO	**1 200.4**	0.1
1995	720.9	720.9	NA	471.8	1.6	28.0	NO	**1 222.3**	0.1
1996	716.2	716.2	NA	436.4	1.5	26.7	NO	**1 180.8**	0.1
1997	687.1	687.1	NA	439.0	1.6	24.9	NO	**1 152.6**	0.1
1998	604.7	604.7	NA	338.9	1.6	22.8	NO	**968.0**	0.1
1999	647.1	647.1	NA	281.2	1.6	20.8	NO	**950.7**	0.1
2000	643.6	643.6	NA	246.7	1.5	18.1	NO	**909.9**	0.1
2001	702.1	702.1	NA	250.0	1.7	18.4	NO	**972.3**	0.1
2002	654.7	654.7	NA	266.1	1.6	19.5	NO	**941.9**	0.1
2003	694.0	694.0	NA	266.5	1.5	20.0	NO	**982.0**	0.1
2004	647.9	647.9	NA	276.8	2.5	20.6	NO	**947.7**	0.1
2005	657.3	656.3	1.0	310.0	1.4	21.7	NO	**990.3**	0.2
2006	684.2	682.9	1.3	316.1	1.2	22.3	NO	**1 023.9**	0.2
2007	670.5	669.4	1.1	334.7	1.3	23.7	NO	**1 030.2**	0.2
2008	683.4	682.7	0.7	334.3	1.3	24.7	NO	**1 043.7**	0.2
2009	646.5	645.8	0.7	251.2	1.2	26.4	NO	**925.2**	0.2
2010	677.7	677.0	0.6	323.5	1.1	27.6	NO	**1 029.8**	0.2
2011	662.2	661.7	0.5	333.3	0.8	28.4	NO	**1 024.6**	0.2
2012	677.0	676.7	0.3	329.1	0.5	30.6	NO	**1 037.2**	0.2
2013	707.3	707.1	0.1	349.3	0.4	31.6	NO	**1 088.5**	0.2
2014	661.4	661.2	0.2	341.6	0.5	32.4	NO	**1 035.9**	0.2
2015	643.3	643.2	0.0	331.8	0.4	35.5	NO	**1 011.0**	0.2
2016	593.8	593.8	0.0	322.9	0.4	35.6	NO	**952.7**	0.2
2017	632.2	632.2	0.0	361.2	0.3	37.9	NO	**1 031.7**	0.2
2018	617.5	617.4	0.1	302.0	0.3	39.2	NO	**959.1**	0.2

Table A-8: Emission trends for Pb [kg] 1990–2018 – 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	193 979.7	193 979.7	NA	37 414.8	3.8	1 016.3	NO	**232 414.6**	0.2
1991	163 396.2	163 396.2	NA	32 145.5	3.7	778.1	NO	**196 323.5**	0.3
1992	116 425.7	116 425.7	NA	22 903.9	3.7	488.8	NO	**139 822.2**	0.3
1993	79 341.5	79 341.5	NA	19 339.5	3.6	381.6	NO	**99 066.2**	0.3
1994	51 655.4	51 655.4	NA	16 696.5	3.7	266.3	NO	**68 621.9**	0.3
1995	11 448.8	11 448.8	NA	8 893.0	3.7	9.8	NO	**20 355.3**	0.3
1996	11 364.3	11 364.3	NA	8 540.5	3.5	9.7	NO	**19 918.1**	0.4
1997	10 365.3	10 365.3	NA	8 459.0	3.5	9.7	NO	**18 837.5**	0.4
1998	9 647.6	9 647.6	NA	8 009.1	3.4	9.6	NO	**17 669.7**	0.4
1999	9 459.5	9 459.5	NA	8 451.5	3.5	9.6	NO	**17 924.1**	0.4
2000	8 973.7	8 973.7	NA	8 179.6	3.4	9.5	NO	**17 166.2**	0.4
2001	9 322.2	9 322.2	NA	7 422.8	3.4	9.5	NO	**16 757.9**	0.4
2002	9 282.5	9 282.5	NA	8 314.9	3.4	9.5	NO	**17 610.2**	0.4
2003	9 672.6	9 672.6	NA	8 112.9	3.2	9.5	NO	**17 798.2**	0.3
2004	9 848.6	9 848.6	NA	7 913.3	4.0	9.5	NO	**17 775.4**	0.4
2005	9 670.0	9 670.0	NA	8 695.7	3.3	9.4	NO	**18 378.3**	0.5
2006	10 102.2	10 102.2	NA	9 078.0	3.2	7.8	NO	**19 191.2**	0.5
2007	10 440.8	10 440.8	NA	9 490.9	3.3	6.6	NO	**19 941.6**	0.5
2008	10 537.1	10 537.1	NA	9 419.9	3.1	5.3	NO	**19 965.4**	0.5
2009	10 346.8	10 346.8	NA	7 225.2	3.0	3.9	NO	**17 578.8**	0.5
2010	11 261.8	11 261.8	NA	8 852.3	2.9	2.7	NO	**20 119.7**	0.5
2011	11 159.8	11 159.8	NA	9 239.3	2.7	2.6	NO	**20 404.4**	0.5
2012	11 361.5	11 361.5	NA	8 963.7	2.5	2.6	NO	**20 330.4**	0.5
2013	11 513.0	11 513.0	NA	9 595.1	2.5	2.5	NO	**21 113.0**	0.5
2014	10 922.5	10 922.5	NA	9 247.4	2.6	2.5	NO	**20 175.0**	0.5
2015	11 167.2	11 167.2	NA	8 401.7	2.5	2.5	NO	**19 573.9**	0.5
2016	11 309.1	11 309.1	NA	8 618.1	2.5	2.4	NO	**19 932.2**	0.6
2017	11 462.5	11 462.5	NA	9 067.7	2.5	2.4	NO	**20 535.2**	0.5
2018	11 474.1	11 474.1	NA	7 778.4	2.5	2.3	NO	**19 257.2**	0.6

Table A-9: Emission trends for PAH [kg] 1990–2018 – 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	11 809.3	11 809.3	NA	7 138.3	81.8	0.2	NO	**19 029.7**	NE
1991	12 749.7	12 749.7	NA	6 936.3	80.3	0.2	NO	**19 766.6**	NE
1992	11 417.0	11 417.0	NA	3 087.5	80.9	0.0	NO	**14 585.4**	NE
1993	11 157.7	11 157.7	NA	519.2	75.8	0.0	NO	**11 752.8**	NE
1994	10 061.9	10 061.9	NA	405.2	78.8	0.0	NO	**10 545.9**	NE
1995	10 418.7	10 418.7	NA	291.9	77.7	0.0	NO	**10 788.3**	NE
1996	10 960.9	10 960.9	NA	254.1	75.0	0.0	NO	**11 290.0**	NE
1997	9 834.8	9 834.8	NA	225.3	76.5	0.0	NO	**10 136.8**	NE
1998	9 205.8	9 205.8	NA	199.1	75.1	0.0	NO	**9 480.0**	NE
1999	8 969.6	8 969.6	NA	201.4	75.9	0.0	NO	**9 246.9**	NE
2000	8 288.6	8 288.6	NA	183.1	69.6	0.0	NO	**8 541.3**	NE
2001	8 419.3	8 419.3	NA	185.0	73.5	0.0	NO	**8 677.8**	NE
2002	7 554.7	7 554.7	NA	194.3	70.5	0.0	NO	**7 819.5**	NE
2003	7 189.4	7 189.4	NA	194.5	68.0	0.0	NO	**7 452.0**	NE
2004	6 942.5	6 942.5	NA	200.6	90.0	0.0	NO	**7 233.1**	NE
2005	6 953.1	6 953.1	NA	219.6	67.0	0.0	NO	**7 239.7**	NE
2006	7 177.5	7 177.5	NA	223.3	64.4	0.0	NO	**7 465.3**	NE
2007	7 149.4	7 149.4	NA	234.0	65.0	0.0	NO	**7 448.5**	NE
2008	7 141.5	7 141.5	NA	232.6	62.5	0.0	NO	**7 436.7**	NE
2009	7 082.8	7 082.8	NA	184.6	58.6	0.0	NO	**7 326.0**	NE
2010	7 790.6	7 790.6	NA	225.8	57.1	0.0	NO	**8 073.5**	NE
2011	7 143.3	7 143.3	NA	231.6	49.4	0.0	NO	**7 424.2**	NE
2012	7 415.1	7 415.1	NA	229.2	43.5	0.0	NO	**7 687.8**	NE
2013	7 585.4	7 585.4	NA	241.8	42.0	0.0	NO	**7 869.3**	NE
2014	6 739.9	6 739.9	NA	237.8	44.4	0.0	NO	**7 022.1**	NE
2015	7 020.2	7 020.2	NA	230.5	42.4	0.0	NO	**7 293.1**	NE
2016	7 077.2	7 077.2	NA	225.3	42.8	0.0	NO	**7 345.3**	NE
2017	7 105.1	7 105.1	NA	247.8	41.7	0.0	NO	**7 394.6**	NE
2018	6 541.4	6 541.4	NA	213.4	41.5	0.0	NO	**6 796.3**	NE

Table A-10: Emission trends for Dioxin/Furan (PCDD/F) [g] 1990–2018 – 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	61.85	61.85	NA	42.85	0.18	20.29	NO	**125.17**	NE
1991	65.79	65.79	NA	38.96	0.18	19.88	NO	**124.81**	NE
1992	49.05	49.05	NA	24.63	0.18	2.68	NO	**76.55**	NE
1993	44.93	44.93	NA	19.14	0.18	2.38	NO	**66.63**	NE
1994	40.50	40.50	NA	13.41	0.18	2.26	NO	**56.35**	NE
1995	40.84	40.84	NA	14.37	0.18	2.27	NO	**57.66**	NE
1996	42.14	42.14	NA	13.31	0.18	2.26	NO	**57.89**	NE
1997	37.53	37.53	NA	18.19	0.18	2.27	NO	**58.17**	NE
1998	35.00	35.00	NA	17.49	0.18	2.28	NO	**54.95**	NE
1999	34.90	34.90	NA	14.26	0.18	2.29	NO	**51.63**	NE
2000	32.22	32.22	NA	15.71	0.18	2.31	NO	**50.41**	NE
2001	33.06	33.06	NA	15.13	0.18	2.31	NO	**50.68**	NE
2002	30.41	30.41	NA	4.73	0.18	2.34	NO	**37.66**	NE
2003	29.99	29.99	NA	4.40	0.17	2.36	NO	**36.91**	NE
2004	28.88	28.88	NA	4.64	0.22	2.37	NO	**36.12**	NE
2005	28.28	28.28	NA	5.29	0.15	2.04	NO	**35.77**	NE
2006	28.96	28.96	NA	5.97	0.15	2.03	NO	**37.10**	NE
2007	28.92	28.92	NA	5.24	0.15	2.54	NO	**36.85**	NE
2008	29.14	29.14	NA	4.72	0.13	2.48	NO	**36.47**	NE
2009	28.60	28.60	NA	5.11	0.13	2.47	NO	**36.32**	NE
2010	31.51	31.51	NA	6.47	0.13	2.89	NO	**41.00**	NE
2011	28.95	28.95	NA	6.34	0.09	2.80	NO	**38.18**	NE
2012	29.79	29.79	NA	6.30	0.07	2.87	NO	**39.04**	NE
2013	30.49	30.49	NA	6.66	0.06	2.52	NO	**39.74**	NE
2014	26.86	26.86	NA	6.82	0.07	2.90	NO	**36.66**	NE
2015	27.90	27.90	NA	6.82	0.06	2.92	NO	**37.70**	NE
2016	27.60	27.60	NA	6.83	0.06	2.75	NO	**37.25**	NE
2017	27.56	27.56	NA	6.78	0.06	2.78	NO	**37.18**	NE
2018	25.58	25.58	NA	6.40	0.05	2.37	NO	**34.41**	NE

Table A-11: Emission trends for HCB [kg] 1990–2018 – 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	54.89	54.89	NA	20.07	10.15	0.39	NO	**85.50**	NE
1991	60.23	60.23	NA	15.72	10.15	0.28	NO	**86.39**	NE
1992	54.75	54.75	NA	13.72	7.65	0.11	NO	**76.24**	NE
1993	52.09	52.09	NA	11.16	7.90	0.05	NO	**71.19**	NE
1994	47.45	47.45	NA	4.70	5.86	0.02	NO	**58.03**	NE
1995	49.06	49.06	NA	3.66	5.59	0.02	NO	**58.34**	NE
1996	51.50	51.50	NA	3.43	3.98	0.02	NO	**58.94**	NE
1997	45.82	45.82	NA	5.60	4.55	0.02	NO	**55.99**	NE
1998	43.14	43.14	NA	5.44	3.12	0.03	NO	**51.72**	NE
1999	42.47	42.47	NA	3.51	3.47	0.03	NO	**49.47**	NE
2000	38.94	38.94	NA	3.83	0.53	0.03	NO	**43.33**	NE
2001	39.95	39.95	NA	3.69	0.51	0.03	NO	**44.17**	NE
2002	36.21	36.21	NA	3.84	0.47	0.03	NO	**40.55**	NE
2003	34.84	34.84	NA	3.81	0.56	0.03	NO	**39.24**	NE
2004	33.25	33.25	NA	3.90	0.54	0.03	NO	**37.72**	NE
2005	33.27	33.27	NA	4.25	0.17	0.03	NO	**37.74**	NE
2006	33.82	33.82	NA	4.29	0.21	0.04	NO	**38.35**	NE
2007	32.99	32.99	NA	4.48	0.23	0.04	NO	**37.73**	NE
2008	33.36	33.36	NA	4.45	0.23	0.04	NO	**38.07**	NE
2009	33.09	33.09	NA	4.08	0.21	0.04	NO	**37.41**	NE
2010	36.72	36.72	NA	5.28	0.83	0.04	NO	**42.87**	NE
2011	33.32	33.32	NA	5.43	0.62	0.04	NO	**39.41**	NE
2012	58.54	58.54	NA	5.37	0.53	0.05	NO	**64.49**	NE
2013	137.26	137.26	NA	5.66	0.70	0.05	NO	**143.67**	NE
2014	138.07	138.07	NA	5.63	0.74	0.05	NO	**144.49**	NE
2015	31.32	31.32	NA	5.71	0.18	0.06	NO	**37.27**	NE
2016	31.49	31.49	NA	5.61	0.94	0.06	NO	**38.09**	NE
2017	31.47	31.47	NA	6.07	1.81	0.06	NO	**39.40**	NE
2018	28.69	28.69	NA	5.36	1.52	0.06	NO	**35.63**	NE

Table A-12: Emission trends for PCB [kg] 1990–2018 – 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	1.90	1.90	NA	35.25	NA	0.01	NO	**37.16**	NE
2014	1.90	1.90	NA	34.73	NA	0.01	NO	**36.64**	NE
2015	1.98	1.98	NA	33.70	NA	0.01	NO	**35.69**	NE
2016	2.03	2.03	NA	32.68	NA	0.01	NO	**34.72**	NE
2017	2.05	2.05	NA	36.15	NA	0.01	NO	**38.22**	NE
2018	1.67	1.67	NA	30.40	NA	0.02	NO	**32.09**	NE

Table A-13: Emission trends for TSP [kt] 1990–2018 – 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	28.60	27.74	0.85	19.31	4.95	0.35	NO	**53.21**	0.28
1995	27.35	26.69	0.65	19.35	4.99	0.37	NO	**52.06**	0.42
2000	25.99	25.33	0.66	19.47	4.81	0.30	NO	**50.58**	0.52
2001	26.42	25.73	0.68	18.72	4.82	0.30	NO	**50.26**	0.51
2002	25.96	25.24	0.72	18.10	4.79	0.32	NO	**49.17**	0.46
2003	25.91	25.17	0.73	17.77	4.79	0.35	NO	**48.81**	0.43
2004	25.21	24.59	0.62	18.34	4.87	0.39	NO	**48.81**	0.51
2005	25.22	24.61	0.61	17.72	4.82	0.37	NO	**48.14**	0.59
2006	25.05	24.47	0.58	16.55	4.76	0.37	NO	**46.74**	0.63
2007	24.40	23.87	0.53	16.07	4.76	0.45	NO	**45.67**	0.66
2008	23.34	22.81	0.53	17.12	4.71	0.40	NO	**45.57**	0.66
2009	22.11	21.73	0.38	15.92	4.72	0.39	NO	**43.14**	0.57
2010	22.93	22.46	0.47	15.68	4.70	0.46	NO	**43.77**	0.62
2011	21.75	21.26	0.48	16.13	4.66	0.48	NO	**43.01**	0.65
2012	21.34	20.90	0.44	15.76	4.62	0.54	NO	**42.26**	0.62
2013	20.82	20.36	0.45	15.69	4.60	0.51	NO	**41.62**	0.59
2014	18.94	18.53	0.41	16.09	4.60	0.62	NO	**40.25**	0.59
2015	18.99	18.55	0.45	15.53	4.58	0.71	NO	**39.81**	0.63
2016	18.61	18.19	0.42	15.53	4.56	0.73	NO	**39.43**	0.70
2017	18.44	18.01	0.44	15.96	4.55	0.73	NO	**39.69**	0.67
2018	17.43	17.05	0.37	15.66	4.54	0.69	NO	**38.32**	0.76

Table A-14: Emission trends for PM_{10} [kt] 1990–2018 – 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	25.22	24.82	0.40	11.16	4.24	0.28	NO	**40.90**	0.28
1995	24.15	23.84	0.31	10.64	4.30	0.29	NO	**39.37**	0.42
2000	22.80	22.49	0.31	10.59	4.17	0.26	NO	**37.82**	0.52
2001	23.18	22.86	0.32	10.18	4.18	0.25	NO	**37.80**	0.51
2002	22.73	22.39	0.34	9.57	4.17	0.27	NO	**36.74**	0.46
2003	22.65	22.30	0.35	9.39	4.16	0.28	NO	**36.48**	0.43
2004	22.02	21.73	0.29	9.61	4.25	0.30	NO	**36.18**	0.51
2005	22.03	21.74	0.29	9.27	4.20	0.27	NO	**35.77**	0.59
2006	21.82	21.54	0.27	8.56	4.14	0.27	NO	**34.78**	0.63
2007	21.15	20.90	0.25	8.17	4.12	0.33	NO	**33.78**	0.66
2008	20.12	19.88	0.25	8.71	4.08	0.31	NO	**33.23**	0.66
2009	19.01	18.83	0.18	8.09	4.08	0.30	NO	**31.48**	0.57
2010	19.68	19.46	0.22	7.98	4.06	0.35	NO	**32.08**	0.62
2011	18.52	18.29	0.23	8.22	4.02	0.36	NO	**31.12**	0.65
2012	18.12	17.91	0.21	8.01	3.99	0.39	NO	**30.51**	0.62
2013	17.58	17.37	0.21	7.98	3.97	0.36	NO	**29.89**	0.59
2014	15.82	15.62	0.19	8.14	3.96	0.43	NO	**28.35**	0.59
2015	15.79	15.58	0.21	7.82	3.94	0.47	NO	**28.02**	0.63
2016	15.40	15.20	0.20	7.84	3.91	0.47	NO	**27.62**	0.70
2017	15.18	14.97	0.21	8.02	3.90	0.48	NO	**27.58**	0.67
2018	14.21	14.03	0.18	7.86	3.90	0.44	NO	**26.40**	0.76

Table A-15: Emission trends for $PM_{2.5}$ [kt] 1990–2018– 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	22.76	22.65	0.11	3.82	0.36	0.23	NO	**27.17**	0.28
1995	21.93	21.85	0.09	3.17	0.36	0.24	NO	**25.69**	0.42
2000	20.60	20.51	0.09	2.96	0.34	0.23	NO	**24.12**	0.52
2001	20.95	20.86	0.09	2.86	0.35	0.23	NO	**24.38**	0.51
2002	20.51	20.41	0.10	2.49	0.34	0.23	NO	**23.56**	0.46
2003	20.39	20.28	0.10	2.43	0.33	0.24	NO	**23.39**	0.43
2004	19.81	19.72	0.09	2.40	0.38	0.24	NO	**22.83**	0.51
2005	19.81	19.72	0.09	2.32	0.33	0.21	NO	**22.67**	0.59
2006	19.55	19.47	0.09	2.09	0.32	0.21	NO	**22.17**	0.63
2007	18.87	18.79	0.08	1.89	0.33	0.26	NO	**21.35**	0.66
2008	17.88	17.80	0.08	1.99	0.32	0.25	NO	**20.44**	0.66
2009	16.85	16.79	0.06	1.85	0.32	0.25	NO	**19.27**	0.57
2010	17.39	17.32	0.07	1.87	0.31	0.29	NO	**19.87**	0.62
2011	16.24	16.17	0.07	1.91	0.30	0.29	NO	**18.73**	0.65
2012	15.84	15.77	0.07	1.85	0.28	0.30	NO	**18.27**	0.62
2013	15.31	15.24	0.07	1.84	0.28	0.26	NO	**17.69**	0.59
2014	13.66	13.60	0.06	1.85	0.28	0.31	NO	**16.11**	0.59
2015	13.56	13.49	0.07	1.78	0.28	0.33	NO	**15.94**	0.63
2016	13.18	13.12	0.06	1.78	0.28	0.31	NO	**15.56**	0.70
2017	12.92	12.86	0.07	1.78	0.28	0.32	NO	**15.30**	0.67
2018	11.99	11.93	0.06	1.72	0.27	0.28	NO	**14.26**	0.76

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 1990–2018 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-16: Emission trends 1990–2018 on the basis of fuel used.

	SO_2 [kt]	NO_x [kt]	NMVOC [kt]	NH_3 [kt]
1990	72.90	199.91	329.26	61.68
1991	69.66	201.55	317.68	62.40
1992	53.15	193.58	298.52	60.94
1993	51.64	185.07	280.44	61.96
1994	46.14	180.89	260.05	61.95
1995	45.85	180.09	244.98	63.06
1996	43.18	180.48	236.83	62.53
1997	39.97	180.78	223.70	62.86
1998	34.97	179.10	213.05	63.10
1999	33.27	179.21	203.49	62.04
2000	31.04	178.87	179.43	60.71
2001	31.81	181.89	172.54	60.64
2002	30.70	181.62	165.43	59.63
2003	30.43	186.13	161.23	59.52
2004	26.54	186.03	148.32	59.35
2005	25.90	189.41	152.63	59.24
2006	26.75	190.95	155.93	59.74
2007	23.41	187.28	151.77	61.05
2008	20.30	180.60	146.55	60.80
2009	14.76	168.03	133.31	62.22
2010	16.00	168.18	133.44	62.19
2011	15.20	166.85	128.40	61.72
2012	14.83	162.72	126.10	62.04
2013	14.40	159.61	120.34	62.16
2014	14.51	155.79	113.64	62.94
2015	13.95	153.92	110.48	63.72
2016	13.28	150.00	108.85	64.52
2017	12.81	143.42	109.94	65.39
2018	11.73	135.74	106.55	64.38

Table A-17: Emission trends for SO_x [kt] 1990–2018 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	70.89	68.89	2.00	1.93	0.01	0.07	NO	**72.90**	0.26
1991	67.99	66.69	1.30	1.61	0.00	0.06	NO	**69.66**	0.29
1992	51.74	49.74	2.00	1.36	0.00	0.04	NO	**53.15**	0.31
1993	50.48	48.38	2.10	1.11	0.00	0.04	NO	**51.64**	0.33
1994	44.97	43.69	1.28	1.12	0.00	0.05	NO	**46.14**	0.34
1995	44.73	43.20	1.53	1.07	0.01	0.05	NO	**45.85**	0.38
1996	42.14	40.94	1.20	0.99	0.00	0.05	NO	**43.18**	0.43
1997	38.95	38.88	0.07	0.96	0.00	0.05	NO	**39.97**	0.44
1998	34.04	34.00	0.04	0.87	0.00	0.06	NO	**34.97**	0.46
1999	32.40	32.35	0.04	0.81	0.01	0.06	NO	**33.27**	0.45
2000	30.20	30.16	0.04	0.78	0.00	0.06	NO	**31.04**	0.48
2001	31.04	30.99	0.05	0.71	0.01	0.06	NO	**31.81**	0.47
2002	29.93	29.89	0.04	0.71	0.01	0.06	NO	**30.70**	0.43
2003	29.66	29.61	0.05	0.71	0.00	0.06	NO	**30.43**	0.40
2004	25.75	25.71	0.04	0.72	0.01	0.06	NO	**26.54**	0.47
2005	25.11	25.07	0.04	0.72	0.00	0.06	NO	**25.90**	0.55
2006	25.97	25.92	0.05	0.73	0.00	0.05	NO	**26.75**	0.58
2007	22.62	22.56	0.05	0.75	0.00	0.04	NO	**23.41**	0.61
2008	19.48	19.44	0.04	0.78	0.00	0.03	NO	**20.30**	0.61
2009	14.04	13.98	0.06	0.70	0.00	0.02	NO	**14.76**	0.53
2010	15.28	15.23	0.05	0.70	0.00	0.01	NO	**16.00**	0.57
2011	14.50	14.46	0.05	0.68	0.00	0.01	NO	**15.20**	0.60
2012	14.17	14.12	0.05	0.65	0.00	0.01	NO	**14.83**	0.57
2013	13.80	13.76	0.04	0.59	0.00	0.01	NO	**14.40**	0.54
2014	13.95	13.91	0.04	0.55	0.00	0.01	NO	**14.51**	0.54
2015	13.37	13.33	0.04	0.57	0.00	0.01	NO	**13.95**	0.58
2016	12.70	12.68	0.02	0.57	0.00	0.01	NO	**13.28**	0.54
2017	12.22	12.19	0.04	0.57	0.00	0.01	NO	**12.81**	0.52
2018	11.15	11.12	0.02	0.57	0.00	0.01	NO	**11.73**	0.59

Table A-18: Emission trends for NO_x [kt] 1990–2018 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	183.48	183.48	IE	4.27	12.05	0.10	NO	**199.91**	2.44
1991	185.54	185.54	IE	3.93	11.99	0.09	NO	**201.55**	2.76
1992	177.78	177.78	IE	4.02	11.73	0.06	NO	**193.58**	3.00
1993	171.99	171.99	IE	1.46	11.57	0.05	NO	**185.07**	3.18
1994	168.03	168.03	IE	1.38	11.43	0.05	NO	**180.89**	3.31
1995	167.53	167.53	IE	0.90	11.61	0.05	NO	**180.09**	3.73
1996	168.07	168.07	IE	0.87	11.50	0.05	NO	**180.48**	4.14
1997	168.30	168.30	IE	0.86	11.57	0.05	NO	**180.78**	4.29
1998	166.60	166.60	IE	0.83	11.62	0.05	NO	**179.10**	4.43
1999	167.07	167.07	IE	0.82	11.27	0.05	NO	**179.21**	4.33
2000	166.91	166.91	IE	0.83	11.08	0.05	NO	**178.87**	6.44
2001	170.01	170.01	IE	0.78	11.05	0.05	NO	**181.89**	6.32
2002	169.72	169.72	IE	0.79	11.07	0.05	NO	**181.62**	5.67
2003	174.68	174.68	IE	0.81	10.59	0.05	NO	**186.13**	5.21
2004	175.23	175.23	IE	0.69	10.06	0.05	NO	**186.03**	6.09
2005	178.54	178.54	IE	0.70	10.12	0.05	NO	**189.41**	6.99
2006	180.16	180.16	IE	0.58	10.16	0.04	NO	**190.95**	7.54
2007	176.45	176.45	IE	0.48	10.31	0.04	NO	**187.28**	7.99
2008	169.11	169.11	IE	0.56	10.90	0.03	NO	**180.60**	7.90
2009	156.91	156.91	IE	0.41	10.69	0.02	NO	**168.03**	6.86
2010	157.84	157.84	IE	0.55	9.78	0.02	NO	**168.18**	7.60
2011	156.03	156.03	IE	0.52	10.28	0.02	NO	**166.85**	7.98
2012	151.76	151.76	IE	0.55	10.40	0.02	NO	**162.72**	7.68
2013	148.85	148.85	IE	0.45	10.29	0.02	NO	**159.61**	7.46
2014	144.72	144.72	IE	0.46	10.60	0.02	NO	**155.79**	7.49
2015	142.40	142.40	IE	0.52	10.99	0.02	NO	**153.92**	8.18
2016	138.29	138.29	IE	0.52	11.17	0.02	NO	**150.00**	10.28
2017	131.94	131.94	IE	0.47	10.99	0.02	NO	**143.42**	10.06
2018	124.56	124.56	IE	0.41	10.75	0.02	NO	**135.74**	11.54

Table A-19: Emission trends for NMVOC [kt] 1990–2018 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	158.38	142.89	15.49	118.54	52.19	0.16	NO	**329.26**	0.18
1991	154.30	139.18	15.12	112.01	51.21	0.16	NO	**317.68**	0.20
1992	144.59	129.40	15.19	105.25	48.54	0.15	NO	**298.52**	0.22
1993	134.49	119.83	14.65	98.55	47.26	0.15	NO	**280.44**	0.24
1994	121.13	110.01	11.12	91.99	46.79	0.14	NO	**260.05**	0.25
1995	113.32	103.83	9.49	85.28	46.25	0.14	NO	**244.98**	0.29
1996	107.88	99.41	8.46	83.72	45.10	0.13	NO	**236.83**	0.34
1997	96.87	88.91	7.95	82.37	44.33	0.13	NO	**223.70**	0.37
1998	87.88	81.44	6.43	81.06	43.99	0.13	NO	**213.05**	0.40
1999	81.77	76.10	5.67	78.32	43.28	0.12	NO	**203.49**	0.39
2000	74.89	69.20	5.69	62.15	42.27	0.12	NO	**179.43**	0.42
2001	70.64	66.81	3.84	59.96	41.82	0.11	NO	**172.54**	0.41
2002	65.27	61.24	4.03	59.11	40.94	0.11	NO	**165.43**	0.37
2003	62.15	58.19	3.96	58.53	40.44	0.11	NO	**161.23**	0.34
2004	58.25	54.68	3.57	49.80	40.16	0.11	NO	**148.32**	0.40
2005	55.70	52.35	3.34	57.32	39.50	0.11	NO	**152.63**	0.47
2006	53.37	50.01	3.36	63.26	39.19	0.10	NO	**155.93**	0.50
2007	50.66	47.68	2.98	61.94	39.07	0.10	NO	**151.77**	0.53
2008	48.96	46.20	2.75	58.71	38.79	0.10	NO	**146.55**	0.52
2009	46.35	43.76	2.59	47.89	38.98	0.09	NO	**133.31**	0.45
2010	48.07	45.62	2.45	46.70	38.58	0.09	NO	**133.44**	0.49
2011	44.37	41.96	2.41	46.03	37.92	0.08	NO	**128.40**	0.51
2012	44.28	41.88	2.40	44.13	37.61	0.08	NO	**126.10**	0.49
2013	43.82	41.52	2.30	38.87	37.58	0.07	NO	**120.34**	0.46
2014	39.13	36.71	2.42	36.81	37.63	0.07	NO	**113.64**	0.46
2015	39.62	37.30	2.32	33.37	37.43	0.06	NO	**110.48**	0.50
2016	39.04	36.77	2.27	32.33	37.42	0.06	NO	**108.85**	0.23
2017	38.61	36.32	2.29	33.96	37.31	0.06	NO	**109.94**	0.20
2018	35.89	33.72	2.17	33.63	36.97	0.06	NO	**106.55**	0.22

Table A-20: Emission trends for NH_3 [kt] 1990–2018 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	1.911	1.911	IE	0.339	59.063	0.367	NO	**61.680**	0.002
1991	2.258	2.258	IE	0.577	59.181	0.382	NO	**62.398**	0.002
1992	2.483	2.483	IE	0.438	57.588	0.434	NO	**60.943**	0.002
1993	2.786	2.786	IE	0.287	58.370	0.515	NO	**61.958**	0.002
1994	2.976	2.976	IE	0.236	58.121	0.622	NO	**61.955**	0.002
1995	3.181	3.181	IE	0.165	59.076	0.642	NO	**63.064**	0.003
1996	3.480	3.480	IE	0.163	58.223	0.668	NO	**62.534**	0.003
1997	3.600	3.600	IE	0.162	58.435	0.666	NO	**62.864**	0.003
1998	3.754	3.754	IE	0.168	58.476	0.697	NO	**63.096**	0.003
1999	3.930	3.930	IE	0.186	57.153	0.767	NO	**62.036**	0.003
2000	3.880	3.880	IE	0.167	55.838	0.822	NO	**60.707**	0.003
2001	3.899	3.899	IE	0.146	55.670	0.922	NO	**60.636**	0.003
2002	3.694	3.694	IE	0.128	54.794	1.018	NO	**59.633**	0.003
2003	3.607	3.607	IE	0.141	54.673	1.099	NO	**59.520**	0.003
2004	3.449	3.449	IE	0.122	54.429	1.346	NO	**59.347**	0.003
2005	3.384	3.379	0.005	0.127	54.292	1.444	NO	**59.246**	0.004
2006	3.349	3.342	0.006	0.136	54.789	1.470	NO	**59.742**	0.004
2007	3.249	3.244	0.005	0.138	56.149	1.515	NO	**61.050**	0.004
2008	3.079	3.075	0.003	0.140	56.051	1.535	NO	**60.805**	0.004
2009	2.876	2.872	0.003	0.148	57.623	1.571	NO	**62.219**	0.004
2010	2.941	2.938	0.003	0.153	57.538	1.565	NO	**62.196**	0.004
2011	2.727	2.725	0.002	0.160	57.273	1.563	NO	**61.723**	0.004
2012	2.634	2.632	0.001	0.153	57.672	1.584	NO	**62.043**	0.004
2013	2.512	2.511	0.001	0.155	57.961	1.532	NO	**62.159**	0.004
2014	2.321	2.320	0.001	0.148	58.896	1.579	NO	**62.944**	0.004
2015	2.347	2.347	0.000	0.140	59.621	1.611	NO	**63.719**	0.004
2016	2.276	2.276	0.000	0.146	60.505	1.598	NO	**64.525**	0.004
2017	2.318	2.317	0.000	0.167	61.300	1.602	NO	**65.386**	0.004
2018	2.282	2.281	0.001	0.135	60.358	1.601	NO	**64.376**	0.005

12.3 Information on PM emission factors (include/exclude the condensable component)

Table A-21: 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 2016		EMEP/EEA GB 2016
1.A.3.b.vii	Road transport: Automobile road	No information in the		EMEP/EEA GB 2016

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
	abrasion	EMEP/EEA GB 2016		
1.A.3.c	Railways	No information in the EMEP/EEA GB 2016		EMEP/EEA GB 2016
1.A.3.d.i(ii)	International inland waterways	No information in the EMEP/EEA GB 2016		EMEP/EEA GB 2016
1.A.3.d.ii	National navigation (shipping)			EMEP/EEA GB 2016
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 2016), (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 2016), (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 2016		EMEP/EEA GB 2016
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 2016
2.C.3	Aluminium production		X	EMEP/EEA GB 2016
2.C.4	Magnesium production	NO		
2.C.5	Lead production		X	EMEP/EEA GB 2016
2.C.6	Zinc production	NO		
2.C.7.a	Copper production		X	EMEP/EEA GB 2016
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 2016		EMEP/EEA GB 2016
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 fertilisers 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