

Austria's National
Inventory Report 2024

Submission under Regulation (EU) No 2018/1999

AUSTRIA'S NATIONAL INVENTORY REPORT 2024

Submission under Regulation (EU) No 2018/1999

REPORT
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This report as well as the CRF Tables submitted together with this report, are elements of the official 2024 submission of Austria under the EU Regulation (EU) 218/1999 ("Governance Regulation") in fulfilment of Article 26. It replaces the one designated as DRAFT submitted on March 14th 2024 and has undergone a complete and final quality control and layout/typesetting. The submission of GHG inventory information to the UNFCCC under the Paris Agreement will take place as a „National Inventory Document“ ("NID") at the end of 2024 in accordance with Decision 6/CP.27.

This report is compiled and published as an inspection report in accordance with the Accreditation Law and the international standard ISO/IEC 17020, in fulfilment of and in compliance with the IPCC 2006 Guidelines, the 2006 GL Revised Supplement KP as well as the 2006 GL Supplement Wetlands (scope of accreditation regarding GHG emissions) as well as the UNFCCC Reporting Guidelines.

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PREFACE

As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), Austria is required to produce and regularly update National Greenhouse Gas Inventories. Methodologies, content and format of the inventory are prescribed by the IPCC (IPCC, 2006) in its reporting guidelines that have been agreed by the Conference of the Parties to the Climate Change Convention. A complete inventory submission requires a National Inventory Report and the common reporting format tables. With Decision 24/CP.19 (FCCC/CP/2013/10/Add.3) the revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention were adopted. According to this decision an annual GHG inventory submission shall consist of an National Inventory Report (NIR) and CRF tables.

The report also presents GHG data relevant under the Effort-sharing Regulation¹ (target period 2021-2030) covering greenhouse gas emissions for sectors not covered by the emissions trading system. It is submitted as final report² to the European Commission in fulfilment of Austria's obligations under Article 26 of Regulation (EU) No 218/1999 ("*Governance Regulation*")³ governing reporting of greenhouse gas inventory data by Member States from 2023 onwards. The purpose of this regulation is to monitor anthropogenic greenhouse gas emissions and to evaluate the progress towards meeting the Union greenhouse gas reduction commitments in accordance with the Paris Agreement.

In 2024 the submission of this report and the CRF Tables only takes place under the EU Governance Regulation, but exceptionally not under the UNFCCC, as according to Decision 6/CP.27 'Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention' the deadline for the submission to the UNFCCC was set to 31 December in 2024. This is because the final version of the reporting tool for electronic reporting of the common reporting tables referred to in Decision 5/CMA.3, paragraph 8, is not expected to be available for use until 30 June 2024.

The structure of the report follows the outline and general structure of the national inventory report as required under Decision 24/CP.19 (Appendix). First, there is an Executive Summary giving an overview of Austria's greenhouse gas inventory. Chapters 1 and 2 provide general information on the inventory preparation process and summarize the overall trends in emissions. Comprehensive information on the methodologies used for estimating emissions of Austria's greenhouse gas inventory is presented in the Sector Analysis Chapters 3–8. Chapter 9 reports on indirect emissions.

¹ REGULATION (EU) 2018/842 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013

² First submission 2024 was done on 15th January 2024 providing inventory data for 2022 and information as stipulated in Art. 26 (3) in the EU Governance Regulation ("*Short-NIR 2024*"; UMWELTBUNDESAMT 2024a)

³ REGULATION (EU) 2018/1999 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

Chapter 10 gives an overview of recalculations, including improvements made and planned in response to the previous reviews (UNFCCC 2023, ESD 2023).

This is the 23rd version of the National Inventory Report (NIR) submitted by Austria and it builds on the NIR submitted in 2023⁴. It is based on AUT CRF tables submitted on 14 March 2024. Aim of this report is to document the methodology in order to facilitate understanding of the calculation of the Austrian GHG emission data. The more interested reader is kindly referred to the background literature cited in this document.

Data differs from last years' reported data as some activity data have been updated or improvements in methodology have been made to enhance accuracy of the greenhouse gas inventory (for further information see Chapter 10 Recalculations and Improvements). Data and information presented in the NIR 2024 replaces the information submitted in previous years.

The CO₂-equivalent emissions presented in this report were calculated by applying the Global Warming Potentials ('GWPs') according to the 5th Assessment Report ('AR5') of the Intergovernmental Panel on Climate Change (IPCC). Austria thus fulfills the requirements of the EU Governance Regulation 2018/1999⁵ on GHG inventories applicable from 2023 onwards, which, by means of its Delegated Regulation 2020/1044⁶ Article 2 ('Greenhouse Gas Potentials'), requires the use of the GHG potentials listed in Annex 1 of this Regulation in accordance with AR5.

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

Michael Anderl in his function as head of the *Inspection Body for Emission Inventories* is responsible for the content of this report and for the quality management system of the Austrian Greenhouse Gas Inventory. Katja Pazdernik acts as deputy head of the *Inspection Body for Emission Inventories*.

Project leader for the preparation of the Austrian GHG inventory is Stephan Poupa.

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- Fuel combustion stationary Stephan Poupa ('Sector Coordinator')
- Fuel combustion mobile Gudrun Stranner ('Sector Coordinator')
- Fuel combustion residential Wolfgang Schieder
- Fugitive emissions Marion Gangl ('Sector Coordinator')

⁴ Austria's National Inventory Report 2023 – Submission under the United Nations Framework Convention of Climate Change and under the Kyoto Protocol. Report REP-0852. Umweltbundesamt, Vienna.

⁵ REGULATION (EU) 2018/1999 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

⁶ COMMISSION DELEGATED REGULATION (EU) 2020/1044 of 8 May 2020 supplementing Regulation (EU) 2018/1999 of the European Parliament and of the Council with regard to values for global warming potentials and the inventory guidelines and with regard to the Union inventory system and repealing Commission Delegated Regulation (EU) No 666/2014

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- LULUCF Peter Weiss ('Sector Coordinator')
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- Key Category Analysis Andreas Zechmeister
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- Chapter 7.4 Stephan Poupa, Simone Mayer
- Chapter 8 Katja Pazdernik
- Chapter 9 Katja Pazdernik
- Chapter 10 all sector experts

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EXECUTIVE SUMMARY

ES.1 BACKGROUND INFORMATION ON GREENHOUSE GAS (GHG) INVENTORIES AND CLIMATE CHANGE

ES.1.1 Background information on climate change

Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. It undergoes natural variability. Since industrialisation started some 150 years ago, mankind has been influencing the climate via the emission of greenhouse gases. In 1992, by adopting the United Nations Convention on Climate Change, the countries of the world came together to prevent harmful effects of climate change. However, the Convention did not include binding commitments to limit GHG emissions. To go this step further the Kyoto Protocol was adopted in 1997: It sets binding emission limits for 37 industrialized countries for the period 2008–2012. An agreement on a second Kyoto commitment period from 2013 to 2020 was achieved 2012 at the 18th Conference of the Parties in Doha (Qatar) (UNFCCC CMP.8). The agreed reduction for the EU is 20% compared to 1990 emissions, which is in line with the climate and energy package 2020 of the EU.

The decision to negotiate a new global agreement for the period after 2020 was made at the Conference of the Parties in Durban in 2011. In December 2015, this was adopted at the 21st Conference of the Parties in Paris. It entered into force on November 4, 2016, as more than 55 Parties covering at least 55% of global GHG emissions ratified it.

The Paris Agreement established the long-term 2°C target for the first time in an international treaty. It also calls for additional efforts to limit temperature increases to 1.5°C. In contrast to the Kyoto Protocol, this new agreement includes not only industrialized but also newly industrializing and developing countries in order to take account of the change in the global distribution of GHG emissions. Plans for emission reductions (Nationally Determined Contributions, NDCs) of the participating countries have been submitted to the UNFCCC.

ES.1.2 Background information on greenhouse gas inventories

To be able to evaluate the trend of greenhouse gas emissions, especially the progress in achieving the emission reduction goal, it is necessary to regularly compile an inventory of GHG emissions.

ES.2 SUMMARY OF NATIONAL EMISSION AND REMOVAL-RELATED TRENDS

In 2022 Austria's total greenhouse gas (GHG) emissions (without Land Use, Land Use Change and Forestry – LULUCF) amounted to 72.8 Mt CO₂ equivalents (CO₂e). Compared to the 1990 base year⁷, 2022 GHG emissions without LULUCF decreased by 7.9%. Compared to 2021 GHG emissions decreased by 5.8%.

The most important gas in the Austrian GHG balance remains carbon dioxide (CO₂) with a share of 84% in total 2022 emissions (without LULUCF). Emissions of CO₂ primarily result from combustion activities. Methane (CH₄), which mainly arises from livestock farming and waste disposal, contributes 8.9% (2022) to total national GHG emissions. Nitrous oxide (N₂O), with agricultural soils as the main source, contributes another 4.2% (2022). The remaining 2.5% are emissions of fluorinated compounds, which are mostly emitted from the use of these gases as substitutes for ozone depleting substances (ODS) in refrigeration equipment.

Table 1: Austria's greenhouse gas emissions by gas.

GHG emissions	CO ₂	CH ₄	N ₂ O	HFCs	PFCs	SF ₆	NF ₃	Total
CO ₂ equivalents (kt)								
1990	62 184	11 321	4 028	2.0	1 063	485	NO,NA	79 083
1995	64 061	10 515	3 871	324	75	1 134	6.0	79 986
2000	66 177	9 218	3 885	678	80	592	9.8	80 640
2005	79 092	8 519	3 200	1 109	150	509	26	92 605
2010	72 008	7 917	3 014	1 434	71	346	3.9	84 793
2011	69 901	7 684	3 108	1 527	66	317	3.8	82 607
2012	67 274	7 551	3 082	1 607	46	321	8.0	79 889
2013	67 767	7 431	3 066	1 678	45	315	9.1	80 310
2014	64 166	7 274	3 148	1 752	48	324	9.9	76 721
2015	66 357	7 188	3 163	1 850	45	319	13	78 935
2016	67 217	7 110	3 251	1 828	46	405	5.7	79 863
2017	69 598	7 081	3 196	1 857	40	412	11	82 195
2018	66 562	6 853	3 156	1 890	29	398	15	78 903
2019	67 946	6 711	3 149	1 755	35	450	13	80 058
2020	62 176	6 607	3 105	1 650	27	455	11	74 030
2021	65 757	6 622	3 143	1 431	23	371	12	77 360
2022	61 489	6 498	3 040	1 411	26	365	14	72 844

Note: Global warming potentials (GWPs) according to the 5th Assessment Report (IPCC 2013) (100 years time horizon): carbon dioxide (CO₂) = 1; methane (CH₄) = 28; nitrous oxide (N₂O) = 265; sulphur hexafluoride (SF₆) = 23 500; nitrogen trifluoride (NF₃) = 16 100; hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) consist of different substances, therefore GWPs have to be calculated individually depending on the substances

⁷ Austria's base year under the UNFCCC is 1990. Under the EU Effort Sharing, the base year is 2005 (relates only to emissions not included in the EU Emissions Trading Scheme). Unless otherwise specified, references to the base year in this report refer always to 1990.

Over the period 1990–2022 CO₂ emissions decreased by 1.1%, mainly due to decreasing emissions from energy industries and the residential sector. During the same period CH₄ emissions decreased by 43%, mainly due to lower emissions from solid waste disposal sites, to a smaller extent also from enteric fermentation. N₂O emissions decreased by 25% due to lower emissions from the chemical industry (nitric acid production) and from agricultural soils. HFC emissions increased remarkably between 1990 and 2022 (from 2.0 to 1 411 kt CO₂e), whereas PFC and SF₆ emissions decreased by 98% and 25% respectively. NF₃ emissions amounted to 14 kt CO₂e in 2022 compared to zero emissions in 1990.

ES.3 OVERVIEW OF SOURCE AND SINK CATEGORY EMISSION ESTIMATES AND TRENDS

The dominant sector regarding GHG emissions in Austria is *Energy*, causing 67% of total national GHG emissions in 2022 (67% in 1990), followed by the sectors *Industrial Processes and Other Product Use* (22% in 2022) and *Agriculture* (10% in 2022).

Table 2: Austria's greenhouse gas emissions by sector.

GHG source and sink categories	1. Energy	2. IPPU	3. Agriculture	4. LULUCF	5. Waste	6. Other
	CO ₂ equivalents (kt)					
1990	52 666	13 633	8 416	-11 682	4 367	NO*
1995	54 161	13 625	8 145	-19 334	4 055	NO
2000	55 290	14 417	7 657	-13 958	3 277	NO
2005	66 714	15 653	7 196	-18 099	3 041	NO
2010	59 279	15 938	7 287	-19 439	2 289	NO
2011	56 970	16 130	7 363	-15 035	2 143	NO
2012	54 829	15 732	7 312	-5 443	2 016	NO
2013	55 004	16 122	7 311	-5 911	1 873	NO
2014	51 279	16 248	7 447	-7 286	1 747	NO
2015	53 062	16 750	7 479	-6 234	1 644	NO
2016	54 285	16 437	7 595	-6 667	1 546	NO
2017	55 999	17 191	7 549	-2 930	1 457	NO
2018	54 553	15 535	7 435	5 222	1 381	NO
2019	54 935	16 470	7 324	2 437	1 329	NO
2020	49 994	15 461	7 297	-5 843	1 278	NO
2021	51 916	16 892	7 322	-11 076	1 230	NO
2022	48 464	15 929	7 277	-4 474	1 174	NO

*not occurring

ES.4 OTHER INFORMATION

Overview of Emission Estimates and Trends of Indirect GHGs and SO₂

Emissions of indirect greenhouse gases decreased in the period from 1990 to 2022: NO_x by 48%, CO by 62%, NMVOC by 70%, and SO₂ by 85%. The most important emission source for NO_x, SO₂ and CO is *Energy* (fuel combustion). The most important emission sources for NMVOC are *Industrial Processes and Other Product Use* and *Agriculture*.

Table 3: Emissions of indirect GHGs and SO₂ 1990–2022.

	NO _x	CO	NMVOC	SO ₂
	[kt]			
1990	218	1 247	328	74
1995	198	972	244	47
2000	211	726	177	31
2005	246	623	153	26
2010	204	578	134	16
2011	196	560	129	15
2012	191	560	127	15
2013	192	564	121	14
2014	185	529	115	14
2015	182	539	111	14
2016	174	534	110	13
2017	165	525	110	13
2018	153	483	107	11
2019	144	496	106	11
2020	123	472	108	10
2021	122	537	108	11
2022	113	480	100	11
1990–2022	-48%	-62%	-70%	-85%

1 INTRODUCTION

1.1 Background information on greenhouse gas (GHG) inventories and climate change

1.1.1 Background information on climate change

1.1.1.1 Global Warming

Temperature around the world has been rising since the Industrial Revolution. Scientific evidence makes clear that human activities are mostly responsible for the increase by emitting greenhouse gases like carbon dioxide, methane, nitrous oxide as well as various fluorinated and chlorinated gases (IPCC 2014).

The average global temperature on earth has increased by a little more than 1° Celsius since 1880, while two-thirds of the warming has occurred since 1975 (NASA 2020).

According to the fifth assessment report of the IPCC 2014, temperature will rise by another 0.9–5.4°C in the 21st century, depending on the emission scenario.

The IPCC 2019 states that global warming from the pre-industrial period to the present will persist for centuries and will continue to cause further long-term changes in the climate system.

It will lead to changes in the hydrological cycle as well as to modification of the albedo (total reflectivity of the earth) and to significant changes of the atmospheric circulation. This will increase the risk of extreme weather events such as hurricanes, droughts and floods and others.

1.1.1.2 Climate Change in Austria

Since 1880, an approx. 2°C increase in the average air temperature in Austria has been recorded (APCC 2014), which is significantly higher than the global average. The effects of global warming in Austria are already visible today: rapid melting of glaciers, thawing of permafrost, an increasing number of hot days, longer vegetation periods, etc.

In 2015, regional climate projections for the near (2050) and distant future (2100) were made available for Austria (called ÖKS15), providing comprehensive, high-resolution and error-corrected information on climate change. All models consistently show significant increases in annual and seasonal mean temperatures throughout Austria, about +1.3°C to +1.4°C by 2050. By the end of the 21st century, with +4.0°C throughout Austria, RCP8.5 predicts a much more pronounced increase in temperature than RCP4.5 at +2.3°C.

Being aware of the need for further research to various topics related to climate change, Austria launched StartClim and the Austrian Climate Research Program (ACRP) in the last century and installed in 2011 the Climate Change Center Austria (CCCA). Furthermore a strategy to adapt to climate change in Austria was developed in 2012 and updated in 2017.

1.1.1.3 The Convention, its Protocols and the flexible mechanisms thereunder

In 1992 Austria signed the United Nations Framework Convention on Climate Change (UNFCCC) which sets an ultimate objective of stabilizing atmospheric concentrations of greenhouse gases at levels that would prevent “dangerous” human interference with the climate system. Such levels, which the Convention does not quantify, should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

The UNFCCC covers all greenhouse gases not covered by the Montreal protocol⁸: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) as well as hydrogenated fluorocarbons (HFCs), perfluorinated halocarbons (PFCs), sulphur hexafluoride (SF₆) and nitrogen trifluoride (NF₃).

Five years after adoption of the Climate Change Convention in 1997, governments took a further step forward and adopted the landmark Kyoto Protocol. Building on the Convention, the Kyoto Protocol broke new ground with its legally binding constraints on greenhouse gas emissions and its innovative ‘mechanisms’ aimed at cutting the cost of curbing emissions. Under the terms of the Protocol, the industrialised world – Parties listed in Annex I of the Convention and known as ‘Annex I countries’ – pledged to reduce their greenhouse (GHG) emissions by 5% below 1990 levels by the period 2008–2012. The European Union is also a Party to the Convention and the KP and agreed on a reduction target of 8% below 1990 levels during the five-year commitment period from 2008 to 2012. The EU and its Member States decided to achieve this goal jointly, for Austria an emission target of minus 13% was set.

The KP entered into force on 16 February 2005, triggered by Russia’s ratification in November 2004 which fulfilled the requirement that at least 55 Parties to the Convention ratified (or approved, accepted, or acceded to) the Protocol, including Annex I Parties accounting for 55% of that group’s carbon dioxide emissions in 1990: by April 2011, 190 Parties had ratified the KP, accounting for 63.7% of emissions of Annex I Parties.

The Protocol sets out three ‘flexible mechanisms’ to help countries meet their obligations to cut emissions.

- *Emission Trading*: Article 17 of the Kyoto Protocol allows Annex I Parties (basically, the industrialised nations) to purchase the rights to emit greenhouse gases (GHG) from other Annex I countries which have reduced their GHG emissions below their assigned amounts. Trading can be carried out by intergovernmental emission trading, or entity-source trading where assigned amounts are allocated to sub-national entities.
- *Joint Implementation*: Article 6 allows an Annex I Party to gain a credit (converted to Assigned Amounts) by investing in another Annex I country in a project which reduces GHG emissions.
- *Clean Development Mechanism*: Article 12 allows an Annex I country (or companies in an Annex I country) which funds projects in developing countries (non-Annex I Party) to get credits for certified emission reductions providing that “benefits” accrue for the host country.

Tradable emission permits tie the emissions to a fixed ceiling, the costs of emission reduction being as low as possible.

⁸ The Montreal Protocol sets the elimination of ozone-depleting substances as its final objective and covers chloro and bromo fluorocarbons.

The final assessment on compliance with the goals of the first commitment period of the KP was made 2016 in the true up process after finalization of the last review reports.

The so called Doha Amendment extends GHG mitigation obligations of the Kyoto Protocol until 2020, establishing a second commitment period. As of 28 October 2020, 147 Parties had deposited their instrument of acceptance, exceeding the threshold of 144 instruments of acceptance. The Doha Amendment entered into force on 31 December 2020.⁹

Independently of the setting into force of the Doha Amendment, the European Community has fixed its goal in the so called Effort Sharing Decision (Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020), with the goal of a 20% cut of emissions below the 1990 emission level by 2020. The ESD Directive also sets national emission targets for the member states, the Austrian target is –16% related to 2005 (not considering the sectors/sources regulated by the EU ETS).

Paris Agreement:

After negotiations on a global climate protection agreement failed in Copenhagen in 2009, the decision to negotiate a new global agreement for the period after 2020 was made at the Conference of the Parties in Durban in 2011. In December 2015, this was adopted at the 21st Conference of the Parties in Paris. It entered into force on November 4, 2016, as more than 55 Parties covering at least 55% of global GHG emissions ratified it.

The Paris Agreement established the long-term 2°C target for the first time in an international treaty. It also calls for additional efforts to limit temperature increases to 1.5°C. In contrast to the Kyoto Protocol, this new agreement includes not only industrialized but also newly industrializing and developing countries in order to take account of the change in the global distribution of GHG emissions. Plans for emission reductions (Nationally Determined Contributions, NDCs) of the participating countries have been submitted to the UNFCCC. From 2020, all Parties are required to submit increasingly ambitious climate change mitigation plans on a regular basis and to report transparently on progress to date from 2024. By the second half of the century, global decarbonization efforts are to result in "net zero emissions.

To meet the goal of the Paris Agreement, the emission reduction target of at least 40 % (relative to 1990) of the EU's 2030 climate and energy policy framework adopted in 2014 has been increased to a net emission reduction target of at least 55 % under the new EU Climate Law, adopted under the European Green Deal.

For 2050, the European Commission has set itself the goal to be climate-neutral, a legally binding target that it is also set out in the EU Climate Law. To achieve the ambitious targets of the Climate Law, the EU Commission presented in July 2021 a legislative 'Fit for 55' package, which includes proposals and amendments to a number of existing legal rules (such as the Effort Sharing Regulation, Emissions Trading Directive and the Energy Efficiency Directive).

⁹ <https://unfccc.int/process/the-kyoto-protocol/the-doha-amendment>

1.1.2 Background information on greenhouse gas inventories

As a Party to the Convention, Austria is required to produce and regularly update National Greenhouse Gas Inventories. Furthermore Parties shall submit a National Inventory Report (NIR) containing detailed and complete information on their inventories, in order to ensure the transparency of the inventory. This report presents the latest results from the Austrian greenhouse gas (GHG) inventory, documenting the annual national GHG emissions for the years 1990 to 2022

The Environmental Control Act ('Umweltkontrollgesetz'; Federal Law Gazette 152/1998)¹⁰ designated the Umweltbundesamt as the single national entity with overall responsibility for inventory preparation. Within the Umweltbundesamt, the Inspection Body for Emission Inventories (IBE) was established and entrusted with the preparation of and reporting on emission inventories; since 2005 the IBE is accredited according to EN ISO/IEC 17020. In 2011, 2016 and 2020 the re-accreditation was passed successfully. In between these re-accreditation audits several external audits were conducted by quality experts appointed by Accreditation Austria, last in June 2023.

For the purpose of Quality Assurance, resulting from increased requirements of transparency, consistency, comparability, completeness and accuracy of the national greenhouse gas inventory, the inventories have been annually reviewed by international experts managed by the Climate Secretariat in Bonn (expert review team ERT). To date, Austria's Greenhouse Gas Inventory was reviewed by three in-country reviews (2006, 2007¹¹ and 2013) and various centralized reviews in 2001 (during the trial period of the review process), 2003, 2004, 2005, 2007, 2008, 2009, 2010, 2011, 2012, 2014, 2015, 2016, 2018, 2020 (as a desk review¹²), 2022 and 2023. In 2017, 2019 and 2021 no UNFCCC Reviews were conducted¹³.

The reports on Austria's inventory reviews can be found on the UNFCCC website, the recommendations from the latest UNFCCC review 2023¹⁴ and their implementation are demonstrated in Table 310.

In addition, annual reviews were conducted for all EU MS inventories 2013–2020 according to Article 19 of the MMR (Monitoring Mechanism Regulation No 525/2013). In 2012 a technical review was done by EU experts, with the aim of supporting the determination of Member States' annual emission allocations under Decision No 406/2009/EC (Effort-Sharing Decision). In 2015 this 'ESD-Review' was conducted as a trial review as inventories were submitted delayed due to the technical problems with the CRF Reporter. Annual ESD reviews of the Austrian inventory were successfully passed in 2017, 2018, 2019, 2021 and 2022. 'Comprehensive ESD-Reviews' were carried out in 2016 and 2020 with no technical corrections being necessary.

¹⁰ <https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10011109>

¹¹ In February 2007 the in-country review of the initial report of Austria (the Pre-commitment period review) took place, covering the review of the assigned amount, the national inventory system and the national registry.

¹² The review 2020 was originally organized as an in-country review, but had to be converted to a 'remote centralised review' given the impacts of Covid-19.

¹³ only initial checks of the greenhouse gas inventory of Austria were conducted

¹⁴ https://unfccc.int/sites/default/files/resource/arr2023_AUT.pdf

1.2 Description of the national inventory arrangements

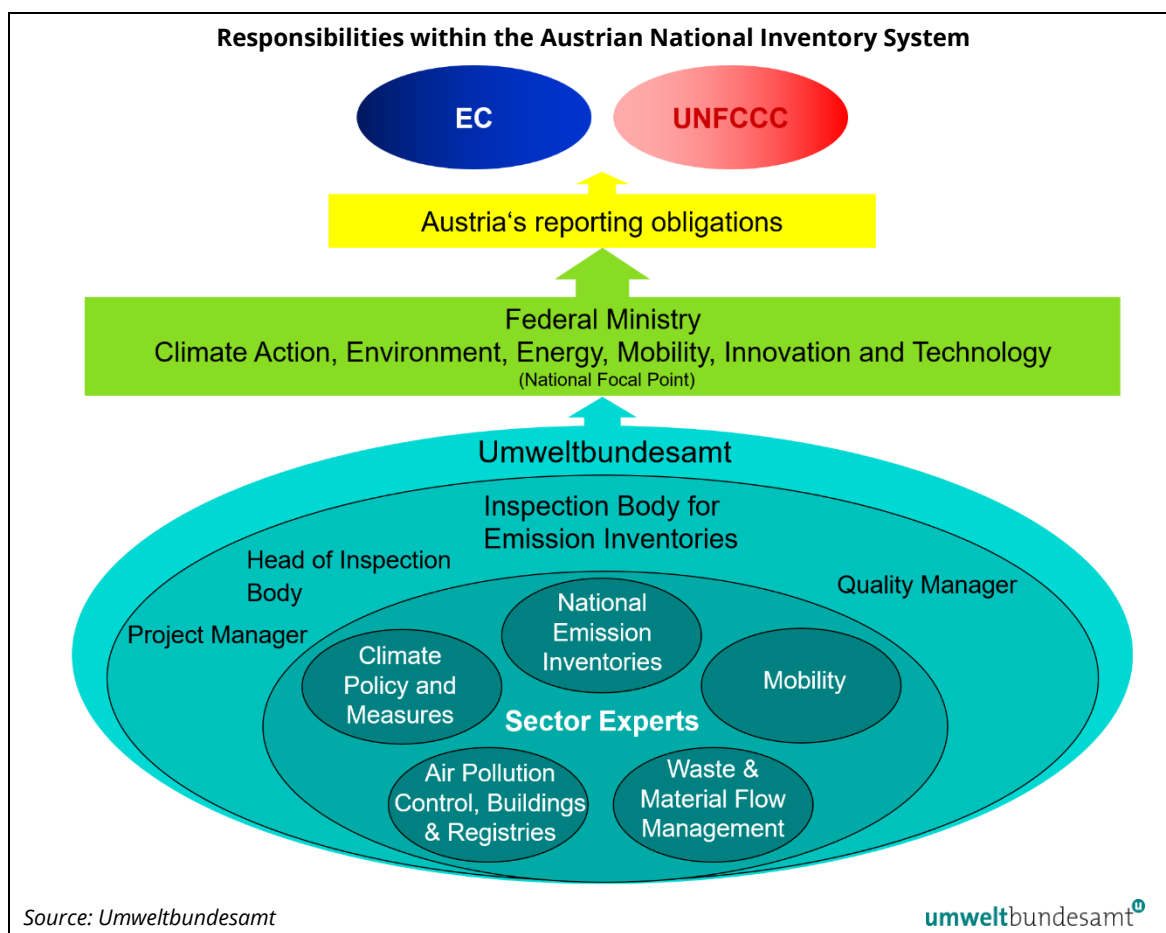
1.2.1 Institutional, legal and procedural arrangements

Austria's reporting obligations to the UNFCCC, UNECE and EC are administered by the Federal Ministry of 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' (BMK). With the Environmental Control Act (Federal Law Gazette 152/1998), that entered into force on the 1st of January 1999, the Umweltbundesamt has been designated as single national entity with overall responsibility for inventory preparation. This law regulates responsibilities of environmental control in Austria and lists the tasks of the Umweltbundesamt. Furthermore, the Environmental Control Act establishes the Umweltbundesamt as a private limited company owned by the Republic of Austria. To assure that the Umweltbundesamt has the resources 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 a project basis by the contracting entity, which may be national, EC authorities or private entities.

One task of the Umweltbundesamt is the preparation of technical expertise and the data basis for fulfilment of the obligations under the UNFCCC and the UNECE LRTAP Convention. 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.

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

Figure 1: Responsibilities within the Austrian National Inventory System (greenhouse gases).



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 9 sectors defined (Energy, Transport, Buildings, Fugitive Emissions, Industrial Processes, Product Use, Agriculture, LULUCF and Waste). At least two experts form a sector team and one of them is nominated as 'Sector Coordinator'. For more information on the QMS please refer to Chapter 1.2.3.

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

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

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

- The Austrian Emissions Certificate Trading Act¹⁵ that regulates monitoring and reporting in the context of the EU Emissions Trading Scheme (ETS) in Austria. The Umweltbundesamt takes the emission reports of the emissions trading scheme into account for the national greenhouse gas inventory in order to comply with requirements of the EU Monitoring Mechanism and the UNFCCC. This is not only important for emissions from combustion of fuels, for which more detailed information is available in the ETS reports than is provided in the national energy balance, but also for emissions from industrial processes. First data from the EU ETS were available for the year 2005. Since then ETS data have been considered in the submissions.
- The Austrian statistical office (Statistik Austria) is required by contract with the BMK 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 2000¹⁶), 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 2000¹⁶ (federal statistics law), which allows the national statistical office to provide confidential data to authorities that have a legal obligation for the processing of these data.
- According to paragraph 38 (1) of the EG-K 2013¹⁷ each licensee of an operating boiler with a thermal capacity of more than two megawatts (MW) is obliged to report the emissions to the competent authority. The Umweltbundesamt can request copies of these emission declarations. This data is used to verify the data from the national energy balance for the Energy sector.
- According to the old Landfill Ordinance (Deponieverordnung 1996)¹⁸ the operators of landfill sites had to report type and amount of waste deposited annually. These reports (collected in a central database run by Umweltbundesamt) still provide the main basis for calculating emissions from the sector *Waste* for the inventory years 1998-2007.
- Starting with the deposited waste of the year 2008 landfill operators have been – pursuant to the new Landfill Ordinance (Deponieverordnung 2008)¹⁹ – obliged to submit their data annually and electronically via the portal <http://edm.gv.at> (Electronic Data Management –

¹⁵ „Emissionszertifikate-Gesetz 2011“; Federal Law Gazette I No 118/2011

¹⁶ „Bundesstatistikgesetz 2000“; Federal Law Gazette I No 163/1999

¹⁷ „Emissionsschutzgesetz für Kesselanlagen 2013“; Federal Law Gazette I No 127/2013

¹⁸ „Deponieverordnung“; Federal Law Gazette No 164/1996

¹⁹ „Deponieverordnung 2008“; Federal Law Gazette II No 39/2008

'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) Ordinance²⁰ for users of FCs for the following applications: refrigeration and air-conditioning, foam blowing, semiconductor manufacture, electrical equipment, fire extinguishers and aerosols. This data is notified via EDM and used for estimating emissions from the consumption of fluorinated compounds (IPCC sector 2.F).

More information on the National Inventory System in Austria (NISA) is provided in Annex 5.

1.2.2 Overview of inventory planning, preparation and management

Umweltbundesamt is designated as the single national entity responsible for Austria's GHG inventory by law, and thus is also responsible for coordinating QA/QC and verification activities. Responsibilities of the different functions – quality representative, sector expert, sector coordinator, project manager, head of inspection body, report coordinator, cross-sector analyst, etc. – are defined in the QMS. Within the inventory system specific responsibilities for the different emission source/sink categories ('Sector Experts') are defined. There are 9 sectors defined (Energy, Transport, Buildings, Fugitive Emissions, Industrial Processes, Product Use, Agriculture, LULUCF and Waste). At least two experts form a sector team and one of them is acting as 'Sector Coordinator'. Sector experts collect activity data, emission factors and all relevant information needed for finally estimating emissions. The sector experts are also responsible for the choice of methods, data processing and archiving and for contracting studies, if needed. Furthermore sector experts perform Quality Assurance and Quality Control (QA/QC) activities regarding their sector.

For the Austrian greenhouse gas inventory the main planning is performed once a year at the so called Management Review, which is conducted in two parts.

The first part comprises the annual sector talks (sectoral improvement planning), in which the sector team discusses all issues related to the respective sector with the head of the inspection body (HI), rates all issues according to their urgency and resource needs, and finally agrees on measures/activities. Furthermore the HI checks the implementation of the previously integrated improvements.

The second part is the actual management review meeting where the QR presents the 'IBE Management Review Report' on activities within and performance of the IBE in the last year to the HI. Based on this report, the HI reviews the QMS, and sets measures for the improvement of the effectiveness of the management system and its processes and improvements of the Inspection Body related to the fulfilment of EN ISO/IEC 17020. The report also includes the planning regarding internal audits, QA and verification activities as well as the training plan and resource planning.

Finally the report, and particularly planned improvements with high resource needs, are presented to the managing directors of the Umweltbundesamt, to obtain the necessary additional resources. Furthermore issues that need intervention by the managing directors or the ministry are discussed. On the basis of the decisions at the management review, the project manager and sector experts work out a detailed working plan including milestones, timelines and responsibilities.

²⁰ „Industriegas-Verordnung (HFKW-FKW-SF6-VO)“; Federal Law Gazette II No. 447/2002

Table 4 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 based on audit and review findings.	Summer
Kick-Off	Meeting of inventory team (HI, sector experts, project-/quality- and data managers of the inventory, report coordinators, cross-sector analyst and all deputies); definition of a working plan.	End of Summer
Activity data collection	Collection of activity data, including contracting out studies.	November 15
Inventory preparation	Estimation of emissions for all sources, including collection of background data.	December 15
Compilation of national inventory	Updating the data base and conversion to the CRF reporter	December 23
Quality checks	Tier 1 and Tier 2 QA/QC activities	December
Compilation of preliminary data and information ²¹ (Short-NIR)	Compilation of the inventory report 'Short NIR' and submission to the EC (Governance Regulation No 2018/1999)	January 15
Preparation of NIR	Compilation of the National Inventory Report	January–March
EU Submission NIR	Submission of the National Inventory Report to the EC (MMR)	March 15
UNFCCC Submission NIR	Submission of the National Inventory Report to the UNFCCC	April 15 ²²

1.2.3 Quality assurance, quality control and verification

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

Since 23 December 2005 the Umweltbundesamt has been accredited²³ as Inspection Body for emission inventories, Type A (ID No. 0241), in accordance with EN ISO/IEC 17020 and the Austrian Accreditation Law (AkkG)²⁴, by decree of Accreditation Austria (first decree, No. BMWA-92.715/0036-I/12/2005, issued by Accreditation Austria / Federal Ministry of Economics and Labour on 19 January 2006).

In addition to the elements of a QMS as described in the EN ISO 9000 series, the EN ISO/IEC 17020 focusses on the competence of the personnel, and ensures strict independence, impartiality and

²¹ Including greenhouse gases and inventory information listed in Annex V to the EU Governance Regulation No 2018/1999

²² 2024 no April submission of the NIR to the UNFCCC is expected in accordance with CP.27 Decision 6 Para 6 and CMA.1 Decision 18 Para 3. Instead Parties shall submit their first biennial transparency report and national inventory report, if submitted as a stand-alone report, at the latest by 31 December 2024.

²³ For more information on the accreditation please refer to Annex 5.

²⁴ Federal Law Gazette I No 28/2012 (Akkreditierungsgesetz 2012)

integrity. The implementation is audited by the Austrian Accreditation Body ('Akkreditierung Austria') regularly (about every 20 months). Every five years the accreditation has to be renewed in a more comprehensive audit. The accreditation of the IBE was awarded for the first time in 2005 and was renewed in 2011, 2016 and 2020.

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

1.2.3.1 Requirements of the EN ISO/IEC 17020 compared to the IPCC 2006 GL

The IPCC 2006 GL set out the major elements of a QA/QC system to be implemented by emission inventory compilers

- inventory agency responsible for coordinating QA/QC activities and definition of roles and responsibilities
- a QA/QC plan
- general QC procedures (Tier 1) and source category-specific QC procedures (Tier 2)
- QA and review procedures and verification activities
- QA/QC system interaction with uncertainty analysis (see chapter on uncertainties)
- reporting, documentation and archiving

Table 5: Overview of QA/QC aspects in different technical and quality standards.

IPCC 2006 GL	EMEP/EEA GB 2019 ²⁵	EN ISO 9001 ²⁶	EN ISO/IEC 17020 ²⁷
Roles and Responsibilities	Roles and Responsibilities	X	X
QA/QC plan	QA/QC plan	X	X
QC procedures	QC procedures	X	X
QA procedures	QA procedures	X	X
QA/QC system interaction with uncertainty analysis	QA/QC system interaction with uncertainty analysis	-	-
Verification activities	Verification activities	(X)	(X)
Reporting, documenting and archiving procedures	Reporting, documenting and archiving procedures	X	X
-	Inventory management report ²⁸	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

²⁵ Requirements largely based on the 'Quality Assurance/Quality Control and Verification' chapter of the 2006 IPCC Guidelines (IPCC 2006).

²⁶ Basic international standard for quality management and quality assurance

²⁷ contains additional requirements compared to ISO 9001

²⁸ According to the EMEP/EEA Guidebook, it also is good practice to summarize lessons learned from previous inventory preparation cycles in an inventory management report.

The implementation of these elements in the Austrian QMS is described in the following chapters.

1.2.3.2 Quality policy and objectives

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

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

- Fulfilment of requirements for emission inventories to provide a solid data basis for the political processes in the context of greenhouse gas and air pollutant emissions.
- Providing emission inventories that facilitate the definition and evaluation of measures, which needs a forward looking maintenance and improvement of the emission inventory. Therefore the IBE keeps its staff updated on the latest technical expertise, scientific findings and the latest developments by encouraging the participation of its staff in international technical and political processes and ensure the transfer of knowledge within the IBE.
- Compliance with the EN ISO/IEC 17020 standard by ensuring the implementation and continuous improvement of a QMS as described in the quality manual by the IBE and its personnel. The QMS procedures are designed to facilitate the preparation of the emission inventories in a professional and timely manner, particularly to enhance the transparency to allow full reproduction, and ensure correctness by applying quality checks and validation activities. One of the key managerial functions is raising the personnel's awareness for quality control.

Aim of the IBE is to provide a best-practise example by setting a high quality standard – even higher than specified in the requirements – 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 air pollutants are covered by the QMS.

1.2.3.3 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:

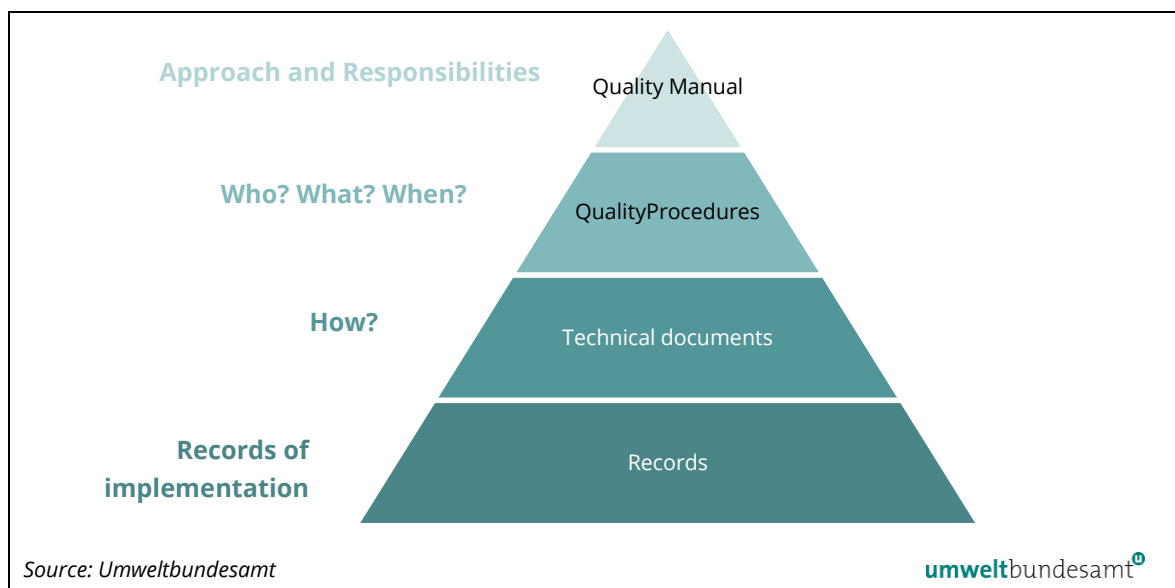
• QC activities	• Inventory improvement plan
• Procedures for country specific methodologies	• Documentation and archiving
• Internal audits (QM specific)	• Treatment of confidential data
• Procedures for service contracting	• Annual Management Review

Quality Manual

The Quality System is divided into three levels:

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

Figure 2: Structure of the Austrian Quality Management System (QMS).



1.2.3.4 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	✓ completeness
✓ documentation of expert judgements	✓ correct transformation/transcription into CRF
✓ clear explanation of recalculations	✓ information on background tables
✓ provision of references	✓ consistency of data and information with information in inspection reports
✓ plausibility of data	✓ treatment of confidential data
✓ consistency of data	

Additionally, in the course of the NIR 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 CRF tables are updated during the preparation of the inventory, the data manager informs the whole team immediately to make sure that comparisons between CRF and NIR data are done by sector experts with the latest data set.

1.2.3.5 QA Activities

The following QA activities are performed:

Validation of methodologies and calculation

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

Annual second party audits for every sector

Once a year the documentation of one emission source per sector is checked throughout the whole emission estimation and reporting process (i.e. archiving of underlying information, emission calculation, input into the data management system, documentation, information in the NIR 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 QA/QC routines.

Second party audits for work performed by service contractors

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

Accreditation audits (third party audits)

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

Input data examination

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

The aim of the examinations is to assess:

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

Resulting areas of improvement are discussed with the data suppliers.

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

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

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

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

1.2.3.6 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. The sources of these findings are:

- UNFCCC Reviews

- Initial checks and comprehensive reviews according to Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action (article 37 para 4 and article 38 para 1 & 2)
- 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 NIR is communicated to every data supplier and Austrian experts involved in emission inventorying after submission)
- personnel of the IBE (head of inspection body, sector experts etc.).

These findings are documented including a plan to improve the inventory, a timeline and responsibilities. The improvement plan and fulfilment of planned improvements is monitored by the head of inspection body. 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 of 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' (BMK).

1.2.3.7 Treatment of confidentiality issues

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

According to the Austrian Environmental Information Act²⁹ §4 (2) emissions data are generally publicly accessible and are explicitly not seen as confidential data, with the possibility to request confidentiality in justified exceptional cases. This is the case for emissions of fluorinated substances for semiconductors, where detailed emissions data could give clues regarding the setting up of industrial processes and therefore emissions are reported at a higher aggregated level.

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

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

- **Confidentiality of statistics**

The strict confidentiality provisions concerning handling of sensitive data relating to individuals and organisations are regulated by the Austrian Federal Statistics Act 2000³⁰. The Environmental Control Act³¹ allows the Umweltbundesamt to request confidential statistical data, this data is then incorporated in the emission inventory. To protect the confidential data, only aggregated results are reported.

²⁹ „Umweltinformationsgesetz“ (UIG) Federal Law Gazette No 495/1993

³⁰ Federal Act on Federal Statistics (Federal Statistics Act 2000) No 163/1999

³¹ „Umweltkontrollgesetz“ (UKG) Federal Law Gazette I No 152/1998

- **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 CRF tables) is obligatory for Umweltbundesamt and consequently also for the Inspection Body.

- **Trust of respondents**

Individuals, associations and organizations providing information to the Inspection Body can be sure that the provided data are used exclusively for purposes of inspection activities.

Data – either of official, private or of another nature – are treated confidentially and will not be passed on to third parties. In the course of inventory reviews, such data and information is exchanged with the review team only if needed for judging the conformity of emission calculation following the strict rules for confidentiality set up by the review process.

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

1.2.3.8 QMS activities and improvements 2023

In the 2023 inventory cycle, several improvements concerning the personnel of the inventory team have been made: The number of sector experts of the agriculture team was raised to three; for LULUCF to five. The new sector experts undergo an initial inventory training, that lasts at least one year and ends, after careful consideration of feedback from the mentors, trainers and the trainee, with the official approval as sector experts. Currently, the IBE team consists of 25 persons and each position is at least double-staffed.

In 2023 four of our experts participated in the UNFCCC inventory review. Furthermore one employee of the Environment Agency Austria was lead reviewer in an BR/NC in-country review. An audit by the accreditation body was successfully passed in June 2023.

1.2.4 Quality assurance/quality control (QA/QC) procedures and extensive review of GHG inventory

QA/QC procedures are performed as defined in the QA/QC plan (see Chapter 1.2.3.3).

As Austria is a small country, many of the experts regarding greenhouse gas inventories have been involved by some means or other e.g. in inventory preparation, in preparation of the uncertainty study, in national or regional task groups etc. The NIR is circulated after publication to all experts that are involved in the estimation of the greenhouse gas emissions in Austria as identified by the Inspection Body. These are in particular:

- experts from federal provinces (some prepare a partly independent emission inventory for their federal province and compare their results with the disaggregated national inventory),
- data supplier, e.g. industrial facilities or association of industries

Any comment received from any expert is considered for the inventory improvement plan.

1.2.5 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 judgements etc. to allow full reproduction and understanding of choices made
- Recalculations
- Planned improvements
- QC activities

Documentation of expert judgements in line with the IPCC 2006 GL:

- 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 NIR.

1.3 Inventory preparation, and data collection, processing and storage

The Austrian greenhouse gas inventory for the period 1990 to 2022 was compiled according to the recommendations for inventories as specified in the UNFCCC reporting guidelines according to Decision 24/CP.19, the Common Reporting Format (CRF), and the IPCC 2006 Guidelines.

In Austria, emissions of greenhouse gases are estimated together with emissions of air pollutants in a single database based on the CORINAIR (COrRe INventory AIR)/SNAP (Selected Nomenclature for sources of Air Pollution) nomenclature. This nomenclature was designed by the ETC/AE (European Topic Centre on Air Emissions) to estimate not only emissions of greenhouse gases but all kind of air pollutants.

During the inventory preparation process, sector experts collect activity data, emission factors and all relevant information needed for finally estimating emissions. The sector experts are also responsible for the choice of methods, data processing and archiving and for service contracting of e.g. studies, if needed. As part of the quality management system the head of the 'Inspection Body for Emission Inventories' approves the methodological choices and the sectoral improvement plans. Sector experts also perform Quality Control (QC) and Quality Assurance (QA) activities regarding their sector. All data collected together with emission estimates are fed into a database (see below), where data sources are well documented for full reproducibility of the inventory.

As mentioned above, the Austrian Inventory is based on the SNAP nomenclature, and has to be transformed according to the IPCC Guidelines into the UNFCCC Common Reporting Format to comply with the reporting obligations under the UNFCCC. In addition to the actual emission data, the background tables of the CRF are filled in by the sector experts, and finally QA/QC procedures as defined in the QA/QC plan are carried out before the data are submitted to the UNFCCC.

For the inventory management a reliable data management to fulfil the data collecting and reporting requirements is needed. As mentioned above, data are collected by the different sector experts and the reporting requirements grow rapidly and may change over time. Data management is carried out by using MS Excel™ spreadsheets in combination with Visual Basic™ macros, which is a very flexible system that can easily be adjusted to new requirements. The data are stored in a central network server which is backed up daily for the needs of data security. The inventory management as part of the QMS includes a control system for all documents and data, for records and their archives as well as documentation on QA/QC activities.

This ensures the necessary documentation and archiving for full reproducibility of the inventory and for the timely response to requests during the review process.

1.4 Brief general description of methodologies (including tiers used) 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 the Federal Ministry of Economy, Family and Youth, „Bundeslastverteiler“ 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 data³².

³² „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.

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

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

Table 6: Main data sources for activity data.

Sector	Data Sources for Activity Data
Energy	• Energy Balance from Statistik Austria • EU-ETS • Steam boiler database • Small scale combustion market data • Direct information from industry or associations of industry
Transport	• Energy Balance from Statistik Austria • Yearly new vehicle registrations from Statistik Austria • Yearly growth rates of transport performance on Austrian roads from Federal Ministry of Climate Action, Environment, Energy, Mobility, In-novation and Technology (BMK) • ZBD: Zentrale Beguchachtungsdatenbank (periodically updated specific mileage) • Yearly flight movements from Austro Control • Yearly FC of airport ground activities at Vienna International Airport
IPPU	• National production statistics • Import/export statistics • EU-ETS • Direct information from industry or associations of industry • Short term statistics for trade and services • Austrian foreign trade statistics • Structural business statistics • Surveys at companies and associations
Agriculture	• National studies • National agricultural statistics obtained from Statistik Austria • National fertilizer statistics obtained from Agrarmarkt Austria (AMA) • Distributing company (sales data)

Sector	Data Sources for Activity Data
LULUCF	• National forest inventory obtained from the Austrian Research Centre for Forests • National agricultural statistics and land use statistics obtained from Statistik Austria and from the IACS system • Wetland and settlement areas from the Real Estate Database
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) • National Studies

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

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

The IBE is responsible for:

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

Service contracts have e.g. entered into with:

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

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

Detailed information on data sources for activity and emission data or emission factors used by sector can be found in the Chapters 3–8.

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 Guidebook are applied.

The main sources for emission factors are:

- National studies for country specific emission factors
- Plant-specific data reported by plant operators

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories³³
- 2019 Refinement to the 2006 IPCC Guidelines³⁴
- EMEP/EEA air pollutant emission inventory guidebooks³⁵
- Handbook emission factors for road transport (HBEFA), Version 4.2 (INFRAS, 2022)
- National forest inventory obtained from the Austrian Research Centre for Forests
- Soil inventories by the Federal States and by the Austrian Federal Office and Research Centre for Forests
- Modelling of the forest soil C stock changes Austrian Research Centre for Forests

For key categories (see Chapter 1.5) the most accurate methods for the preparation of the greenhouse gas inventory should be used. Required methodological changes and planned improvements are described in the corresponding sector analysis chapters (Chapters 3–8).

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 Council³⁶ and amended by several legal acts³⁷. 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, CO₂ 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.

³³ <https://www.ipcc-nggip.iges.or.jp/public/2006gl/?mckid=f48edfa2badf11ec90525bf3c93873fc>

³⁴ The 2019 Refinement does not revise the 2006 IPCC Guidelines, but updates, supplements and/or elaborates the 2006 IPCC Guidelines where gaps or out-of-date science have been identified. It does not replace the 2006 IPCC Guidelines, but should be used in conjunction with the 2006 IPCC Guidelines and, where indicated, with the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement).

³⁵ Prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections (TFEIP) and published by the European Environment Agency (EEA). Latest update: <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023>

³⁶ 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

³⁷ Directive 2004/101/EC, Directive 2008/101/EC, Regulation (EC) No 219/2009, Directive 2009/29/EC, Decision No 1359/2013/EU, Regulation (EU) No 421/2014, Decision (EU) 2015/1814, Regulation (EU) 2017/2392, Directive (EU) 2018/410, Commission Delegated Decision (EU) 2020/1071, Commission Delegated Regulation (EU) 2021/1416 and Decision (EU) 2023/136

Greenhouse gases covered under the EU ETS are CO₂ (since 2005), N₂O (since 2010) and PFC (since 2013).³⁸ About one third of total Austrian GHG emissions currently result from installations under the EU-ETS (~27 Mt CO₂ in 2022).

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

General rules for reporting and verification of emissions in the EU ETS are defined in EU Directive 2003/87/EC and specific rules can be found in Commission Regulation (EU) No 2018/2066³⁹. In Austria, Member State specific regulations are defined in the Austrian Emissions Allowance Trading Act⁴⁰. This ordinance also specifies that the Umweltbundesamt has to incorporate, as far as necessary, the verified emissions of the emissions trading scheme into the national greenhouse gas inventory. For a detailed description of the sectors covered and the incorporation of these emissions into the national inventory please refer to the chapters 3 Energy (CRF Sector 1) and 4 Industrial Processes and Product Use (CRF Sector 2).

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

1.4.2 Electronic Data Management (EDM)

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

³⁸ Austria unilaterally opted-in N₂O as of 2010. Since 2013 N₂O and PFCs have been included in the EU ETS at EU level.

³⁹ Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 601/2012, amended by Commission Implementing Regulation (EU) 2020/2085, Commission Implementing Regulation (EU) 2022/388 and Commission Implementing Regulation (EU) 2022/1371

⁴⁰ Emissionszertifikatesgesetz 2011, Federal Law Gazette I No. 118/2011, as amended

1.4.3 Other data (E-PRTR)

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

E-PRTR was preceded by the European Pollutant Emission Register (EPER), with reporting years 2001 or 2002 and 2004. It covers 91 pollutants from nine activity groups, including all pollutants reported already under EPER. However, emissions only have to be reported if they exceed certain thresholds. In contrast to EPER, E-PRTR also includes data on releases to land, accidental releases, waste transfers and diffuse emissions⁴¹.

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 EPRTR 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.

1.5 Brief description of key categories

The identification of key categories is described in the IPCC 2006 GL (Volume 1, Chapter 4). It stipulates that a key category is one that is prioritised within the National System because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions or removals, the trend in emissions or removals, or both.

⁴¹ Data can be downloaded from: <https://www.umweltbundesamt.at/umweltthemen/industrie/daten-industrie/prtr>

All notations, descriptions of identification and results for key categories included in this chapter are based on the IPCC 2006 GL. The identification includes all reported greenhouse gases CO₂, CH₄, N₂O, HFC, PFC, SF₆ and NF₃, and all IPCC categories.

The presented key category analysis was performed by the Umweltbundesamt with data for greenhouse gas emissions of the submission 2022 and comprises a level assessment for the years 1990 and 2022 and a trend assessment for the trend of the year 2022 with respect to the 1990 emissions. As also described in the IPCC 2006 GL categories were first identified for the inventory excluding LULUCF and then the key category analysis was repeated for the full inventory including LULUCF categories.

The key category analysis presented here follows approach 1 and 2 of the guidelines and is carried out at a more detailed level in comparison to the KCA of the CRF Reporter. Therefore the key categories described in the Austrian NIR differ slightly from the ones in the corresponding CRF table 7.

The detailed methodology for identifying the key categories is described in detail in Annex 1.

The key categories without LULUCF (determined by Approach 1 and Approach 2) comprise 70 901 kt CO₂e in the year 2022, which corresponds to 97.3% of Austria's total greenhouse gas emissions (without LULUCF). The key categories including LULUCF amounted to 66 357 kt CO₂e (97.1%) in 2022. The following tables present the results of the KCA approach 1 and approach 2 including LULUCF and excluding LULUCF by indicating the ranking of the different subcategories as well as emissions/removal data.

Table 7: Key categories excluding LULUCF.

			Approach 1			Approach 2					
IPCC Category Code	IPCC Category	GHG	LA 1990	LA 2022	TA 1990–2022	LA 1990	LA 2022	TA 1990–2022	1990	2022	Share 2022
1 A 1 a gaseous	Public Electricity and Heat Production	CO ₂	8	3	7	7	3		3 294	4 500	6,2%
1 A 1 a liquid	Public Electricity and Heat Production	CO ₂	15	37	11				1 229	236	0,3%
1 A 1 a other	Public Electricity and Heat Production	CO ₂	44	16	13	20	13	6	286	1 028	1,4%
1 A 1 a solid	Public Electricity and Heat Production	CO ₂	3						6 247	NO	-
1 A 1 a biomass	Public Electricity and Heat Production	N ₂ O						23	3	67	0,1%
1 A 1 b gaseous	Petroleum refining	CO ₂	36	33	44				437	300	0,4%
1 A 1 b liquid	Petroleum refining	CO ₂	11	8	38				1 958	1 955	2,7%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO ₂	31	29	42				506	344	0,5%
1 A 2 a gaseous	Iron and Steel	CO ₂	24	15	20		12	33	650	1 049	1,4%
1 A 2 a solid	Iron and Steel	CO ₂	17	19	37				1 107	843	1,2%
1 A 2 b gaseous	Non-ferrous Metals	CO ₂		36	30				75	279	0,4%
1 A 2 c gaseous	Chemicals	CO ₂	28	17	17		14	29	519	991	1,4%
1 A 2 c other	Chemicals	CO ₂		31	33		18	20	125	308	0,4%
1 A 2 d gaseous	Pulp, Paper and Print	CO ₂	20	12	18	13	9	31	943	1 372	1,9%
1 A 2 d liquid	Pulp, Paper and Print	CO ₂	21		14				853	24	0,0%
1 A 2 d solid	Pulp, Paper and Print	CO ₂	37		28				398	130	0,2%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO ₂	30	21	23			40	507	776	1,1%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO ₂	41		27				345	73	0,1%

			Approach 1			Approach 2					
IPCC Category Code	IPCC Category	GHG	LA 1990	LA 2022	TA 1990–2022	LA 1990	LA 2022	TA 1990–2022	1990	2022	Share 2022
1 A 2 f gaseous	Other	CO ₂	26	25	48				559	593	0,8%
1 A 2 f liquid	Other	CO ₂	29		24				508	160	0,2%
1 A 2 f other	Other	CO ₂		24	16		16	9	67	616	0,8%
1 A 2 f solid	Other	CO ₂	27	39	26				535	209	0,3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO ₂	46	11	10				256	1 453	2,0%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO ₂	19	14	22	12	11	38	1 014	1 272	1,7%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO ₂	25		19				610	107	0,1%
1 A 2 g 8 solid	Other Manufacturing Industries	CO ₂			46				91	2	0,0%
1 A 3 b diesel oil	Road Transportation	CO ₂	5	1	1	4	1	3	5 358	15 639	21,5%
1 A 3 b diesel oil	Road Transportation	N ₂ O		41	36		23	15	11	190	0,3%
1 A 3 b gasoline	Road Transportation	CO ₂	1	4	4	1	4	5	7 896	4 389	6,0%
1 A 3 b gasoline	Road Transportation	CH ₄						36	77	7	0,0%
1 A 3 b gasoline	Road Transportation	N ₂ O				28		17	83	6	0,0%
1 A 3 e gaseous	Other	CO ₂	48						224	152	0,2%
1 A 4 a gaseous	Commercial/Institutional	CO ₂	23	22					698	718	1,0%
1 A 4 a liquid	Commercial/Institutional	CO ₂	14	27	12				1 420	495	0,7%
1 A 4 b biomass	Residential	CH ₄	45	40		21	22	34	264	200	0,3%
1 A 4 b gaseous	Residential	CO ₂	12	6	9	9	6	13	1 856	3 032	4,2%
1 A 4 b liquid	Residential	CO ₂	4	7	5	3		28	5 633	2 791	3,8%
1 A 4 b solid	Residential	CO ₂	9		6			30	2 511	34	0,0%
1 A 4 b solid	Residential	CH ₄	49		32	22		8	224	3	0,0%
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO ₂	16	20	25				1 180	800	1,1%
1 A 4 c liquid	Agriculture/Forestry/Fishing	N ₂ O						39	68	30	0,0%
1 B 1 a	Coal Mining and Handling	CH ₄	38			16			373	NA	-
1 B 2 b	Natural Gas	CH ₄	43	38					290	225	0,3%
2 A 1	Cement Production	CO ₂	10	9		8	7		2 033	1 832	2,5%
2 A 2	Lime Production	CO ₂	35	23	31	15			456	624	0,9%
2 A 4 c	Non-metallurgical Magnesium	CO ₂	32	30	41				481	317	0,4%
2 B 1	Ammonia Production	CO ₂	34	28					467	418	0,6%
2 B 2	Nitric Acid Production	N ₂ O	22		15			35	780	23	0,0%
2 C 1	Iron and Steel Production	CO ₂	2	2	2	2	2	26	6 840	10 280	14,1%
2 C 3	Aluminium Production	PFC	18			11			1 032	0	0,0%
2 C 3	Aluminium Production	CO ₂			40			27	150	5	0,0%
2 C 4	SF ₆ used in Mg Foundries	SF ₆	47		29				235	2	0,0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO ₂	40	42	39	18	24	16	349	172	0,2%
2 E	Electronics Industry	SF ₆			47				100	13	0,0%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		13	8		10	2	0	1 355	1,9%
2 G 1	Other product manufacture and use - Electrical Equipment	SF ₆					30	18	11	49	0,1%
2 G 2	Other product manufacture and use - SF ₆ and PFCs from other product use	SF ₆		32	34	24	19	7	124	301	0,4%
3 A 1	Cattle	CH ₄	6	5	21	5	5	10	4 854	4 035	5,5%
3 A 4	Other (please specify)	CH ₄						32	44	95	0,1%
3 B 1 1	Cattle	CH ₄	33	26	45	14	17	37	467	522	0,7%
3 B 1 1	Cattle	N ₂ O	42	35		19	21		294	281	0,4%
3 B 1 3	Swine	N ₂ O				26	29	19	99	53	0,1%
3 B 2 5	Indirect N ₂ O Emissions	N ₂ O				25	26	22	103	111	0,2%
3 D 1	Direct N ₂ O Emissions from Managed Soils	N ₂ O	13	10	35	10	8	4	1 776	1 455	2,0%
3 D 2	Indirect N ₂ O emissions from Managed Soils	N ₂ O	39	34		17	20	11	357	288	0,4%

			Approach 1			Approach 2					
IPCC Category Code	IPCC Category	GHG	LA 1990	LA 2022	TA 1990–2022	LA 1990	LA 2022	TA 1990–2022	1990	2022	Share 2022
3 G	Liming	CO ₂					27	25	46	99	0,1%
5 A	Solid Waste Disposal	CH ₄	7	18	3	6	15	1	4 081	846	1,2%
5 B	Biological Treatment of Solid Waste	CH ₄					28	21	15	77	0,1%
5 B	Biological Treatment of Solid Waste	N ₂ O						24	20	72	0,1%
5 D	Waste Water Treatment and Discharge	N ₂ O				27	25	12	86	152	0,2%
5 D	Waste Water Treatment and Discharge	CH ₄			43	23		14	137	24	0,0%
									76 723	70 901	97,3%

Table 8: Key categories including LULUCF.

			Approach 1			Approach 2					
IPCC Category Code	IPCC Category	GHG	LA 1990	LA 2022	TA 1990–2022	LA 1990	LA 2022	TA 1990–2022	1990	2022	Share 2022
1 A 1 a gaseous	Public Electricity and Heat Production	CO ₂	9	3	6				3 294	4 500	5,5%
1 A 1 a liquid	Public Electricity and Heat Production	CO ₂	18	40	14				1 229	236	0,3%
1 A 1 a other	Public Electricity and Heat Production	CO ₂	51	16	13		13	10	286	1 028	1,3%
1 A 1 a solid	Public Electricity and Heat Production	CO ₂	4						6 247	NO	0,0%
1 A 1 a biomass	Public Electricity and Heat Production	N ₂ O						31	3	67	0,1%
1 A 1 b gaseous	Petroleum refining	CO ₂	41	36					437	300	0,4%
1 A 1 b liquid	Petroleum refining	CO ₂	14	8	23				1 958	1 955	2,4%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO ₂	35	31					506	344	0,4%
1 A 2 a gaseous	Iron and Steel	CO ₂	28	15	21			37	650	1 049	1,3%
1 A 2 a solid	Iron and Steel	CO ₂	20	19					1 107	843	1,0%
1 A 2 b gaseous	Non-ferrous Metals	CO ₂		39	30				75	279	0,3%
1 A 2 c gaseous	Chemicals	CO ₂	32	17	19			36	519	991	1,2%
1 A 2 c other	Chemicals	CO ₂		33	32			26	125	308	0,4%
1 A 2 d gaseous	Pulp, Paper and Print	CO ₂	23	12	17		10	33	943	1 372	1,7%
1 A 2 d liquid	Pulp, Paper and Print	CO ₂	25		15				853	24	0,0%
1 A 2 d solid	Pulp, Paper and Print	CO ₂	42		36				398	130	0,2%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO ₂	34	21	25				507	776	0,9%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO ₂	47		34				345	73	0,1%
1 A 2 f gaseous	Other	CO ₂	30	26	43				559	593	0,7%
1 A 2 f liquid	Other	CO ₂	33		28				508	160	0,2%
1 A 2 f other	Other	CO ₂		25	20		16	12	67	616	0,8%
1 A 2 f solid	Other	CO ₂	31	43	31				535	209	0,3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO ₂	53	11	11				256	1 453	1,8%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO ₂	22	14	22		12		1 014	1 272	1,6%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO ₂	29		24				610	107	0,1%
1 A 3 b diesel oil	Road Transportation	CO ₂	6	1	1	4	1	5	5 358	15 639	19,1%
1 A 3 b diesel oil	Road Transportation	N ₂ O		45	38			19	11	190	0,2%
1 A 3 b gasoline	Road Transportation	CO ₂	2	4	7	2	3	16	7 896	4 389	5,4%
1 A 3 b gasoline	Road Transportation	N ₂ O						22	83	6	0,0%

			Approach 1			Approach 2					
IPCC Category Code	IPCC Category	GHG	LA 1990	LA 2022	TA 1990–2022	LA 1990	LA 2022	TA 1990–2022	1990	2022	Share 2022
1 A 4 a gaseous	Commercial/Institutional	CO ₂	27	23	41				698	718	0,9%
1 A 4 a liquid	Commercial/Institutional	CO ₂	17	29	16				1 420	495	0,6%
1 A 4 b biomass	Residential	CH ₄	52	44		21	24		264	200	0,2%
1 A 4 b gaseous	Residential	CO ₂	15	6	9		6	17	1 856	3 032	3,7%
1 A 4 b liquid	Residential	CO ₂	5	7	8				5 633	2 791	3,4%
1 A 4 b solid	Residential	CO ₂	12		5				2 511	34	0,0%
1 A 4 b solid	Residential	CH ₄			39	22		14	224	3	0,0%
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO ₂	19	20	44				1 180	800	1,0%
1 B 1 a	Coal Mining and Handling	CH ₄	44			16			373	NA	0,0%
1 B 2 b	Natural Gas	CH ₄	50	42					290	225	0,3%
2 A 1	Cement Production	CO ₂	13	9	29	9			2 033	1 832	2,2%
2 A 2	Lime Production	CO ₂	40	24	27				456	624	0,8%
2 A 4 c	Non-metallurgical Magnesium	CO ₂	37	32					481	317	0,4%
2 B 1	Ammonia Production	CO ₂	39	30					467	418	0,5%
2 B 2	Nitric Acid Production	N ₂ O	26		18				780	23	0,0%
2 C 1	Iron and Steel Production	CO ₂	3	2	2	3	2	30	6 840	10 280	12,6%
2 C 3	Aluminium Production	PFC	21			11			1 032	0	0,0%
2 C 3	Aluminium Production	CO ₂			46				150	5	0,0%
2 C 4	SF ₆ used in Mg Foundries	SF ₆	54		37				235	2	0,0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO ₂	46	46	47	18	25	27	349	172	0,2%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		13	10		11	3	0	1 355	1,7%
2 G 1	Other product manufacture and use - Electrical Equipment	SF ₆						23	11	49	0,1%
2 G 2	Other product manufacture and use - SF ₆ and PFCs from other product use	SF ₆		35	33		20	11	124	301	0,4%
3 A 1	Cattle	CH ₄	7	5	35	5	4	25	4 854	4 035	4,9%
3 B 1 1	Cattle	CH ₄	38	27	42	14	17	34	467	522	0,6%
3 B 1 1	Cattle	N ₂ O	49	38		20	22	20	294	281	0,3%
3 B 1 3	Swine	N ₂ O				26			99	53	0,1%
3 B 2 5	Indirect N ₂ O Emissions	N ₂ O				25	29	18	103	111	0,1%
3 D 1	Direct N ₂ O Emissions from Managed Soils	N ₂ O	16	10		10	8	13	1 776	1 455	1,8%
3 D 2	Indirect N ₂ O emissions from Managed Soils	N ₂ O	45	37		17	21		357	288	0,4%
3 G	Liming	CO ₂						32	46	99	0,1%
4	Total land use categories	N ₂ O				24	28		143	127	0,2%
4	Total land use categories	CH ₄					30		27	27	0,0%
4A1	Forest land remaining forest land	CO ₂	1	49	3	1	5	1	-8 122	-3 192	3,9%
4A2	Land converted to forest land	CO ₂	11	47	12	8	9	2	-2 955	-1 420	1,7%
4B1	Cropland remaining cropland	CO ₂						24	-18	84	0,1%
4B2	Land converted to cropland	CO ₂		41	50	23	23	28	202	233	0,3%
4C1	Grassland remaining grassland	CO ₂	48	34		19	19	9	304	304	0,4%
4C2	Land converted to grassland	CO ₂	43		40	15	27	6	393	140	0,2%
4E2	Land converted to Settlements	CO ₂	24	22		12	15		917	746	0,9%
4F2	Land converted to Other land	CO ₂	36	28	45	13	18	8	502	517	0,6%
4G	HWP	CO ₂	10	48	26	7	7	7	-3 122	-2 110	2,6%
5 A	Solid Waste Disposal	CH ₄	8	18	4	6	14	4	4 081	846	1,0%
5 B	Biological Treatment of Solid Waste	CH ₄						29	15	77	0,1%
5 B	Biological Treatment of Solid Waste	N ₂ O						35	20	72	0,1%

			Approach 1			Approach 2					
IPCC Category Code	IPCC Category	GHG	LA 1990	LA 2022	TA 1990–2022	LA 1990	LA 2022	TA 1990–2022	1990	2022	Share 2022
5 D	Waste Water Treatment and Discharge	N ₂ O			48		26	15	86	152	0,2%
5 D	Waste Water Treatment and Discharge	CH ₄			49			21	137	24	0,0%
									64 147	65 809	96,3%

The key category with the highest contribution to the national total emissions excl. LULUCF in 2022 is *1.A.3.b Road Transportation – diesel oil (CO₂)* 21.5% in 2022 (share of 6.8% in 1990). This strong increase is mainly due to the increase of road performance. This category is also the most important category in terms of emission trends: Since 1990 emissions increased by 192%. The second most important source of greenhouse gas emissions in Austria is *2.C.1 Iron and Steel Production*, with a contribution to national total emissions of 14.1% in 2022. The key category with the highest contribution to national removals is *4.A.1 Forest land remaining forest land (CO₂)*.

Comparison Approach 1 – Approach 2 KCA

The following categories have been identified as key additionally to the Approach 1 analysis:

Table 9: comparison results Approach 1 – Approach 2 KCA.

IPCC Category Code	IPCC Category	Greenhouse Gas
1 A 1 a biomass	Public Electricity and Heat Production	N ₂ O
1 A 3 b gasoline	Road Transportation	CH ₄
1 A 3 b gasoline	Road Transportation	N ₂ O
1 A 4 c liquid	Agriculture/Forestry/Fishing	N ₂ O
2.G.1	Other product manufacture and use - Electrical Equipment	SF ₆
3.A.4	Other (please specify)	CH ₄
3.B.1.3	Swine	N ₂ O
3.B.2.5	Indirect N ₂ O Emissions	N ₂ O
3.G	Liming	CO ₂
4	Total land use categories	N ₂ O
4	Total land use categories	CH ₄
4.B.1	Cropland remaining cropland	CO ₂
5.B	Biological Treatment of Solid Waste	CH ₄
5.B	Biological Treatment of Solid Waste	N ₂ O

1.6 General assessment of completeness

CRF Table 9 (Completeness) as well as the sections of completeness in the sectoral chapters include detailed information on the completeness of the Austrian GHG Inventory. An overview is provided in this chapter.

Sources and sinks

All sources and sinks included in the IPCC 2006 Guidelines are addressed.

Gases

Both direct GHGs as well as precursor gases are covered by the Austrian inventory.

Geographic coverage

The geographic coverage is complete. There is no part of the Austrian territory not covered by the inventory.

Notation keys

The sources and sinks not considered in the inventory but included in the IPCC 2006 Guidelines are clearly indicated, the reasons for such exclusion are explained. In addition, the notation keys presented below are used to fill in the blanks in all the tables in the CRF. Notation keys used in the NIR are consistent with those reported in the CRF. Notation keys are used according to the UNFCCC reporting guidelines (FCCC/CP/2013/10).

Allocations to categories may differ from Party to Party. The main reasons for different category allocations are different allocations in national statistics, insufficient information on the national statistics, national methods, and the impossibility to disaggregate emission declarations.

IE (*included elsewhere*):

'IE' is used for emissions by sources and removals by sinks of greenhouse gases that have been estimated but included elsewhere in the inventory instead of the expected source/sink category. Where 'IE' is used in the inventory, the CRF completeness table (Table 9) indicates where (in the inventory) these emissions or removals have been included. Such deviation from the expected category is explained.

NE (*not estimated*):

'NE' is used for existing emissions by sources and removals by sinks of greenhouse gases which have not been estimated. Where 'NE' is used in an inventory for emissions or removals, both the NIR and the CRF completeness table indicate why emissions or removals have not been estimated. For emissions by sources and removals by sinks of greenhouse gases marked by 'NE' check-ups are in progress to establish if they actually are 'NO' (not occurring). As part of the improvement programme of the inventory, it is planned that these source or sink categories are either estimated or reported as 'NO'.

NA (*not applicable*):

'NA' is used for activities in a given source/sink category that do not produce emissions or lead to removals of a specific gas.

C (*confidential*):

'C' is used for emissions which could lead to the disclosure of confidential information if reported at the most disaggregated level. In this case a minimum of aggregation is required to protect business information.

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

$$\text{Transparency [\%]} = [1 - (\text{number of IE} / \text{number of entries})] * 100$$

$$\text{Completeness [\%]} = [1 - (\text{number of NE} / \text{number of entries})] * 100$$

The total number of entries cover data records (emission/removal data) as well as notation keys ('IE', 'NE', 'NO', 'NA'). Then the respective shares of 'NE' and 'IE' in the total number of entries are determined.

The following Table 10 shows the results of this years' evaluation of transparency and completeness. The notation key 'IE' is applied in most sectors, in particular in the sector Energy. Explanations are provided in the respective sectoral chapters on 'Completeness' as well as in CRF Table 9. The 'NE' reported in the LULUCF sector are related to the categories 4.D.1.2 (flooded land remaining flooded land) and 4.D.1.3 (other wetlands remaining other wetlands). However, the number of 'NE' in this sector decreased clearly compared to historical submissions due to improved reporting for 4.A.1 Forest land remaining forest land – forest not in yield beginning with submission 2023.

Table 10: Transparency and completeness in UNFCCC submission 2024.

Sector	Submission 2024			
	IE	NE	Transparency	Completeness
1 Energy	47	0	93%	100%
2 IPPU	5	0	99%	100%
3 Agriculture	0	0	100%	100%
4 LULUCF	8	10	98%	97%
5 Waste	2	0	97%	100%
Total	62	10	96%	99%
Total number of estimates*	1 581			

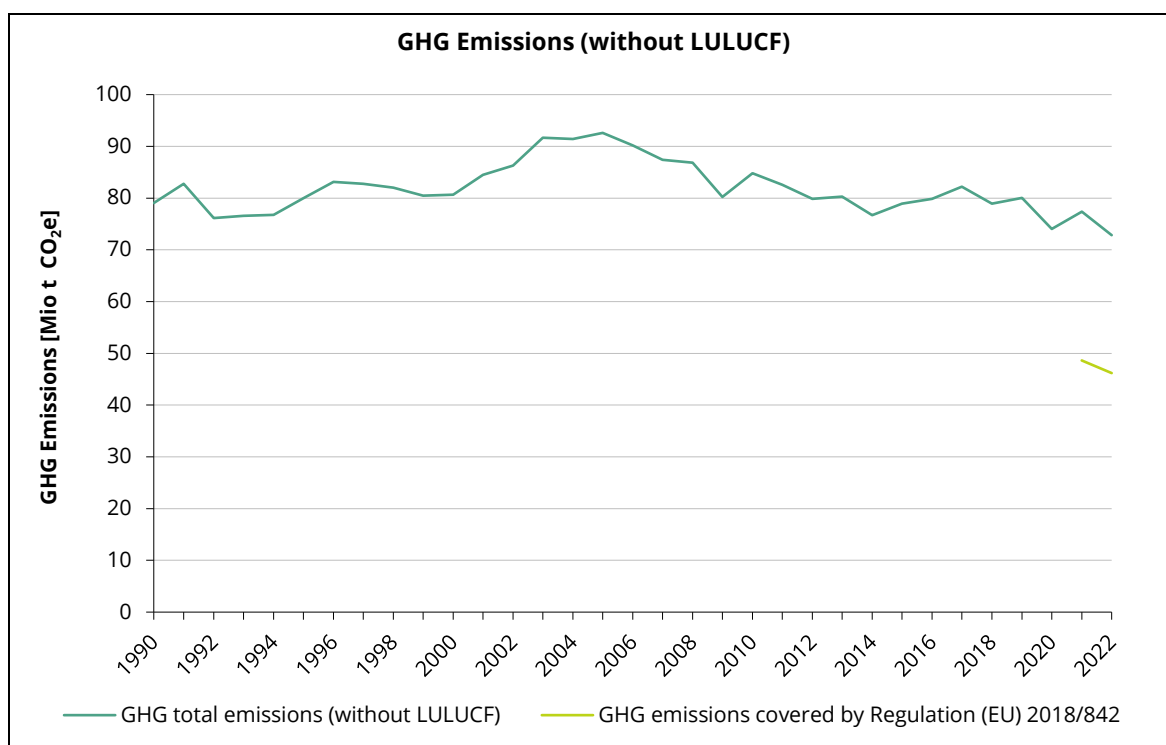
* including IE and NE, but also NO and NA

2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Description and interpretation of emission trends for aggregated greenhouse gas emissions

In 2022 Austria's total greenhouse gas (GHG) emissions (without Land Use, Land Use Change and Forestry – LULUCF) amounted to 72.8 Mt CO₂ equivalents (CO₂e). Compared to the 1990 base year⁴², 2022 GHG emissions without LULUCF decreased by 7.9%. Compared to 2021 GHG emissions decreased by 5.8%.

Figure 3: Trend in GHG emissions 1990–2022 without LULUCF.



Greenhouse gas emissions covered by Regulation (EU) No. 2018/842 ('Effort Sharing Regulation') amounted to 46 188 123 t CO₂ equivalents in 2022, and were thus below the level of the annual emission allocation (AEA) for that year.

⁴² Austria's base year under the UNFCCC is 1990. Under the EU Effort Sharing, the base year is 2005 (relates only to emissions not included in the EU Emissions Trading Scheme). Unless otherwise specified, references to the base year in this report refer always to 1990.

Table 11: GHG Emissions (covered by the ESR) and status of ESR-target achievement

t CO ₂ -Äquivalent (AR5)	2021	2022
Total GHG emissions without LULUCF	77 359 765	72 844 017
Total verified emissions from stationary installations under Directive 2003/87/EC ²	28 703 349	26 626 258
Total ESR emissions ⁴³	48 632 496*	46 188 123*
Annual Emission Allocations (AEA) pursuant to Article 4(3) of Regulation (EU) 2018/842 ⁴⁴	48 768 448	47 402 495
Difference between AEA and reported total ESR emissions	+135 952	+1 214 372

* Defined as: Total greenhouse gas emissions without LULUCF minus total verified emissions from stationary installations under Directive 2003/87/EC ("ETS emissions") minus CO₂ emissions from 1.A.3.a civil aviation.

Table 11 shows that Austria's ESR emissions in 2022 are around 1.2 million t CO₂ equivalents below the level of the annual emission allocation (AEA) for that year.

Trend 2021–2022

The largest decreases in emissions between 2021 and 2022 took place in the sectors *Energy (CRF 1)* (–3 453 kt CO₂e; –6.7%) and *Industrial Processes and Other Product Use (CRF 2)* (–962 kt CO₂e; –5.7%).

The main reasons for the emissions decrease in sector *Energy (CRF 1)* were the lower natural gas and gasoil consumption in category 1.A.4 *Other Sectors* as well as the lower diesel sales (category 1.A.3 *Transport*), especially in fuel exports with heavy duty vehicles.

The emissions decrease in *Industrial Processes and Other Product Use (CRF 2)* was mainly due to a decrease in production, such as iron and steel production, as well as ammonia production. The main driver for this reduction was increased energy costs that were affected by the geopolitical situation.

Net removals from *LULUCF (CRF 4)* show a decrease of 60% (–6 602 kt CO₂e) from 2021 to 2022, mainly caused by a decreased sink in the soil pool of 4.A.1 *Forest land remaining forest land*. However it should be noted, that large annual variations (both positive and negative) in the GHG balance of *Forest land remaining forest land* (and the *LULUCF* sector) occur over the entire 1990–2022 time series.⁴⁵

Emissions from *Agriculture (CRF 3)* decreased slightly by 0.6% (–45 kt CO₂e) from 2021 to 2022, mainly due to falling emissions from mineral fertilizer application, caused by high prices.

The declining emission trend of recent decades continues for the sector *Waste (CRF 5)* with a further decline by 4.6% (–56 kt CO₂e) 2021–2022 mainly due to the decreasing carbon content of waste deposited in preceding years.

⁴³ GHG emissions covered by Regulation (EU) 2018/842

⁴⁴ as included in Annex II of COMMISSION IMPLEMENTING DECISION (EU) 2020/2126 of 16 December 2020 on setting out the annual emission allocations of the Member States for the period from 2021 to 2030 pursuant to Regulation (EU) 2018/842 of the European Parliament and of the Council

⁴⁵ Furthermore, the results of the soil pool of 4.A.1 in 2022 represent an interim extrapolation of the average of the model simulations for the years 2009–2019 until new model results will be available.

The most important gas in the Austrian GHG balance remains carbon dioxide (CO₂) with a share of 84% in total 2022 emissions (without LULUCF). Emissions of CO₂ primarily result from combustion activities. Methane (CH₄), which mainly arises from livestock farming and waste disposal, contributes 8.9% to total national GHG emissions. Nitrous oxide (N₂O), with agricultural soils as the main source, contributes another 4.2% in 2022. The remaining 2.5% are emissions of fluorinated compounds, which are mostly emitted from the use of these gases as substitutes for ozone depleting substances (ODS) in refrigeration equipment.

Table 12: Austria's anthropogenic greenhouse gas emissions (without LULUCF) by gas

GHG emissions	CO ₂	CH ₄	N ₂ O	HFCs	PFCs	SF ₆	NF ₃	Total
CO ₂ equivalents (kt)								
1990	62 184	11 321	4 028	2.0	1 063	485	NO, NA	79 083
1995	64 061	10 515	3 871	324	75	1 134	6.0	79 986
2000	66 177	9 218	3 885	678	80	592	9.8	80 640
2005	79 092	8 519	3 200	1 109	150	509	26	92 605
2010	72 008	7 917	3 014	1 434	71	346	3.9	84 793
2011	69 901	7 684	3 108	1 527	66	317	3.8	82 607
2012	67 274	7 551	3 082	1 607	46	321	8.0	79 889
2013	67 767	7 431	3 066	1 678	45	315	9.1	80 310
2014	64 166	7 274	3 148	1 752	48	324	9.9	76 721
2015	66 357	7 188	3 163	1 850	45	319	13	78 935
2016	67 217	7 110	3 251	1 828	46	405	5.7	79 863
2017	69 598	7 081	3 196	1 857	40	412	11	82 195
2018	66 562	6 853	3 156	1 890	29	398	15	78 903
2019	67 946	6 711	3 149	1 755	35	450	13	80 058
2020	62 176	6 607	3 105	1 650	27	455	11	74 030
2021	65 757	6 622	3 143	1 431	23	371	12	77 360
2022	61 489	6 498	3 040	1 411	26	365	14	72 844

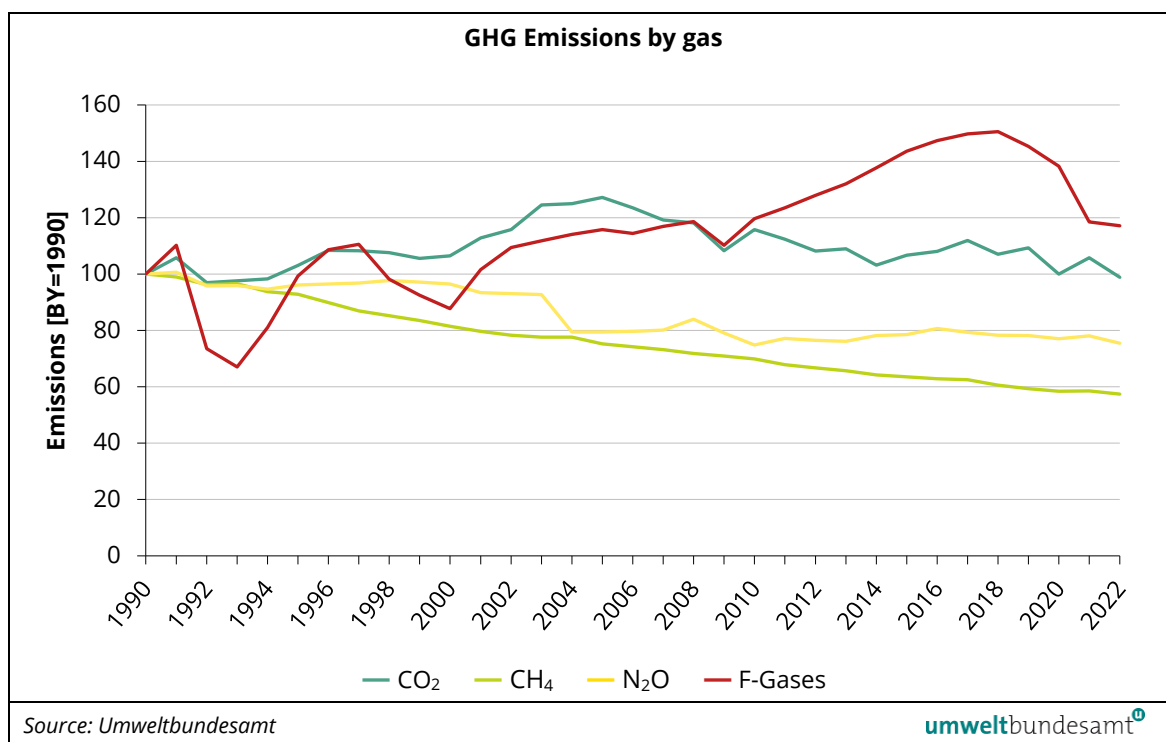
Note: Global warming potentials (GWPs) according to the 5th Assessment Report (Ipcc 2013) (100 years time horizon): carbon dioxide (CO₂) = 1; methane (CH₄) = 28; nitrous oxide (N₂O) = 265; sulphur hexafluoride (SF₆) = 23 500; nitrogen trifluoride (NF₃) = 16 100; hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) consist of different substances, therefore GWPs have to be calculated individually depending on the substances

Table 13: Austria's greenhouse gas emissions by gas 1990 and 2022

GHG	1990	2022	Trend	1990	2022
	CO ₂ equivalent [kt]		1990–2022	Share in national total [%]	
Total	79 083	72 844	-7.9%	100%	100%
CO ₂	62 184	61 489	-1.1%	79%	84%
CH ₄	11 321	6 498	-43%	14%	8.9%
N ₂ O	4 028	3 040	-25%	5.1%	4.2%
F-gases	1 550	1 816	17%	2.0%	2.5%

Emissions without LULUCF

Figure 4: Trend in greenhouse gas emissions 1990–2022 by gas in index form (1990 = 100).



CO₂

The main source of CO₂ emissions in Austria is fossil fuel combustion; within the fuel combustion sector transport is the most important sub-source.

CO₂ emissions in 2022 were 1.1% below the level 1990. In absolute figures, CO₂ emissions decreased from 62 184 to 61 489 kt during the period from 1990 to 2022 mainly due to lower CO₂ emissions from the stationary combustion in other sectors, in particular the residential sector, as well as lower emissions from the public electricity and heat production.

CH₄

The main sources of CH₄ emissions in Austria are agriculture (enteric fermentation) and solid waste disposal on land (landfills).

CH₄ emissions decreased steadily during the period from 1990 to 2021 from 11 321 to 6 498 kt CO₂ equivalents. In 2022, CH₄ emissions were 43% below the level of 1990, mainly due to lower emissions from solid waste disposal sites.

N₂O

The main source of N₂O emissions is sector Agriculture with a share of 73% (2022) in national total N₂O emissions. Agricultural soils contribute most to national N₂O emissions (57% in 2022). Other important sources of N₂O emissions are fuel combustion (18%) and manure management (15%).

N₂O emissions show a decreasing trend, resulting in 3 040 kt CO₂ equivalents in 2022 compared to 4 028 kt CO₂ equivalents in 1990 (–25%). The general decrease is mainly due to lower N₂O emissions from agricultural soils and chemical industry; the strong decrease 2003–2004 was also due to emission reduction measures in the chemical industry.

HFCs

HFC emissions increased remarkably during the period from 1990 to 2022 from 2.0 to 1 411 kt CO₂ equivalents. HFCs are used as substitutes for HCFCs (Hydro Chloro Fluoro Carbons; these are ozone depleting substances), the use of which has been banned for most applications.

PFCs

PFC emissions show an inverse trend of HFC emissions. PFC emissions decreased remarkably during the period from 1990 to 2022, from 1 063 to 26 kt CO₂ equivalents (–98%). In 1990 PFCs were mainly emitted as by-products of primary aluminium production, which closed down in Austria in 1992; Semiconductor manufacture is the main source of PFC emissions.

SF₆

SF₆ emissions in 1990 amounted to 485 kt CO₂ equivalents. Until 1996 emissions increased steadily as a result of increasing emissions from metal production and semiconductor manufacture reaching 1 213 kt CO₂ equivalents. In 2022 SF₆ emissions amounted to 365 kt CO₂ equivalents, which was 25% below the level of 1990. Current emissions mainly result from disposal of noise insulating windows.

NF₃

In 1990 no NF₃ was emitted in Austria. NF₃ emissions solely arise from semiconductor manufacture; NF₃ has been in use in Austria since 1994. In 2022, NF₃ emissions amounted to 14 kt CO₂ equivalents.

2.2 Description and interpretation of emission trends by sector

Table 14 presents a summary of Austria's anthropogenic greenhouse gas emissions by sector.

Table 14: Summary of Austria's anthropogenic greenhouse gas emissions by sector.

GHG source and sink categories	1. Energy	2. IPPU	3. Agriculture	4. LULUCF	5. Waste	6. Other
	CO ₂ equivalents (kt)					
1990	52 666	13 633	8 416	-11 682	4 367	NO*
1995	54 161	13 625	8 145	-19 334	4 055	NO
2000	55 290	14 417	7 657	-13 958	3 277	NO
2005	66 714	15 653	7 196	-18 099	3 041	NO
2010	59 279	15 938	7 287	-19 439	2 289	NO
2011	56 970	16 130	7 363	-15 035	2 143	NO
2012	54 829	15 732	7 312	-5 443	2 016	NO
2013	55 004	16 122	7 311	-5 911	1 873	NO
2014	51 279	16 248	7 447	-7 286	1 747	NO
2015	53 062	16 750	7 479	-6 234	1 644	NO
2016	54 285	16 437	7 595	-6 667	1 546	NO
2017	55 999	17 191	7 549	-2 930	1 457	NO

GHG source and sink categories	1. Energy	2. IPPU	3. Agriculture	4. LULUCF	5. Waste	6. Other
CO ₂ equivalents (kt)						
2018	54 553	15 535	7 435	5 222	1 381	NO
2019	54 935	16 470	7 324	2 437	1 329	NO
2020	49 994	15 461	7 297	-5 843	1 278	NO
2021	51 916	16 892	7 322	-11 076	1 230	NO
2022	48 464	15 929	7 277	-4 474	1 174	NO

*not occurring

The dominant sector regarding GHG emissions in Austria is *Energy*, causing 67% of the total national GHG emissions in 2022 (67% in 1990), followed by the sectors *Industrial Processes and Other Product Use* (22% in 2022) and *Agriculture* (10% in 2022).

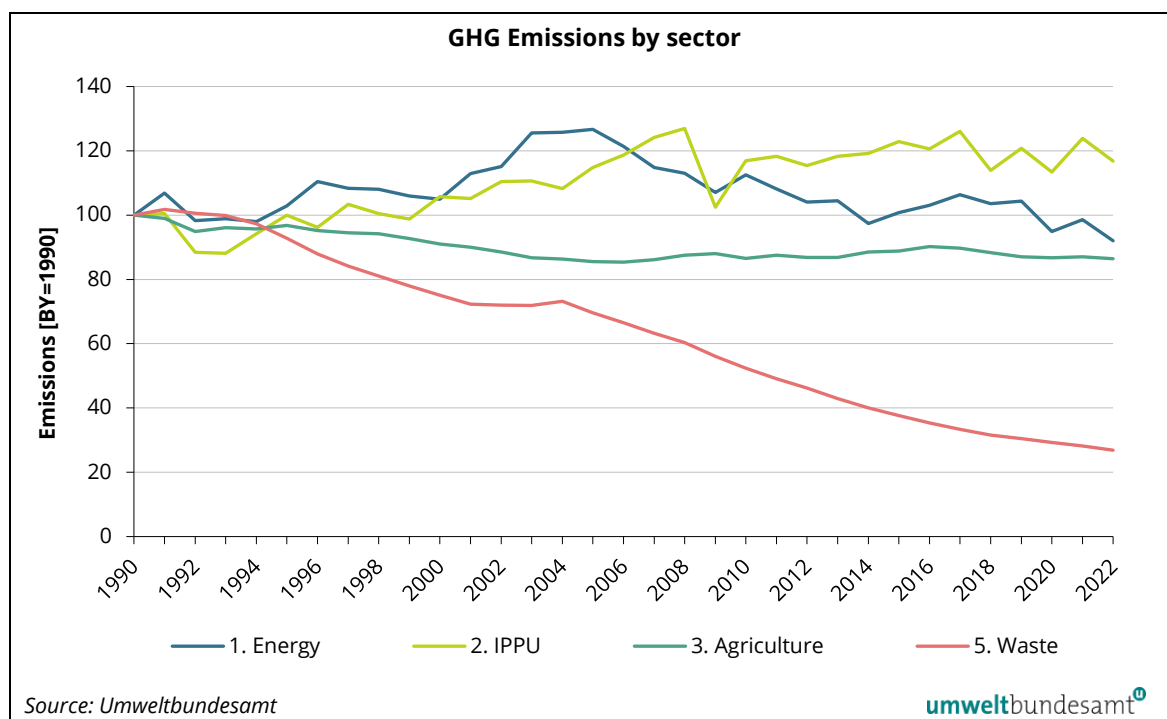
Table 15: Austria's greenhouse gas emissions (without LULUCF) for 1990 and 2022 expressed as aggregate levels and trends, as well as respective sector contributions.

GHG	1990	2022	Trend 1990–2022	1990	2022
	Emissions [kt CO ₂ e]			Share [%]	
Total	79 083	72 844	-7.9%	100%	100%
1 Energy	52 666	48 464	-8.0%	67%	67%
2 IPPU	13 633	15 929	+17%	17%	22%
3 Agriculture	8 416	7 277	-14%	11%	10%
5 Waste	4 367	1 174	-73%	5.5%	1.6%

Total emissions without emissions from sector LULUCF

The only sector with 2022 GHG emissions above the level 1990 is *Industrial Processes and Other Product Use* (+17%; +2 296 kt CO₂e). All other sectors show decreasing trends, with the most significant decreases in GHG emissions in the sectors *Waste* (-73%; -3 193 kt CO₂e) and *Agriculture* (-14%; -1 139 kt CO₂e).

Figure 5: Trend in greenhouse gas emissions 1990–2022 by sector in index form (1990 = 100).



A more detailed description and interpretation of emissions trends per sector is given in the following sub-chapters.

2.2.1 Energy

In 2022, greenhouse gas emissions from sector 1 *Energy* amounted to 48 464 kt CO₂ equivalents which corresponds to 66.5% of total national emissions. Emissions from fuel combustion (1.A) contribute 99% of total Energy emissions, while fugitive emissions from fuels (1.B) are of minor importance.

The most important **sub-category** is *transport* with a share of 43% in 2022, followed by *manufacturing industries and construction* (22%), the sub-category *other sectors* (17%) and *energy industries* (17%). The most important **greenhouse gas** is CO₂, contributing 98% to total sectoral GHG emissions, followed by N₂O (1.1%) and CH₄ (0.7%).

From 2021 to 2022, emissions from the energy sector decreased by 6.7%, mainly due to decreasing emissions from 1.A.4 *Other Sectors*, 1.A.3 *Transport* and 1.A.1 *Energy Industries*.

Emissions from *Other Sectors* decreased by 1 516 kt CO₂e due to lower natural gas and gasoil consumption which is mainly because heating degree days decreased by 12.8%.

Emissions from transport decreased by 1 210 kt CO₂e, in particular emissions from 1.A.3.b *Road transport* (- 1 033 kt CO₂e), mainly due to lower sales of diesel oil (- 1 189 kt CO₂), although sales of gasoline increased (+ 176 kt CO₂e).

Decreased emissions (-273 kt CO₂e) were also reported for *Manufacturing Industries*, mainly due to lower natural gas consumption.

Emissions from energy industries decreased by 432 kt CO₂e, mainly due to lower emissions from the oil refinery caused by a prolonged system outage.

From 1990 to 2022, the **overall trend** in GHG emissions from the sector *Energy* shows a decrease by 4 202 kt CO₂e.

The dips and jumps from year to year are mainly due to:

- the weather circumstances in the corresponding years (in particular cold or mild winters, and/or dry or wet summers) which affect the heating demand, and the availability of electricity from hydro and wind power plants
- the economic situation as reflected in the gross domestic product (GDP)
- change in power generation (switch from coal to gas and wind power plants)
- national “lockdowns” due to the COVID pandemic (2020–2021)

Trend 1990–2022 by sub-category

In 2022, the emissions from sub-category **1.A.1 Energy Industries** were 39% below the 1990 level. GHG emissions from thermal power plants have generally been decreasing since 2005, mainly because of the growing contribution of renewable energy sources, the substitution of solid and liquid fuels by natural gas and biomass as well as improvements in efficiency. In 2020, the last Austrian coal-fired power plant was shut down.

The share of biomass used as a fuel in this sector increased from 2% (1990) to 34% (2022). The contribution of hydro, wind and photovoltaic power plants to total public electricity production increased from 69% (1990) to 81% (2022). Electricity consumption increased by 49.2% since 1990 and since 2002 the increase is to a large extent covered by electricity imports (depending on year).

GHG emissions from **1.A.2 Manufacturing Industries and Construction** increased by 11% from 1990 to 2022, mainly from Off-road vehicles and other machinery (1.A.2.g.vii) as well as the Chemicals Industry (1.A.2.c). However, emissions from the pulp, paper and printing industry (1.A.2.d) and other manufacturing industry (1.A.2.g.viii) have been decreasing since 1990. Fuel consumption increased by 40% in that period, mainly due to increased use of natural gas and biomass. As natural gas has a lower carbon content, and CO₂ emissions from biomass combustion are not accounted for under the UNFCCC reporting framework, the increase in GHG emissions from this category is significantly smaller compared to the increase in fuel consumption.

The category **1.A.3 Transport** showed an increase in GHG emissions since 1990 (+48%) mainly due to an increase of road performance (mileage) of diesel cars and freight transport. In addition to the increase of road performance **within** Austria, the amount of fuel sold in Austria but **used elsewhere** – an effect called fuel export mainly caused by a lower fuel tax compared to Austria's neighbouring countries – has increased considerably since 1990. Between 2005 and 2012 total GHG emissions decreased due to lower amounts of fuel sold together with an increased use of biofuels for blending and the gradual replacement with newer vehicles with lower specific fuel consumption. Since then GHG emissions from transport have been **gradually increasing** with rising traffic volumes. In the pandemic year 2020 a sharp decrease of emissions was observed followed by an increase due to a slight economic recovery. **From 2021 to 2022** emissions from sub-category **1.A.3.b Road Transportation** declined by 4.8% due to a drop in diesel sales especially in fuel exports with heavy duty vehicles.

The variation in demand for heating and hot water generation due to climatic circumstances and the shift in the fuel mix are the most important drivers for emissions from sub-category **1.A.4 Other Sectors**. Emissions in 2022 were 42% lower than in 1990. This reduction is mainly attributable to the displacement of coal-fired heating systems and the progressive shift of heating oil towards natural gas (less carbon intensity of overall declining fossil fuel use), biomass, district heating and heat pumps, as well as the long-term decreasing trend in the number of heating degree-days. This development is supported by increased energy performance of buildings (thermal renovation, energy-efficient new buildings). Total fuel consumption of this sub-category has decreased by 19% since 1990.

Emissions from **1.B Fugitive emissions** decreased by 60% since 1990. This is mainly due to the progressive closure of coal mines up until 2006. There have been no coal-mining activities in Austria since 2007 (*1.B.1 Coal Mining and Handling*). Fugitive Emissions from *1.B.2 Oil and Natural gas* are also below 1990 level (–22%) mainly because volumes of crude oil and crude gas produced declined in the last years.

2.2.2 Industrial Processes and Other Product Use

In 2022, greenhouse gas emissions from *Industrial Processes and Other Product Use* amounted to 15 929 kt CO₂ equivalent, which corresponds to 22% of total national emissions.

The most important **categories** of this sector are *metal industry* and *mineral industry*, generating 65% and 18% of total sectoral emissions, respectively. The most important **greenhouse gas** of this sector is CO₂ with a contribution of 88% to total sectoral emissions, followed by HFCs with 9% and SF₆ with 2.3%, the other GHGs contribute less than 0.4% each.

From 2021 to 2022, overall emissions from this sector decreased by 5.7% mainly due to a decrease in iron and steel production (–6.5% of emissions), in ammonia production (–16% of emissions) and some mineral industry sub categories.

The **overall trend** in GHG emissions from *Industrial Processes and Other Product Use* shows an increase of 17% from 1990 to 2022. Within this period, emissions were at minimum in 1993 then increased until peaking in 2008. Since then, emissions fluctuated just below this maximum. **Main drivers** for the trend in emissions from this sector were (i) the termination of primary aluminium production in 1993, (ii) the introduction of N₂O abatement technologies in the chemical industry in 2004 and in 2009 (which became fully operational in 2010), (iii) the impacts of the 2007-2008 financial crisis, (iv) increasing iron and steel production resulting in 50% higher GHG emissions in 2022 compared to 1990 and (iv) a strong increase of HFC emissions over the 1990-2022 period from 2 to 1 411 kt CO₂ equivalent.

Sub-category trends between 1990 and 2021

The largest increase in GHG emissions between 1990 and 2022 can be observed in the *metal industry* due to an increase in GHG emissions from iron and steel production (+50%). In the categories *mineral industry* and *chemical industry*, GHG emissions declined over the same period by 6.8% and 54%, respectively. Emissions from *non-energy products from fuels and solvent use* dropped by 51%, due to legal measures controlling the solvent content of products and their use.

Emissions of *fluorinated gases* increased by 17% compared to 1990, driven by increasing emissions of HFCs (+335% since 1995) due to HFCs replacing Ozone Depleting Substances (ODSs) as cooling agents. The maximum was reached in 2018; since then emissions are decreasing.

2.2.3 Agriculture

In 2022, greenhouse gas emissions from *Agriculture* amounted to 7 277 kt CO₂ equivalent, which correspond to 10% of total national emissions.

The **most important categories** of this sector are *enteric fermentation* (59%) and *agricultural soils* (24%). *Agriculture* is the largest source of national N₂O and CH₄ emissions: in 2022, 73% (8.3 kt N₂O) of total N₂O emissions and 76% (176 kt CH₄) of total CH₄ emissions originated from this sector. Total GHG emissions from the sector *Agriculture* are dominated by CH₄, with a share of 68%, and N₂O, with a share of 30%. CO₂ emissions account for 2.0% of the emissions from this sector.

From 2021 to 2022 GHG emissions decreased by 0.6%, mainly due to falling emissions from mineral fertilizer application (–8.7%). The reason for this is lower sales volumes due to the significant increase in energy and raw material prices, which lead to higher prices on the fertilizer market.

The **overall trend** in GHG emissions from *Agriculture* shows a decrease of 14% from 1990 to 2022. The **main drivers** for this trend are decreasing livestock numbers of cattle and swine as well as lower amounts of N-fertilizers applied on agricultural soils.

2.2.4 LULUCF

In 2022, net removals from sector *LULUCF* amounted to –4 474 kt CO₂ equivalent, which correspond to 6.1 % of national total GHG emissions (without LULUCF) in the same year.

With regard to the **overall trend**, the net removals from *LULUCF* are 62% lower in 2022 compared to those in the base year 1990 with substantial annual variations over the observed period (according to a regression trend over the time series, the decrease of net removals between 1990 and 2022 is about 75%). The **main driver** for this trend is the biomass and soil carbon stock changes in *Forest land*. Fluctuations are due to weather conditions, which influence growth rates (e.g. very low increment in 2003) as well as decay in forest soils, natural disturbances (windthrows and bark beetle infestations), timber demand and prices (e.g. very high harvest rates in 2007 and 2008).

The **most important category** is *Forest land (4.A)* with net removals of –4 594 kt CO₂ equivalent in 2022 (including indirect emissions).

The *LULUCF* sector and the *Forest land* category represent net GHG sources in single years, namely in 2018 and 2019. The net source values in these years are explained by high harvest rates due to natural disturbances and low increments due to weather conditions. It should be noted that the *Forest land* results for the years 2020 to 2022 are extrapolated using the results of the last NFI 2016/21 and relative harvest indices based on the harvest statistics for these years. An update for these most recent years will be reported in the 2025 submission.

Harvested Wood Products (4.G) is the second largest sink category and contributed –2 110 kt CO₂ equivalent in 2022. After the low domestic production and consequently exceptionally low HWP

sink in 2020 (due to a huge amount of salvage logged disturbance wood from the years before, as well as low wood prices and the effects of the Corona pandemic), the net sink of the HWP category has increased in 2021 and 2022 again to a typical level as in the last years before 2020.

Together, CH₄ and N₂O emissions amounted to 155 kt CO₂ equivalent (including indirect emissions). Total net emissions arising from the other non-forest categories (excluding HWPs) amounted to 2 230 kt CO₂ equivalent in 2022 (including indirect emissions).

2.2.5 Waste

In 2022, greenhouse gas emissions from the sector *Waste* amounted to 1 174 kt CO₂ equivalent, which correspond to 1.6% of total national emissions.

The most important category of *Waste* is *solid waste disposal*, which caused 72% of the emissions from this sector in 2022, followed by *waste water treatment and discharge* (15%) and *biological treatment of solid waste* (13%). The most important greenhouse gas is CH₄ with a share of 81% in emissions, mainly arising from *solid waste disposal*, followed by N₂O with 19% and CO₂ with 0.2%.

From 2021 to 2022 GHG emissions continued to decrease (–4.6%) mainly due to the decreasing carbon content of waste deposited in preceding years.

The **overall trend** in GHG emissions from *Waste* is decreasing, with a decrease of 73% from 1990 to 2022. The **main driver** for this trend is the implementation of waste management policies: Waste separation, reuse and recycling activities have increased since 1990 and the amount of disposed waste has decreased correspondingly especially since 2004 when pre-treatment of waste became obligatory (although some exceptions were granted to some Austrian provinces). The legal basis for the reduced disposal of waste as well as the landfill gas recovery is the Landfill Ordinance. Since 2009 all waste with high organic content has to be pre-treated before deposition (without exceptions). Furthermore, methane recovery from landfills was implemented in the 1990s and continues since.

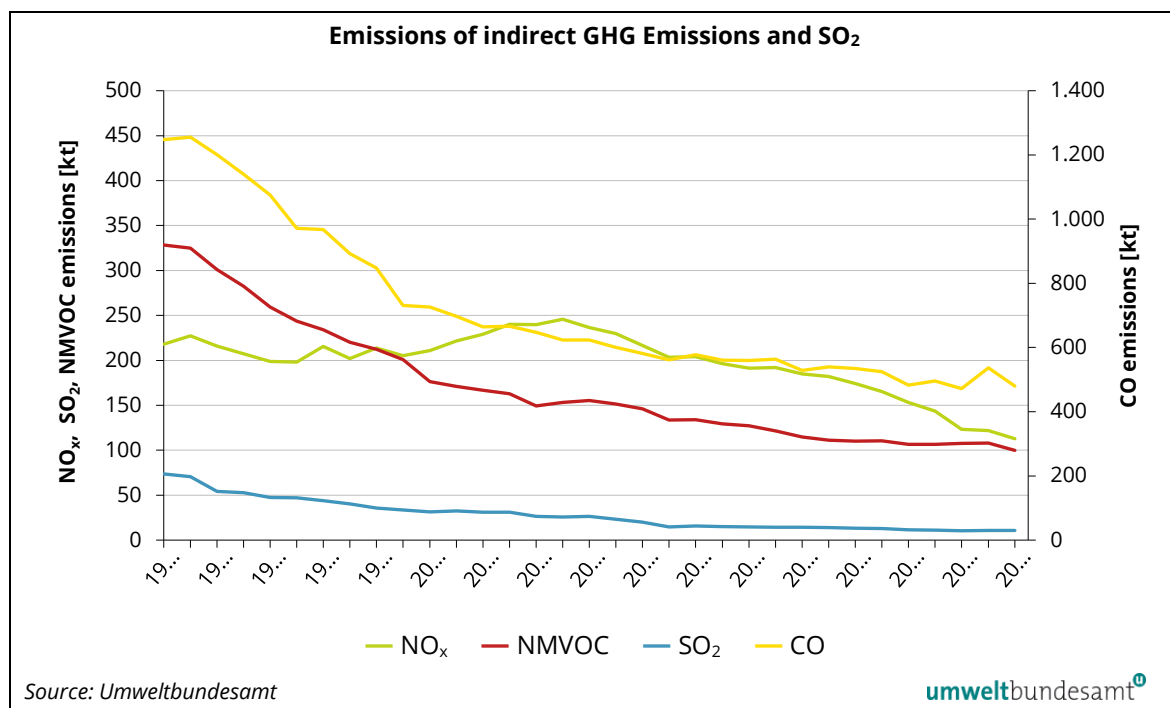
2.3 Emission Trends for Indirect Greenhouse Gases and SO₂

Emission estimates for NO_x, CO, NMVOC and SO₂ are also reported in the CRF. This chapter summarizes the trends for these gases.

A detailed description of the methodology used to estimate these emissions is provided in *Austria's Informative Inventory Report (IIR) 2024, Submission under the UNECE/CLRTAP Convention*, published in spring 2024 (UMWELTBUNDESAMT 2024b). Total emissions shown below are different from totals reported under UNECE/CLRTAP due to differences in the accounting of emissions from aviation and shipping.

Table 16: Total emissions and trends 1990–2022 of indirect GHGs and SO₂.

	NO _x	CO	NM VOC	SO ₂
	[kt]			
1990	218	1 247	328	74
1995	198	972	244	47
2000	211	726	177	31
2005	246	623	153	26
2010	204	578	134	16
2011	196	560	129	15
2012	191	560	127	15
2013	192	564	121	14
2014	185	529	115	14
2015	182	539	111	14
2016	174	534	110	13
2017	165	525	110	13
2018	153	483	107	11
2019	144	496	106	11
2020	123	472	108	10
2021	122	537	108	11
2022	113	480	100	11
1990–2022	-48%	-62%	-70%	-85%

Figure 6: Emissions of indirect GHGs and SO₂ 1990–2022.

The most important emission source for NO_x, SO₂ and CO is fuel combustion. The most important emission source for NMVOC is *Industrial Processes*.

NO_x

NO_x emissions decreased from 218 to 113 kt during the period from 1990 to 2022. In 2022 NO_x emissions were 48% below the level of 1990. In 2022 about 90% of NO_x emissions in Austria originated from fossil fuel combustion, with the major part originating from *1.A.3.b Road transportation* (44% in national total NO_x emissions in 2022).

CO

CO emissions decreased from 1 247 to 480 kt during the period from 1990 to 2022. In 2022 CO emissions were 62% below the level of 1990. In the year 2022, 97% of total CO emissions in Austria originated from fuel combustion activities. The most important sub-source regarding CO emissions is *1.A.4 Other sectors* (47% in national total CO emissions) followed by *1.A.2 Manufacturing industries and construction* with 38% and *1.A.3.b Road Transport* with 9.6% share in national total CO emissions in 2022.

NMVOC

NMVOC emissions decreased from 328 to 100 kt during the period from 1990 to 2022. In 2022 NMVOC emissions were 70% below the level of 1990. The most important source of NMVOC emissions is *2 Industrial Processes*, contributing 35% to national total NMVOC emissions in 2022 (contribution of *2.D.3.1 Solvent Use* 31%), followed by *1.A. Fuel Combustion Activities* (30%).

SO₂

SO₂ emissions decreased from 74 to 11 kt during the period 1990 to 2022. In 2022 SO₂ emissions were 85% below the level of 1990. Fuel combustion activities (*1.A*) contribute 94% to total emissions (2022).

2.4 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals

The uncertainty calculation was performed applying approach 1 of the IPCC 2006 GL, for all sectors including and excluding LULUCF. As a result of the uncertainty analysis, the following tables show a total uncertainty of 5.1% for the base year 1990 and 4.5% for 2022 (excluding LULUCF), as well as a total uncertainty of 9.1% for the base year 1990 and of 6.1% for the year 2022 (including LULUCF). Further details can be found in the Annex 2.

Table 17: Approach 1 Uncertainty calculation and reporting according IPCC 2006 GL for 1990 – excluding LULUCF.

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			K ² + L ²
1.A Stationary Combustion – Biomass	CH ₄	5.0	50.0	50.2	0.04	0.00
1.A Stationary Combustion – Biomass	CO ₂	5.0	1.0	5.1	0.00	0.00
1.A Stationary Combustion – Biomass	N ₂ O	5.0	50.0	50.2	0.00	0.01
1.A Stationary Combustion – Gaseous Fuels	CH ₄	2.0	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Gaseous Fuels	CO ₂	2.0	0.2	2.0	0.08	0.30
1.A Stationary Combustion – Gaseous Fuels	N ₂ O	2.0	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CH ₄	0.5	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CO ₂	0.5	0.5	0.7	0.02	0.01
1.A Stationary Combustion – Liquid Fuels	N ₂ O	0.5	50.0	50.0	0.01	0.00
1.A Stationary Combustion – Other fuels	CH ₄	10.0	50.0	51.0	0.00	0.00
1.A Stationary Combustion – Other fuels	CO ₂	10.0	15.0	18.0	0.02	0.20
1.A Stationary Combustion – Other fuels	N ₂ O	10.0	50.0	51.0	0.00	0.00
1.A Stationary Combustion – Solid Fuels	CH ₄	0.5	50.0	50.0	0.02	0.02
1.A Stationary Combustion – Solid Fuels	CO ₂	0.5	0.5	0.7	0.01	0.00
1.A Stationary Combustion – Solid Fuels	N ₂ O	0.5	50.0	50.0	0.00	0.00
1.A.3.a Transport – Civil Aviation	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.a Transport – Civil Aviation	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.a Transport – Civil Aviation	N ₂ O	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CO ₂	3.0	3.0	4.2	0.08	0.87
1.A.3.b Transport – Road Transportation – Diesel	N ₂ O	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	CH ₄	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	N ₂ O	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CO ₂	3.0	3.0	4.2	0.18	0.07
1.A.3.b Transport – Road Transportation – Gasoline	N ₂ O	3.0	70.0	70.1	0.01	0.00
1.A.3.b Transport – Road Transportation – LPG	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	CH ₄	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	N ₂ O	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CH ₄	5.0	50.0	50.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CO ₂	5.0	30.0	30.4	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	N ₂ O	5.0	3.0	5.8	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CH ₄	5.0	70.0	70.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CO ₂	5.0	3.0	5.8	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	N ₂ O	5.0	50.0	50.2	0.00	0.00
1.A.3.c Transport – Railways	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.c Transport – Railways	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.c Transport – Railways	N ₂ O	3.0	30.0	30.1	0.00	0.00
1.A.3.d Transport – Navigation	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.d Transport – Navigation	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.d Transport – Navigation	N ₂ O	3.0	70.0	70.1	0.00	0.00
1.A.3.e Transport – Other Transportation	CH ₄	2.0	50.0	50.0	0.00	0.00
1.A.3.e Transport – Other Transportation	CO ₂	2.0	0.2	2.0	0.00	0.00
1.A.3.e Transport – Other Transportation	N ₂ O	2.0	50.0	50.0	0.00	0.00
1.A.5.b Mobile	CH ₄	1.0	50.0	50.0	0.00	0.00
1.A.5.b Mobile	CO ₂	1.0	0.5	1.1	0.00	0.00
1.A.5.b Mobile	N ₂ O	1.0	50.0	50.0	0.00	0.00

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			K ² + L ²
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH ₄	5.0	50.0	50.2	0.06	0.05
1.B.2.a Fugitive Emission – Oil	CH ₄	0.5	50.0	50.0	0.00	0.00
1.B.2.a Fugitive Emission – Oil	CO ₂	0.5	0.5	0.7	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CH ₄	5.0	10.0	11.2	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CO ₂	5.0	0.2	5.0	0.00	0.00
2.A.1 Mineral Industry – Cement Production	CO ₂	5.0	2.0	5.4	0.02	0.03
2.A.2 Mineral Industry – Lime Production	CO ₂	10.0	2.0	10.2	0.00	0.01
2.A.3 Mineral Industry – Glass Production	CO ₂	5.0	2.0	5.4	0.00	0.00
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO ₂	5.0	2.0	5.4	0.00	0.00
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO ₂	30.0	2.0	30.1	0.00	0.00
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO ₂	2.0	2.0	2.8	0.00	0.00
2.A.4.d Other Process Uses of Carbonates – other	CO ₂	0.0	0.0	0.0	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CH ₄	2.0	10.0	10.2	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CO ₂	2.0	5.0	5.4	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	CO ₂	2.0	2.0	2.8	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	N ₂ O	2.0	2.0	2.8	0.00	0.00
2.B.5 Chemical Industry – Carbide Production	CO ₂	1.0	5.0	5.1	0.00	0.00
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH ₄	20.0	10.0	22.4	0.00	0.00
2.B.10 Chemical Industry – Other	CH ₄	2.0	2.0	2.8	0.00	0.00
2.B.10 Chemical Industry – Other	CO ₂	2.0	2.0	2.8	0.00	0.00
2.C.1 Metal Industry – Iron and Steel Production	CO ₂	2.0	0.5	2.1	0.03	0.14
2.C.1 Metal Industry – Iron and Steel Production	CH ₄	2.0	20.0	20.1	0.00	0.00
2.C.2 Metal Industry – Ferroalloys Production	CO ₂	5.0	25.0	25.5	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	CO ₂	2.0	5.0	5.4	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	PFC	2.0	50.0	50.0	0.43	0.36
2.C.3 Metal Industry – Aluminium Production	SF ₆	2.0	50.0	50.0	0.00	0.00
2.C.4 Metal Industry – Magnesium Production	SF ₆	5.0	5.0	7.1	0.00	0.00
2.C.5 Metal Industry – Lead Production	CO ₂	5.0	50.0	50.2	0.00	0.00
2.D Non-Energy Products from Fuels and Solvent Use	CO ₂	20.0	30.0	36.1	0.03	0.01
2.E Electronics Industry	HFC	5.0	10.0	11.2	0.00	0.00
2.E Electronics Industry	PFC	5.0	10.0	11.2	0.00	0.00
2.E Electronics Industry	SF ₆	5.0	10.0	11.2	0.00	0.00
2.E Electronics Industry	NF ₃	5.0	10.0	11.2	0.00	0.00
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	10.0	50.0	51.0	0.00	0.79
2.F.2 Foam Blowing	HFC	10.0	0.0	10.0	0.00	0.00
2.F.3 Fire Extinguishers	HFC	10.0	100.0	100.5	0.00	0.00
2.F.4 Aerosols	HFC	20.0	10.0	22.4	0.00	0.00
2.F.5 Solvents	HFC	100.0	0.0	100.0	0.00	0.00
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	5.0	100.0	100.1	0.00	0.00
2.G.2 Other product manufacture and use – SF ₆ and PFCs from other product use	PFC	5.0	100.0	100.1	0.00	0.00
2.G.2 Other product manufacture and use – SF ₆ and PFCs from other product use	SF ₆	5.0	100.0	100.1	0.02	0.06
2.G. Other Product Manufacture and Use	N ₂ O	20.0	0.0	20.0	0.00	0.00
3.A.1 Enteric Fermentation – Cattle	CH ₄	10.0	20.0	22.4	1.88	0.53
3.A.2 Enteric Fermentation – Sheep	CH ₄	10.0	40.0	41.2	0.00	0.00
3.A.3 Enteric Fermentation – Swine	CH ₄	10.0	20.0	22.4	0.00	0.00
3.A.4 Enteric Fermentation – Other	CH ₄	10.0	40.0	41.2	0.00	0.00

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			$K^2 + L^2$
3.B.1.1 Manure Management – Cattle	CH ₄	10.0	20.0	22.4	0.02	0.01
3.B.1.1 Manure Management – Cattle	N ₂ O	10.0	100.0	100.5	0.14	0.00
3.B.1.2 Manure Management – Sheep	CH ₄	10.0	30.0	31.6	0.00	0.00
3.B.1.2 Manure Management – Sheep	N ₂ O	10.0	100.0	100.5	0.00	0.00
3.B.1.3 Manure Management – Swine	CH ₄	10.0	20.0	22.4	0.00	0.00
3.B.1.3 Manure Management – Swine	N ₂ O	10.0	100.0	100.5	0.02	0.00
3.B.1.4. Manure Management – Other	CH ₄	10.0	30.0	31.6	0.00	0.00
3.B.1.4. Manure Management – Other	N ₂ O	10.0	100.0	100.5	0.00	0.00
3.B.2.5 Indirect N ₂ O Emissions	N ₂ O	5.0	200.0	200.1	0.07	0.00
3.D.1 Direct N ₂ O Emissions from Managed Soils	N ₂ O	5.0	200.0	200.1	20.19	0.23
3.D.2 Indirect N ₂ O emissions from Managed Soils	N ₂ O	5.0	200.0	200.1	0.82	0.01
3.F Field Burning of Agricultural Residues	CH ₄	100.0	40.0	107.7	0.00	0.00
3.F Field Burning of Agricultural Residues	N ₂ O	100.0	50.0	111.8	0.00	0.00
3.G Liming	CO ₂	5.0	50.0	50.2	0.00	0.00
3.H Urea application	CO ₂	5.0	50.0	50.2	0.00	0.00
3.I Other	CO ₂	5.0	50.0	50.2	0.00	0.00
5.A Solid Waste Disposal	CH ₄	12.0	25.0	27.7	2.05	0.88
5.B Biological Treatment of Solid Waste	CH ₄	20.0	50.0	53.9	0.00	0.00
5.B Biological Treatment of Solid Waste	N ₂ O	20.0	50.0	53.9	0.00	0.00
5.C Incineration and Open Burning of Waste	CH ₄	7.0	0.0	7.0	0.00	0.00
5.C Incineration and Open Burning of Waste	CO ₂	7.0	20.0	21.2	0.00	0.00
5.C Incineration and Open Burning of Waste	N ₂ O	7.0	0.0	7.0	0.00	0.00
5.D Waste Water Treatment and Discharge	CH ₄	20.0	50.0	53.9	0.01	0.00
5.D Waste Water Treatment and Discharge	N ₂ O	20.0	100.0	102.0	0.01	0.01
Total					26.27	4.62
				Uncertainty in total inventory %:		
Total Uncertainties					5.12	2.15

Table 18: Approach 1 Uncertainty calculation and reporting according IPCC 2006 GL for 2022 – excluding LULUCF.

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			$K^2 + L^2$
1.A Stationary Combustion – Biomass	CH ₄	5.0	50.0	50.2	0.04	0.00
1.A Stationary Combustion – Biomass	CO ₂	5.0	1.0	5.1	0.00	0.00
1.A Stationary Combustion – Biomass	N ₂ O	5.0	50.0	50.2	0.02	0.01
1.A Stationary Combustion – Gaseous Fuels	CH ₄	1.0	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Gaseous Fuels	CO ₂	1.0	0.2	1.0	0.05	0.07
1.A Stationary Combustion – Gaseous Fuels	N ₂ O	1.0	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CH ₄	0.5	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CO ₂	0.5	0.5	0.7	0.01	0.01
1.A Stationary Combustion – Liquid Fuels	N ₂ O	0.5	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Other fuels	CH ₄	5.0	50.0	50.2	0.00	0.00
1.A Stationary Combustion – Other fuels	CO ₂	5.0	15.0	15.8	0.19	0.11
1.A Stationary Combustion – Other fuels	N ₂ O	5.0	50.0	50.2	0.00	0.00

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			K ² + L ²
1.A Stationary Combustion – Solid Fuels	CH ₄	0.5	50.0	50.0	0.00	0.02
1.A Stationary Combustion – Solid Fuels	CO ₂	0.5	0.5	0.7	0.00	0.00
1.A Stationary Combustion – Solid Fuels	N ₂ O	0.5	50.0	50.0	0.00	0.00
1.A.3.a Transport – Civil Aviation	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.a Transport – Civil Aviation	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.a Transport – Civil Aviation	N ₂ O	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CO ₂	3.0	3.0	4.2	0.83	0.87
1.A.3.b Transport – Road Transportation – Diesel	N ₂ O	3.0	30.0	30.1	0.01	0.00
1.A.3.b Transport – Road Transportation – Gaseous	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	CH ₄	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	N ₂ O	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CO ₂	3.0	3.0	4.2	0.07	0.07
1.A.3.b Transport – Road Transportation – Gasoline	N ₂ O	3.0	70.0	70.1	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	CH ₄	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	N ₂ O	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CH ₄	5.0	50.0	50.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CO ₂	5.0	30.0	30.4	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	N ₂ O	5.0	3.0	5.8	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CH ₄	5.0	70.0	70.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CO ₂	5.0	3.0	5.8	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	N ₂ O	5.0	50.0	50.2	0.00	0.00
1.A.3.c Transport – Railways	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.c Transport – Railways	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.c Transport – Railways	N ₂ O	3.0	30.0	30.1	0.00	0.00
1.A.3.d Transport – Navigation	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.d Transport – Navigation	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.d Transport – Navigation	N ₂ O	3.0	70.0	70.1	0.00	0.00
1.A.3.e Transport – Other Transportation	CH ₄	1.0	50.0	50.0	0.00	0.00
1.A.3.e Transport – Other Transportation	CO ₂	1.0	0.2	1.0	0.00	0.00
1.A.3.e Transport – Other Transportation	N ₂ O	1.0	50.0	50.0	0.00	0.00
1.A.5.b Mobile	CH ₄	1.0	50.0	50.0	0.00	0.00
1.A.5.b Mobile	CO ₂	1.0	0.5	1.1	0.00	0.00
1.A.5.b Mobile	N ₂ O	1.0	50.0	50.0	0.00	0.00
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH ₄	5.0	50.0	50.2	0.00	0.05
1.B.2.a Fugitive Emission – Oil	CH ₄	0.5	50.0	50.0	0.00	0.00
1.B.2.a Fugitive Emission – Oil	CO ₂	0.5	0.5	0.7	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CH ₄	5.0	10.0	11.2	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CO ₂	5.0	0.2	5.0	0.00	0.00
2.A.1 Mineral Industry – Cement Production	CO ₂	1.0	2.0	2.2	0.00	0.00
2.A.2 Mineral Industry – Lime Production	CO ₂	5.0	2.0	5.4	0.00	0.00
2.A.3 Mineral Industry – Glass Production	CO ₂	1.0	2.0	2.2	0.00	0.00
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO ₂	1.0	2.0	2.2	0.00	0.00
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO ₂	30.0	2.0	30.1	0.00	0.00
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO ₂	2.0	2.0	2.8	0.00	0.00
2.A.4.d Other Process Uses of Carbonates – other	CO ₂	0.0	0.0	0.0	0.00	0.00

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			K ² + L ²
2.B.1 Chemical Industry – Ammonia Production	CH ₄	2.0	10.0	10.2	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CO ₂	2.0	5.0	5.4	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	CO ₂	2.0	2.0	2.8	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	N ₂ O	2.0	2.0	2.8	0.00	0.00
2.B.5 Chemical Industry – Carbide Production	CO ₂	1.0	5.0	5.1	0.00	0.00
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH ₄	20.0	10.0	22.4	0.00	0.00
2.B.10 Chemical Industry – Other	CH ₄	2.0	2.0	2.8	0.00	0.00
2.B.10 Chemical Industry – Other	CO ₂	2.0	2.0	2.8	0.00	0.00
2.C.1 Metal Industry – Iron and Steel Production	CO ₂	0.5	0.5	0.7	0.01	0.01
2.C.1 Metal Industry – Iron and Steel Production	CH ₄	0.5	20.0	20.0	0.00	0.00
2.C.2 Metal Industry – Ferroalloys Production	CO ₂	5.0	25.0	25.5	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	CO ₂	20.0	5.0	20.6	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	PFC	20.0	50.0	53.9	0.00	0.36
2.C.3 Metal Industry – Aluminium Production	SF ₆	20.0	50.0	53.9	0.00	0.00
2.C.4 Metal Industry – Magnesium Production	SF ₆	5.0	5.0	7.1	0.00	0.00
2.C.5 Metal Industry – Lead Production	CO ₂	5.0	50.0	50.2	0.00	0.00
2.D Non-Energy Products from Fuels and Solvent Use	CO ₂	20.0	30.0	36.1	0.01	0.01
2.E Electronics Industry	HFC	5.0	10.0	11.2	0.00	0.00
2.E Electronics Industry	PFC	5.0	10.0	11.2	0.00	0.00
2.E Electronics Industry	SF ₆	5.0	10.0	11.2	0.00	0.00
2.E Electronics Industry	NF ₃	5.0	10.0	11.2	0.00	0.00
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	10.0	50.0	51.0	0.90	0.79
2.F.2 Foam Blowing	HFC	10.0	0.0	10.0	0.00	0.00
2.F.3 Fire Extinguishers	HFC	10.0	100.0	100.5	0.00	0.00
2.F.4 Aerosols	HFC	20.0	10.0	22.4	0.00	0.00
2.F.5 Solvents	HFC	100.0	0.0	100.0	0.00	0.00
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	5.0	100.0	100.1	0.00	0.00
2.G.2 Other product manufacture and use – SF ₆ and PFCs from other product use	PFC	5.0	100.0	100.1	0.00	0.00
2.G.2 Other product manufacture and use – SF ₆ and PFCs from other product use	SF ₆	5.0	100.0	100.1	0.17	0.06
2.G. Other Product Manufacture and Use	N ₂ O	20.0	0.0	20.0	0.00	0.00
3.A.1 Enteric Fermentation – Cattle	CH ₄	1.0	20.0	20.0	1.23	0.02
3.A.2 Enteric Fermentation – Sheep	CH ₄	10.0	40.0	41.2	0.00	0.00
3.A.3 Enteric Fermentation – Swine	CH ₄	4.0	20.0	20.4	0.00	0.00
3.A.4 Enteric Fermentation – Other	CH ₄	10.0	40.0	41.2	0.00	0.00
3.B.1.1 Manure Management – Cattle	CH ₄	1.0	20.0	20.0	0.02	0.00
3.B.1.1 Manure Management – Cattle	N ₂ O	1.0	100.0	100.0	0.15	0.00
3.B.1.2 Manure Management – Sheep	CH ₄	10.0	30.0	31.6	0.00	0.00
3.B.1.2 Manure Management – Sheep	N ₂ O	10.0	100.0	100.5	0.00	0.00
3.B.1.3 Manure Management – Swine	CH ₄	4.0	20.0	20.4	0.00	0.00
3.B.1.3 Manure Management – Swine	N ₂ O	4.0	100.0	100.1	0.01	0.00
3.B.1.4. Manure Management – Other	CH ₄	10.0	30.0	31.6	0.00	0.00
3.B.1.4. Manure Management – Other	N ₂ O	10.0	100.0	100.5	0.00	0.00
3.B.2.5 Indirect N ₂ O Emissions	N ₂ O	5.0	200.0	200.1	0.09	0.00
3.D.1 Direct N ₂ O Emissions from Managed Soils	N ₂ O	5.0	200.0	200.1	15.96	0.23
3.D.2 Indirect N ₂ O emissions from Managed Soils	N ₂ O	5.0	200.0	200.1	0.63	0.01
3.F Field Burning of Agricultural Residues	CH ₄	100.0	40.0	107.7	0.00	0.00
3.F Field Burning of Agricultural Residues	N ₂ O	100.0	50.0	111.8	0.00	0.00
3.G Liming	CO ₂	5.0	50.0	50.2	0.00	0.00
3.H Urea application	CO ₂	5.0	50.0	50.2	0.00	0.00
3.I Other	CO ₂	5.0	50.0	50.2	0.00	0.00

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			$K^2 + L^2$
5.A Solid Waste Disposal	CH ₄	12.0	25.0	27.7	0.10	0.88
5.B Biological Treatment of Solid Waste	CH ₄	20.0	50.0	53.9	0.00	0.00
5.B Biological Treatment of Solid Waste	N ₂ O	20.0	50.0	53.9	0.00	0.00
5.C Incineration and Open Burning of Waste	CH ₄	7.0	0.0	7.0	0.00	0.00
5.C Incineration and Open Burning of Waste	CO ₂	7.0	20.0	21.2	0.00	0.00
5.C Incineration and Open Burning of Waste	N ₂ O	7.0	0.0	7.0	0.00	0.00
5.D Waste Water Treatment and Discharge	CH ₄	20.0	50.0	53.9	0.00	0.00
5.D Waste Water Treatment and Discharge	N ₂ O	20.0	100.0	102.0	0.05	0.01
Total					20.56	3.61
Total Uncertainties				Uncertainty in total inventory %:	4.53	1.90

Table 19: Approach 1 Uncertainty calculation and reporting according IPCC 2006 GL for 1990 – including LULUCF.

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			$K^2 + L^2$
1.A Stationary Combustion – Biomass	CH ₄	5.0	50.0	50.2	0.05	0.00
1.A Stationary Combustion – Biomass	CO ₂	5.0	1.0	5.1	0.00	0.00
1.A Stationary Combustion – Biomass	N ₂ O	5.0	50.0	50.2	0.00	0.01
1.A Stationary Combustion – Gaseous Fuels	CH ₄	2.0	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Gaseous Fuels	CO ₂	2.0	0.2	2.0	0.11	0.41
1.A Stationary Combustion – Gaseous Fuels	N ₂ O	2.0	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CH ₄	0.5	50.0	50.0	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CO ₂	0.5	0.5	0.7	0.02	0.01
1.A Stationary Combustion – Liquid Fuels	N ₂ O	0.5	50.0	50.0	0.01	0.00
1.A Stationary Combustion – Other fuels	CH ₄	10.0	50.0	51.0	0.00	0.00
1.A Stationary Combustion – Other fuels	CO ₂	10.0	15.0	18.0	0.02	0.27
1.A Stationary Combustion – Other fuels	N ₂ O	10.0	50.0	51.0	0.00	0.00
1.A Stationary Combustion – Solid Fuels	CH ₄	0.5	50.0	50.0	0.03	0.03
1.A Stationary Combustion – Solid Fuels	CO ₂	0.5	0.5	0.7	0.01	0.01
1.A Stationary Combustion – Solid Fuels	N ₂ O	0.5	50.0	50.0	0.00	0.00
1.A.3.a Transport – Civil Aviation	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.a Transport – Civil Aviation	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.a Transport – Civil Aviation	N ₂ O	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CO ₂	3.0	3.0	4.2	0.11	1.18
1.A.3.b Transport – Road Transportation – Diesel	N ₂ O	3.0	30.0	30.1	0.00	0.01
1.A.3.b Transport – Road Transportation – Gaseous	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	CH ₄	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	N ₂ O	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CO ₂	3.0	3.0	4.2	0.25	0.10
1.A.3.b Transport – Road Transportation – Gasoline	N ₂ O	3.0	70.0	70.1	0.01	0.01
1.A.3.b Transport – Road Transportation – LPG	CO ₂	3.0	3.0	4.2	0.00	0.00

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			K ² + L ²
1.A.3.b Transport – Road Transportation – LPG	CH ₄	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	N ₂ O	3.0	50.0	50.1	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CH ₄	5.0	50.0	50.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CO ₂	5.0	30.0	30.4	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	N ₂ O	5.0	3.0	5.8	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CH ₄	5.0	70.0	70.2	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CO ₂	5.0	3.0	5.8	0.00	1.14
1.A.3.b Transport – Road Transportation – Other Fuels	N ₂ O	5.0	50.0	50.2	0.00	0.00
1.A.3.c Transport – Railways	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.c Transport – Railways	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.c Transport – Railways	N ₂ O	3.0	30.0	30.1	0.00	0.00
1.A.3.d Transport – Navigation	CH ₄	3.0	30.0	30.1	0.00	0.00
1.A.3.d Transport – Navigation	CO ₂	3.0	3.0	4.2	0.00	0.00
1.A.3.d Transport – Navigation	N ₂ O	3.0	70.0	70.1	0.00	0.00
1.A.3.e Transport – Other Transportation	CH ₄	2.0	50.0	50.0	0.00	0.00
1.A.3.e Transport – Other Transportation	CO ₂	2.0	0.2	2.0	0.00	0.00
1.A.3.e Transport – Other Transportation	N ₂ O	2.0	50.0	50.0	0.00	0.00
1.A.5.b Mobile	CH ₄	1.0	50.0	50.0	0.00	0.00
1.A.5.b Mobile	CO ₂	1.0	0.5	1.1	0.00	0.00
1.A.5.b Mobile	N ₂ O	1.0	50.0	50.0	0.00	0.00
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH ₄	5.0	50.0	50.2	0.08	0.08
1.B.2.a Fugitive Emission – Oil	CH ₄	0.5	50.0	50.0	0.00	0.00
1.B.2.a Fugitive Emission – Oil	CO ₂	0.5	0.5	0.7	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CH ₄	5.0	10.0	11.2	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CO ₂	5.0	0.2	5.0	0.00	0.00
2.A.1 Mineral Industry – Cement Production	CO ₂	5.0	2.0	5.4	0.03	0.04
2.A.2 Mineral Industry – Lime Production	CO ₂	10.0	2.0	10.2	0.00	0.02
2.A.3 Mineral Industry – Glass Production	CO ₂	5.0	2.0	5.4	0.00	0.00
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO ₂	5.0	2.0	5.4	0.00	0.00
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO ₂	30.0	2.0	30.1	0.00	0.00
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO ₂	2.0	2.0	2.8	0.00	0.00
2.A.4.d Other Process Uses of Carbonates – other	CO ₂	0.0	0.0	0.0	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CH ₄	2.0	10.0	10.2	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CO ₂	2.0	5.0	5.4	0.0014	0.00
2.B.2 Chemical Industry – Nitric Acid Production	CO ₂	2.0	2.0	2.8	0.0000	0.00
2.B.2 Chemical Industry – Nitric Acid Production	N ₂ O	2.0	2.0	2.8	0.0011	0.00
2.B.5 Chemical Industry – Carbide Production	CO ₂	1.0	5.0	5.1	0.0000	0.00
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH ₄	20.0	10.0	22.4	0.0001	0.00
2.B.10 Chemical Industry – Other	CH ₄	2.0	2.0	2.8	0.0000	0.00
2.B.10 Chemical Industry – Other	CO ₂	2.0	2.0	2.8	0.0000	0.00
2.C.1 Metal Industry – Iron and Steel Production	CO ₂	2.0	0.5	2.1	0.0438	0.19
2.C.1 Metal Industry – Iron and Steel Production	CH ₄	2.0	20.0	20.1	0.0000	0.00
2.C.2 Metal Industry – Ferroalloys Production	CO ₂	5.0	25.0	25.5	0.0001	0.00
2.C.3 Metal Industry – Aluminium Production	CO ₂	2.0	5.0	5.4	0.0001	0.00
2.C.3 Metal Industry – Aluminium Production	PFC	2.0	50.0	50.0	0.5874	0.60
2.C.3 Metal Industry – Aluminium Production	SF ₆	2.0	50.0	50.0	0.0001	0.00
2.C.4 Metal Industry – Magnesium Production	SF ₆	5.0	5.0	7.1	0.0006	0.00

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			K ² + L ²
2.C.5 Metal Industry – Lead Production	CO ₂	5.0	50.0	50.2	0.0000	0.00
2.D Non-Energy Products from Fuels and Solvent Use	CO ₂	20.0	30.0	36.1	0.0348	0.01
2.E Electronics Industry	HFC	5.0	10.0	11.2	0.0000	0.00
2.E Electronics Industry	PFC	5.0	10.0	11.2	0.0000	0.00
2.E Electronics Industry	SF ₆	5.0	10.0	11.2	0.0003	0.00
2.E Electronics Industry	NF ₃	5.0	10.0	11.2	0.0000	0.00
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	10.0	50.0	51.0	0.0000	1.09
2.F.2 Foam Blowing	HFC	10.0	0.0	10.0	0.0000	0.00
2.F.3 Fire Extinguishers	HFC	10.0	100.0	100.5	0.0000	0.00
2.F.4 Aerosols	HFC	20.0	10.0	22.4	0.0000	0.00
2.F.5 Solvents	HFC	100.0	0.0	100.0	0.0000	0.00
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	5.0	100.0	100.1	0.0003	0.00
2.G.2 Other product manufacture and use – SF ₆ and PFCs from other product use	PFC	5.0	100.0	100.1	0.0000	0.00
2.G.2 Other product manufacture and use – SF ₆ and PFCs from other product use	SF ₆	5.0	100.0	100.1	0.0342	0.07
2.G. Other Product Manufacture and Use	N ₂ O	20.0	0.0	20.0	0.0012	0.00
3.A.1 Enteric Fermentation – Cattle	CH ₄	10.0	20.0	22.4	2.5930	0.79
3.A.2 Enteric Fermentation – Sheep	CH ₄	10.0	40.0	41.2	0.0018	0.00
3.A.3 Enteric Fermentation – Swine	CH ₄	10.0	20.0	22.4	0.0008	0.00
3.A.4 Enteric Fermentation – Other	CH ₄	10.0	40.0	41.2	0.0007	0.00
3.B.1.1 Manure Management – Cattle	CH ₄	10.0	20.0	22.4	0.0241	0.01
3.B.1.1 Manure Management – Cattle	N ₂ O	10.0	100.0	100.5	0.1919	0.00
3.B.1.2 Manure Management – Sheep	CH ₄	10.0	30.0	31.6	0.0000	0.00
3.B.1.2 Manure Management – Sheep	N ₂ O	10.0	100.0	100.5	0.0001	0.00
3.B.1.3 Manure Management – Swine	CH ₄	10.0	20.0	22.4	0.0024	0.00
3.B.1.3 Manure Management – Swine	N ₂ O	10.0	100.0	100.5	0.0216	0.00
3.B.1.4. Manure Management – Other	CH ₄	10.0	30.0	31.6	0.0000	0.00
3.B.1.4. Manure Management – Other	N ₂ O	10.0	100.0	100.5	0.0002	0.00
3.B.2.5 Indirect N ₂ O Emissions	N ₂ O	5.0	200.0	200.1	0.0927	0.00
3.D.1 Direct N ₂ O Emissions from Managed Soils	N ₂ O	5.0	200.0	200.1	27.7997	1.08
3.D.2 Indirect N ₂ O emissions from Managed Soils	N ₂ O	5.0	200.0	200.1	1.1242	0.05
3.F Field Burning of Agricultural Residues	CH ₄	100.0	40.0	107.7	0.0000	0.00
3.F Field Burning of Agricultural Residues	N ₂ O	100.0	50.0	111.8	0.0000	0.00
3.G Liming	CO ₂	5.0	50.0	50.2	0.0012	0.00
3.H Urea application	CO ₂	5.0	50.0	50.2	0.0001	0.00
3.I Other	CO ₂	5.0	50.0	50.2	0.0005	0.00
5.A Solid Waste Disposal	CH ₄			220.4	0.0079	0.00
4 Total land use categories	CH ₄			109.5	0.0540	0.00
4 Total land use categories	N ₂ O			50.4	36.9178	0.00
4.A.1 Forest land remaining forest land	CO ₂			35.7	2.4562	0.00
4.A.2 Land converted to forest land	CO ₂			229.0	0.0038	0.00
4.B.1 Cropland remaining cropland	CO ₂			59.2	0.0315	0.00
4.B.2 Land converted to cropland	CO ₂			230.5	1.0819	0.00
4.C.1 Grassland remaining grassland	CO ₂			52.6	0.0942	0.00
4.C.2 Land converted to grassland	CO ₂			42.6	0.0000	0.00
4.D.1 Wetlands remaining Wetlands	CO ₂			42.6	0.0009	0.00
4.D.2 Land converted to Wetlands	CO ₂			34.0	0.2141	0.00
4.E.2 Land converted to Settlements	CO ₂			76.9	0.3273	0.00
4.F.2 Land converted to Other land	CO ₂			49.0	5.1523	0.00
4.G HWP	CO ₂	12.0	25.0	27.7	2.8194	1.54
5.B Biological Treatment of Solid Waste	CH ₄	20.0	50.0	53.9	0.0001	0.00
5.B Biological Treatment of Solid Waste	N ₂ O	20.0	50.0	53.9	0.0003	0.00

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			$K^2 + L^2$
5.C Incineration and Open Burning of Waste	CH ₄	7.0	0.0	7.0	0.0000	0.00
5.C Incineration and Open Burning of Waste	CO ₂	7.0	20.0	21.2	0.0001	0.00
5.C Incineration and Open Burning of Waste	N ₂ O	7.0	0.0	7.0	0.0000	0.00
5.D Waste Water Treatment and Discharge	CH ₄	20.0	50.0	53.9	0.0119	0.01
5.D Waste Water Treatment and Discharge	N ₂ O	20.0	100.0	102.0	0.0169	0.01
Total					82.50	8.79
				Uncertainty in total inventory %:	9.08	2.96

Table 20: Approach 1 Uncertainty calculation and reporting according IPCC 2006 GL for 2022 – including LULUCF.

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			$K^2 + L^2$
1.A Stationary Combustion – Biomass	CH ₄	5.0	50.0	50.25	0.04	0.00
1.A Stationary Combustion – Biomass	CO ₂	5.0	1.0	5.10	0.00	0.00
1.A Stationary Combustion – Biomass	N ₂ O	5.0	50.0	50.25	0.02	0.01
1.A Stationary Combustion – Gaseous Fuels	CH ₄	1.0	50.0	50.01	0.00	0.00
1.A Stationary Combustion – Gaseous Fuels	CO ₂	1.0	0.2	1.02	0.05	0.10
1.A Stationary Combustion – Gaseous Fuels	N ₂ O	1.0	50.0	50.01	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CH ₄	0.5	50.0	50.00	0.00	0.00
1.A Stationary Combustion – Liquid Fuels	CO ₂	0.5	0.5	0.71	0.01	0.01
1.A Stationary Combustion – Liquid Fuels	N ₂ O	0.5	50.0	50.00	0.00	0.00
1.A Stationary Combustion – Other fuels	CH ₄	5.0	50.0	50.25	0.00	0.00
1.A Stationary Combustion – Other fuels	CO ₂	5.0	15.0	15.81	0.21	0.14
1.A Stationary Combustion – Other fuels	N ₂ O	5.0	50.0	50.25	0.00	0.00
1.A Stationary Combustion – Solid Fuels	CH ₄	0.5	50.0	50.00	0.00	0.03
1.A Stationary Combustion – Solid Fuels	CO ₂	0.5	0.5	0.71	0.00	0.01
1.A Stationary Combustion – Solid Fuels	N ₂ O	0.5	50.0	50.00	0.00	0.00
1.A.3.a Transport – Civil Aviation	CH ₄	3.0	30.0	30.15	0.00	0.00
1.A.3.a Transport – Civil Aviation	CO ₂	3.0	3.0	4.24	0.00	0.00
1.A.3.a Transport – Civil Aviation	N ₂ O	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CH ₄	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport – Road Transportation – Diesel	CO ₂	3.0	3.0	4.24	0.94	1.18
1.A.3.b Transport – Road Transportation – Diesel	N ₂ O	3.0	30.0	30.15	0.01	0.01
1.A.3.b Transport – Road Transportation – Gaseous	CO ₂	3.0	3.0	4.24	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	CH ₄	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – Gaseous	N ₂ O	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CH ₄	3.0	30.0	30.15	0.00	0.00
1.A.3.b Transport – Road Transportation – Gasoline	CO ₂	3.0	3.0	4.24	0.07	0.10
1.A.3.b Transport – Road Transportation – Gasoline	N ₂ O	3.0	70.0	70.06	0.00	0.01
1.A.3.b Transport – Road Transportation – LPG	CO ₂	3.0	3.0	4.24	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	CH ₄	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – LPG	N ₂ O	3.0	50.0	50.09	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	CH ₄	5.0	50.0	50.25	0.00	0.00

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			K ² + L ²
1.A.3.b Transport – Road Transportation – Biomass	CO ₂	5.0	30.0	30.41	0.00	0.00
1.A.3.b Transport – Road Transportation – Biomass	N ₂ O	5.0	3.0	5.83	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CH ₄	5.0	70.0	70.18	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	CO ₂	5.0	3.0	5.83	0.00	0.00
1.A.3.b Transport – Road Transportation – Other Fuels	N ₂ O	5.0	50.0	50.25	0.00	0.00
1.A.3.c Transport – Railways	CH ₄	3.0	30.0	30.15	0.00	0.00
1.A.3.c Transport – Railways	CO ₂	3.0	3.0	4.24	0.00	0.00
1.A.3.c Transport – Railways	N ₂ O	3.0	30.0	30.15	0.00	0.00
1.A.3.d Transport – Navigation	CH ₄	3.0	30.0	30.15	0.00	0.00
1.A.3.d Transport – Navigation	CO ₂	3.0	3.0	4.24	0.00	0.00
1.A.3.d Transport – Navigation	N ₂ O	3.0	70.0	70.06	0.00	0.00
1.A.3.e Transport – Other Transportation	CH ₄	1.0	50.0	50.01	0.00	0.00
1.A.3.e Transport – Other Transportation	CO ₂	1.0	0.2	1.02	0.00	0.00
1.A.3.e Transport – Other Transportation	N ₂ O	1.0	50.0	50.01	0.00	0.00
1.A.5.b Mobile	CH ₄	1.0	50.0	50.01	0.00	0.00
1.A.5.b Mobile	CO ₂	1.0	0.5	1.12	0.00	0.00
1.A.5.b Mobile	N ₂ O	1.0	50.0	50.01	0.00	0.00
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH ₄	5.0	50.0	50.25	0.00	0.08
1.B.2.a Fugitive Emission – Oil	CH ₄	0.5	50.0	50.00	0.00	0.00
1.B.2.a Fugitive Emission – Oil	CO ₂	0.5	0.5	0.71	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CH ₄	5.0	10.0	11.18	0.00	0.00
1.B.2.b Fugitive Emission – Natural Gas	CO ₂	5.0	0.2	5.00	0.00	0.00
2.A.1 Mineral Industry – Cement Production	CO ₂	1.0	2.0	2.24	0.00	0.00
2.A.2 Mineral Industry – Lime Production	CO ₂	5.0	2.0	5.39	0.00	0.00
2.A.3 Mineral Industry – Glass Production	CO ₂	1.0	2.0	2.24	0.00	0.00
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO ₂	1.0	2.0	2.24	0.00	0.00
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO ₂	30.0	2.0	30.07	0.00	0.00
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO ₂	2.0	2.0	2.83	0.00	0.00
2.A.4.d Other Process Uses of Carbonates – other	CO ₂	0.0	0.0	0.00	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CH ₄	2.0	10.0	10.20	0.00	0.00
2.B.1 Chemical Industry – Ammonia Production	CO ₂	2.0	5.0	5.39	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	CO ₂	2.0	2.0	2.83	0.00	0.00
2.B.2 Chemical Industry – Nitric Acid Production	N ₂ O	2.0	2.0	2.83	0.00	0.00
2.B.5 Chemical Industry – Carbide Production	CO ₂	1.0	5.0	5.10	0.00	0.00
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH ₄	20.0	10.0	22.36	0.00	0.00
2.B.10 Chemical Industry – Other	CH ₄	2.0	2.0	2.83	0.00	0.00
2.B.10 Chemical Industry – Other	CO ₂	2.0	2.0	2.83	0.00	0.00
2.C.1 Metal Industry – Iron and Steel Production	CO ₂	0.5	0.5	0.71	0.01	0.01
2.C.1 Metal Industry – Iron and Steel Production	CH ₄	0.5	20.0	20.01	0.00	0.00
2.C.2 Metal Industry – Ferroalloys Production	CO ₂	5.0	25.0	25.50	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	CO ₂	20.0	5.0	20.62	0.00	0.00
2.C.3 Metal Industry – Aluminium Production	PFC	20.0	50.0	53.85	0.00	0.60
2.C.3 Metal Industry – Aluminium Production	SF ₆	20.0	50.0	53.85	0.00	0.00
2.C.4 Metal Industry – Magnesium Production	SF ₆	5.0	5.0	7.07	0.00	0.00
2.C.5 Metal Industry – Lead Production	CO ₂	5.0	50.0	50.25	0.00	0.00
2.D Non-Energy Products from Fuels and Solvent Use	CO ₂	20.0	30.0	36.06	0.01	0.01

IPCC category/Group	GHG	Activity data	Emission factor / estimation parameter uncertainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in total national emissions
		uncertainty (1)	uncertainty (1)			
		%	%			%
		input data Note A	input data Note A			K ² + L ²
2.E Electronics Industry	HFC	5.0	10.0	11.18	0.00	0.00
2.E Electronics Industry	PFC	5.0	10.0	11.18	0.00	0.00
2.E Electronics Industry	SF ₆	5.0	10.0	11.18	0.00	0.00
2.E Electronics Industry	NF ₃	5.0	10.0	11.18	0.00	0.00
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	10.0	50.0	50.99	1.02	1.09
2.F.2 Foam Blowing	HFC	10.0	0.0	10.00	0.00	0.00
2.F.3 Fire Extinguishers	HFC	10.0	100.0	100.50	0.00	0.00
2.F.4 Aerosols	HFC	20.0	10.0	22.36	0.00	0.00
2.F.5 Solvents	HFC	100.0	0.0	100.00	0.00	0.00
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	5.0	100.0	100.12	0.01	0.00
2.G.2 Other product manufacture and use – SF ₆ and PFCs from other product use	PFC	5.0	100.0	100.12	0.00	0.00
2.G.2 Other product manufacture and use – SF ₆ and PFCs from other product use	SF ₆	5.0	100.0	100.12	0.19	0.07
2.G. Other Product Manufacture and Use	N ₂ O	20.0	0.0	20.00	0.00	0.00
3.A.1 Enteric Fermentation – Cattle	CH ₄	1.0	20.0	20.02	1.40	0.08
3.A.2 Enteric Fermentation – Sheep	CH ₄	10.0	40.0	41.23	0.00	0.00
3.A.3 Enteric Fermentation – Swine	CH ₄	4.0	20.0	20.40	0.00	0.00
3.A.4 Enteric Fermentation – Other	CH ₄	10.0	40.0	41.23	0.00	0.00
3.B.1.1 Manure Management – Cattle	CH ₄	1.0	20.0	20.02	0.02	0.00
3.B.1.1 Manure Management – Cattle	N ₂ O	1.0	100.0	100.00	0.17	0.00
3.B.1.2 Manure Management – Sheep	CH ₄	10.0	30.0	31.62	0.00	0.00
3.B.1.2 Manure Management – Sheep	N ₂ O	10.0	100.0	100.50	0.00	0.00
3.B.1.3 Manure Management – Swine	CH ₄	4.0	20.0	20.40	0.00	0.00
3.B.1.3 Manure Management – Swine	N ₂ O	4.0	100.0	100.08	0.01	0.00
3.B.1.4. Manure Management – Other	CH ₄	10.0	30.0	31.62	0.00	0.00
3.B.1.4. Manure Management – Other	N ₂ O	10.0	100.0	100.50	0.00	0.00
3.B.2.5 Indirect N ₂ O Emissions	N ₂ O	5.0	200.0	200.06	0.11	0.00
3.D.1 Direct N ₂ O Emissions from Managed Soils	N ₂ O	5.0	200.0	200.06	18.12	1.08
3.D.2 Indirect N ₂ O emissions from Managed Soils	N ₂ O	5.0	200.0	200.06	0.71	0.05
3.F Field Burning of Agricultural Residues	CH ₄	100.0	40.0	107.70	0.00	0.00
3.F Field Burning of Agricultural Residues	N ₂ O	100.0	50.0	111.80	0.00	0.00
3.G Liming	CO ₂	5.0	50.0	50.25	0.01	0.00
3.H Urea application	CO ₂	5.0	50.0	50.25	0.00	0.00
3.I Other	CO ₂	5.0	50.0	50.25	0.00	0.00
5.A Solid Waste Disposal	CH ₄			218.82	0.01	0.00
4 Total land use categories	CH ₄			121.48	0.05	0.00
4 Total land use categories	N ₂ O			38.77	3.28	0.00
4.A.1 Forest land remaining forest land	CO ₂			113.34	5.54	0.00
4.A.2 Land converted to forest land	CO ₂			55.88	0.00	0.00
4.B.1 Cropland remaining cropland	CO ₂			50.80	0.03	0.00
4.B.2 Land converted to cropland	CO ₂			228.90	1.04	0.00
4.C.1 Grassland remaining grassland	CO ₂			166.99	0.12	0.00
4.C.2 Land converted to grassland	CO ₂			63.59	0.00	0.00
4.D.1 Wetlands remaining Wetlands	CO ₂			63.59	0.00	0.00
4.D.2 Land converted to Wetlands	CO ₂			30.14	0.11	0.00
4.E.2 Land converted to Settlements	CO ₂			123.14	0.87	0.00
4.F.2 Land converted to Other land	CO ₂			48.99	2.29	0.00
4.G HWP	CO ₂	12.0	25.0	27.73	0.12	1.54
5.B Biological Treatment of Solid Waste	CH ₄	20.0	50.0	53.85	0.00	0.00
5.B Biological Treatment of Solid Waste	N ₂ O	20.0	50.0	53.85	0.00	0.00
5.C Incineration and Open Burning of Waste	CH ₄	7.0	0.0	7.00	0.00	0.00
5.C Incineration and Open Burning of Waste	CO ₂	7.0	20.0	21.19	0.00	0.00
5.C Incineration and Open Burning of Waste	N ₂ O	7.0	0.0	7.00	0.00	0.00

IPCC category/Group	GHG	Activity data	Emission fac- tor / estima- tion parame- ter uncer- tainty (1)	Combined uncertainty	Contribution to variance by category in year x	Uncertainty introduced into the trend in to- tal national emissions
		uncertainty (1)				
		%	%			%
		input data Note A	input data Note A			$K^2 + L^2$
5.D Waste Water Treatment and Discharge	CH ₄	20.0	50.0	53.85	0.00	0.01
5.D Waste Water Treatment and Discharge	N ₂ O	20.0	100.0	101.98	0.05	0.01
Total					36.67	6.26
Total Uncertainties				Uncertainty in total in- ventory %:	6.06	2.50

3 ENERGY (CRF SECTOR 1)

3.1 Sector Overview

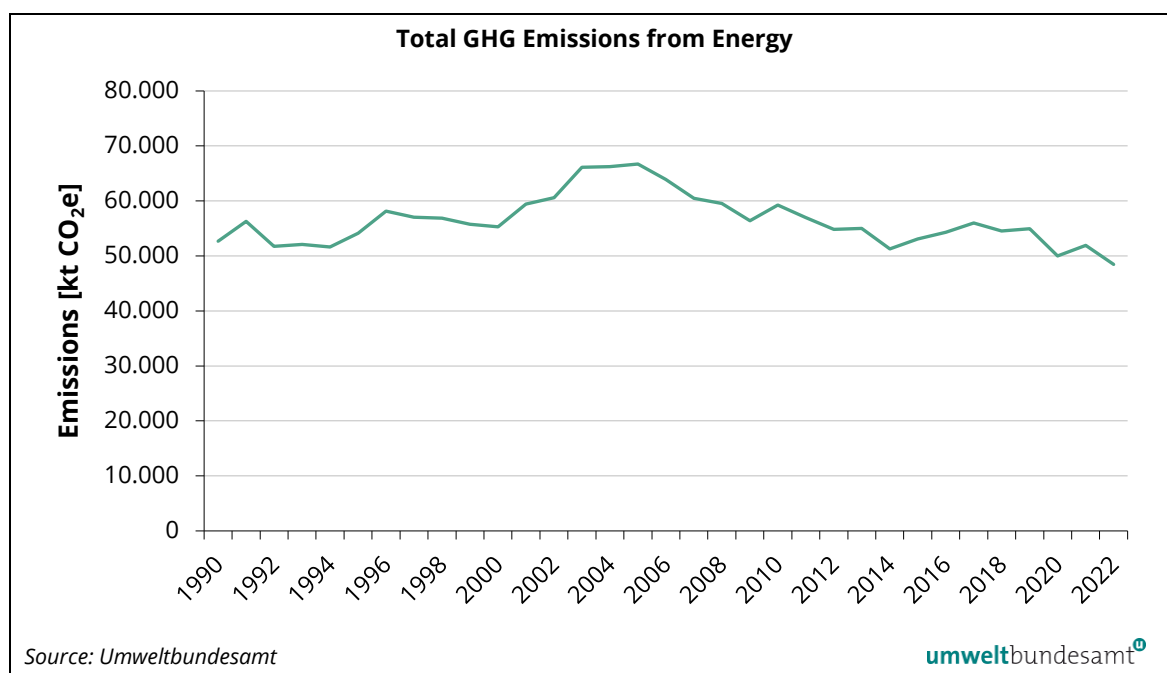
In the energy sector emissions originating from fuel combustion activities in road traffic, in the energy and manufacturing industry and in the commercial, agricultural and residential sector (Category 1.A) as well as fugitive emissions from fuels (Category 1.B) are considered. However, fugitive emissions make up only about 0.6% of total emissions from this sector.

Emissions from the energy sector are the main source of GHGs in Austria. In the year 2022, about 66.5% of national total GHGs emissions and 77% of national total CO₂ emissions from Austria arose from the energy sector.

Emission trends

Emissions from the energy sector decreased by 8% from 52.7 Mt CO₂ equivalents in 1990 to 48.5 Mt CO₂ equivalents in 2022, which is mainly caused by decreasing emissions from energy industries and the residential sector while emissions from the transport sector increased.

Figure 7: Trend of GHG emissions from 1990–2022 for Energy.



Total emissions from energy mainly consist of CO₂ whereas N₂O and CH₄ emissions only make up about 1.1% and 1.2%, respectively. The increase in N₂O emissions is primarily due the increasing activity of transport. The decrease of CH₄ emissions mainly occurs in the residential sector due to a shift to more efficient biomass heating and in category 1.B.1.a Coal Mining and Handling due to the closure of coalmines. The strong increase in CO₂ emissions from 2002 to 2003 is primarily due to increased coal consumption of power plants. Between 2005 and 2022, CO₂ emissions decreased by 27.7%. Between 2021 and 2022, emissions from public electricity and heat generation increased by 1.6%; higher electricity generation from gas turbine power plants offset lower heat production from natural gas. Emissions from road transport decreased by 4.8% due to lower diesel fuel sales,

whereas gasoline sales showed an increase. In 2022, emissions from households (1.A.4.b.i) fell by 16 %, which can be attributed to lower demand for heating due to warm weather conditions (heating degree days were 12.8 % lower than in 2021), but also to high fuel prices.

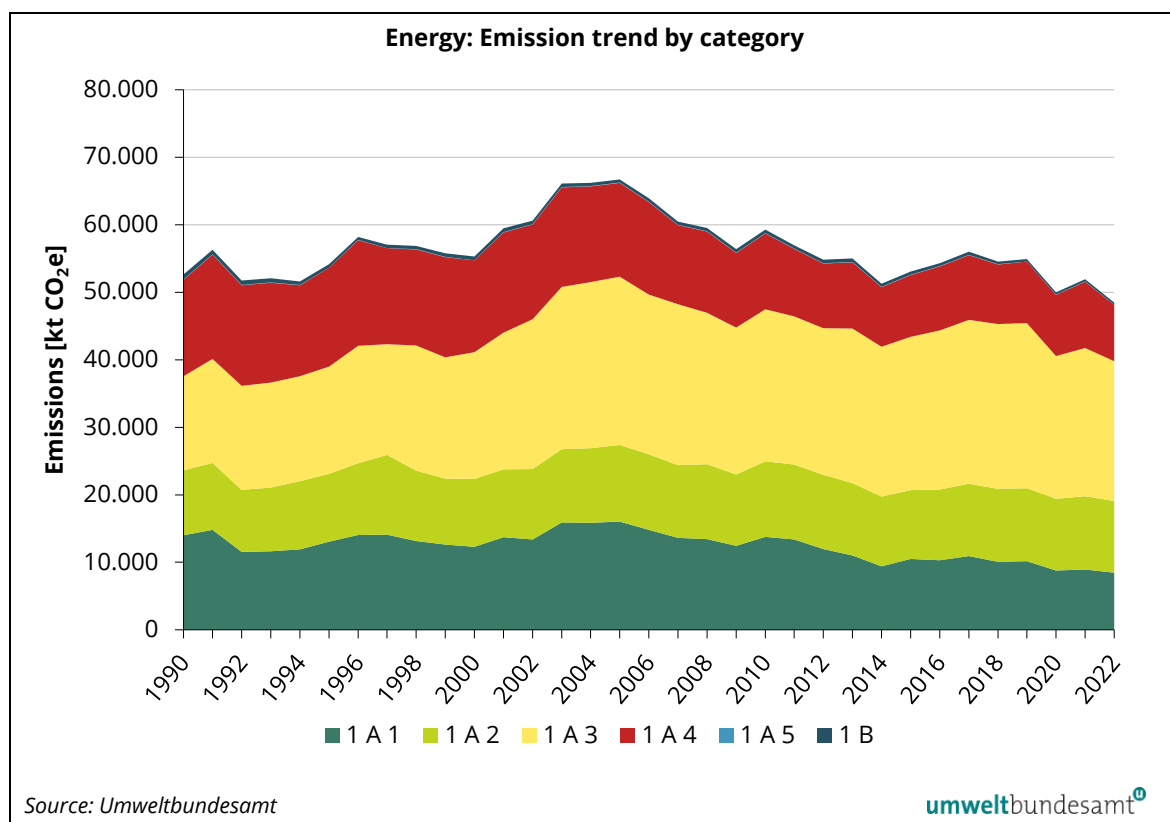
Table 21: Emissions of greenhouse gases and their trend from 1990–2022 from category 1 Energy.

Year	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	kt CO ₂ equivalent
1990	50 930	48.32	1.44	52 666
1995	52 777	34.44	1.59	54 161
2000	53 997	29.84	1.72	55 290
2005	65 475	25.78	1.95	66 714
2010	57 968	27.04	2.09	59 279
2011	55 700	25.71	2.08	56 970
2012	53 530	26.58	2.09	54 829
2013	53 706	26.32	2.12	55 004
2014	50 056	24.21	2.06	51 279
2015	51 824	24.31	2.10	53 062
2016	53 038	24.47	2.12	54 285
2017	54 703	25.83	2.16	55 999
2018	53 343	22.91	2.14	54 553
2019	53 742	22.26	2.15	54 935
2020	48 846	21.70	2.04	49 994
2021	50 684	23.57	2.16	51 916
2022	47 340	20.56	2.07	48 464
1990–2022	-7.0%	-57.5%	43.2%	-8.0%

The most important sub categories regarding total emissions in 1990 were *Energy Industries* (1.A.1), *Transport* (1.A.3) and *Other Sectors* (1.A.4), mainly residential space heating.

While emissions from *Energy Industries* and *Other Sectors* are well below the level of 1990 (-39% and -42% respectively), emissions from *Transport* show higher emissions in 2022 compared to 1990 (+48%) mainly due to an increase of road performance (mileage) of cars (in particular diesel-powered), and freight transport.

Emissions from power plants have decreased since 2005, mainly because of the growing contribution of renewable energy sources, the substitution of solid and liquid fuels by natural gas and biomass, as well as improvements in efficiency. GHG emissions from the residential category have decreased since 1990 because of a change in the fuel mix. The decrease in GHG emissions from *1.B fugitive emissions from fuels* is primarily due to the the gradual closure of coal mines by 2006.

Figure 8: GHG emissions [kt CO₂e] from 1990–2022 from Energy by sub-categories.Table 22: GHG emissions [kt CO₂e] from 1990–2022 from Energy by sub-categories.

	1	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.B	1.B.1	1.B.2
1990	52 666	51 892	14 008	9 609	13 949	14 287	38	774	373	401
1995	54 161	53 656	13 059	10 065	15 845	14 652	35	505	41	463
2000	55 290	54 753	12 314	10 023	18 791	13 582	43	537	30	506
2005	66 714	66 244	16 026	11 361	24 928	13 883	44	471	0	470
2010	59 279	58 777	13 747	11 188	22 567	11 231	43	502	0	502
2011	56 970	56 475	13 409	11 098	21 917	10 011	42	495	0	495
2012	54 829	54 319	11 975	10 993	21 733	9 579	40	510	0	510
2013	55 004	54 499	11 006	10 733	22 911	9 810	39	505	0	505
2014	51 279	50 808	9 387	10 339	22 226	8 819	37	471	0	471
2015	53 062	52 606	10 502	10 204	22 702	9 162	36	456	0	456
2016	54 285	53 862	10 287	10 515	23 554	9 472	34	423	0	423
2017	55 999	55 537	10 903	10 722	24 305	9 573	33	462	0	462
2018	54 553	54 153	10 054	10 833	24 423	8 812	32	400	0	400
2019	54 935	54 561	10 170	10 818	24 472	9 071	30	374	0	374
2020	49 994	49 638	8 800	10 589	21 156	9 065	29	355	0	355
2021	51 916	51 585	8 908	10 892	21 922	9 834	28	331	0	331
2022	48 464	48 153	8 476	10 619	20 712	8 318	28	311	0	311
1990–2022	-8.0%	-7.2%	-39%	10.5%	48.5%	-41.8%	-28.0%	-59.8%	-100.0%	-22.4%

3.2 Fuel Combustion Activities (Category 1.A)

This chapter gives an overview of emissions and key sources of fuel combustion activities. It includes information on completeness, QA/QC, uncertainty, recalculations and planned improvements as well as on emissions, emission trends and methodologies applied (including emission factors). In addition, this chapter provides information on the sectoral/referential approach comparison and the feedstock/non-energy use of fuels.

3.2.1 Comparison of the Sectoral Approach with the Reference Approach

3.2.1.1 Comparison of CO₂ emissions

In the following, CO₂ emissions from the sectoral and reference approach are compared and explanations for the differences are provided.

The reference approach shows 0.6% higher CO₂ emissions in 2022 which is mainly due to solid fuels. The mean value of differences for all years 1990 to 2022 shows that the reference approach is 1.4% higher than the sectoral approach. The mean value for the more recent years 2010 to 2022 shows 0.5% higher CO₂ emissions from the reference approach (with a range of -0.11% to 1.79%).

Since submission 2021, the reference approach considers energy balance data of pure fossil diesel and gasoline while in previous submissions blended biofuels were included in those fuel data. Furthermore, double counting of coal tar in the reference approach is removed and some double counting of liquid fuels is removed in the sectoral approach. In addition, the carbon content of waste non-biomass fraction in the reference approach is harmonized with the sectoral approach.

The following figure shows the results for the two approaches for the period 1990–2022. Solid fuels show the most significant deviation.

Figure 9: CO₂ emissions of the Reference and Sectoral Approach 1990 to 2022.

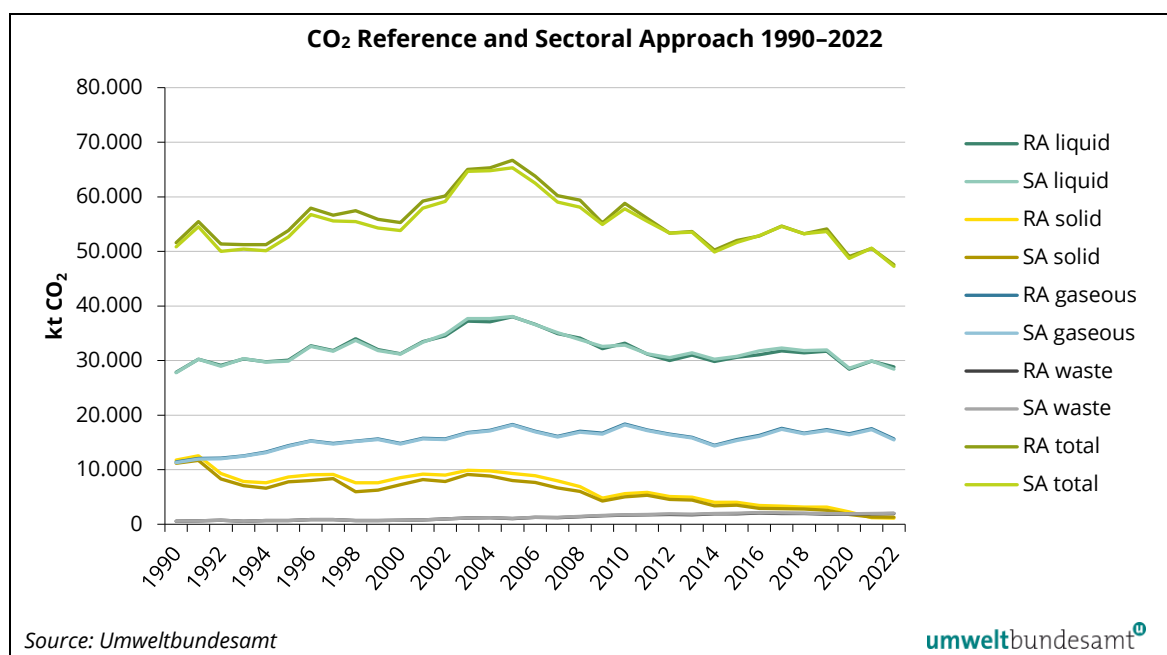


Table 23 presents CO₂ emissions of the sectoral and reference approach in tabular form.

Table 23: CO₂ emissions [kt] of sectoral and reference approach.

	Reference Approach					Sectoral Approach 1 A Fuel Combustion				
	Liquid	Solid	Gaseous	Waste	Total	Liquid	Solid	Gaseous	Waste	Total
1990	27 849	11 766	11 417	580	51 612	27 764	11 183	11 301	580	50 828
1995	30 081	8 653	14 404	690	53 829	29 862	7 779	14 317	690	52 649
2000	31 254	8 512	14 791	714	55 270	31 176	7 248	14 695	714	53 833
2005	38 023	9 318	18 293	1 059	66 693	38 072	8 013	18 156	1 073	65 315
2010	33 193	5 583	18 366	1 678	58 820	32 803	5 019	18 209	1 754	57 785
2011	31 185	5 828	17 288	1 738	56 040	31 230	5 331	17 144	1 815	55 520
2012	29 980	5 051	16 523	1 819	53 374	30 517	4 553	16 382	1 895	53 347
2013	30 998	4 938	15 954	1 757	53 647	31 412	4 450	15 821	1 832	53 515
2014	29 840	4 038	14 476	1 886	50 240	30 234	3 355	14 325	1 973	49 887
2015	30 564	4 018	15 523	1 919	52 024	30 784	3 497	15 369	2 011	51 662
2016	31 068	3 428	16 278	2 066	52 840	31 759	2 893	16 112	2 143	52 907
2017	31 775	3 322	17 570	1 995	54 663	32 266	2 826	17 407	2 066	54 565
2018	31 432	3 140	16 720	1 964	53 256	31 828	2 779	16 569	2 041	53 216
2019	31 727	3 139	17 350	1 879	54 095	31 913	2 577	17 180	1 953	53 623
2020	28 402	2 260	16 547	1 870	49 078	28 619	1 803	16 382	1 932	48 737
2021	29 887	1 230	17 498	1 931	50 545	29 937	1 330	17 336	1 996	50 600
2022	28 820	1 115	15 620	1 985	47 540	28 447	1 302	15 463	2 047	47 260

Table 24 presents the difference of CO₂ emissions in percent between reference and sectoral approach.

Table 24: Difference of CO₂ emissions by type of fuel in percent.

Year	Liquid	Solid	Gaseous	Waste	Total
1990	0.31%	5.21%	1.03%	0.00%	1.54%
1995	0.73%	11.23%	0.61%	0.00%	2.24%
2000	0.25%	17.44%	0.65%	0.00%	2.67%
2005	-0.13%	16.28%	0.75%	-1.30%	2.11%
2010	1.19%	11.25%	0.86%	-4.33%	1.79%
2011	-0.14%	9.32%	0.84%	-4.23%	0.94%
2012	-1.76%	10.95%	0.86%	-3.99%	0.05%
2013	-1.32%	10.98%	0.84%	-4.09%	0.25%
2014	-1.30%	20.34%	1.05%	-4.43%	0.71%
2015	-0.71%	14.88%	1.00%	-4.58%	0.70%
2016	-2.18%	18.49%	1.03%	-3.60%	-0.13%
2017	-1.52%	17.57%	0.93%	-3.42%	0.18%
2018	-1.24%	12.99%	0.91%	-3.77%	0.07%
2019	-0.58%	21.79%	0.99%	-3.76%	0.88%
2020	-0.76%	25.33%	1.01%	-3.25%	0.70%
2021	-0.17%	-7.56%	0.93%	-3.27%	-0.11%
2022	1.31%	-14.38%	1.02%	-3.05%	0.59%

Positive numbers indicate that CO₂ emissions from the reference approach are higher than emissions from the sectoral approach.

Explanation of differences

- **Solid fuels:** In the sectoral approach plant specific CO₂ emission factors are used for large coal boilers since 2005

According to the IPCC 2006 Guidelines, the total coal consumption from **integrated steel plants** except the use for coke production must be reported in category 2.C.1. The methodology of calculating 2.C.1 emissions includes higher uncertainty, because year specific carbon

contents of the different fuel types are not available at the level of final use, and because total reported CO₂ emissions from integrated steel plants are calculated by means of an **input/output mass balance**. Thus, the emissions reported under 1.A.2.a covers the uncertainty of the approach for 2.C.1. E.g. in 2022 about 10.2 Mt of solid fuels CO₂ from integrated iron plants are considered in 2.C.1 and 1.4 Mt CO₂ are considered in 1.A.2.a.

- *Liquid Fuels*: The energy balance is mass-balanced but not carbon balanced. Fuel category *Other Oil* is an aggregation of several fuel types and therefore it is difficult to quantify a reliable carbon emission factor for the reference approach. The reference approach takes a share of feedstocks used for plastics and solvent production as non-carbon stored. In the sectoral approach, emissions from plastics waste incineration are reported as “other fuels”, but in the reference approach, it is included in “liquid fuels”. Emissions from solvent use are included in category 2.D.3 under subcategory *Solvent Use*.
- *Gaseous fuels*: The small difference is due to the methodological uncertainty of subtracting emissions from Non-Energy Use used for chemical processes.
- *Other fuels*: The sectoral approach considers industrial waste with sector/plant specific carbon contents since the year 2005 while the methodology for the reference approach uses a single emission factor of 75 t CO₂/TJ. Furthermore, the activity data for the MSW non-bio-mass-fraction has been taken from the national energy balance while for the sectoral approach a different fraction has been chosen.

At current, it is not possible to quantify the amount of solvents and plastic products, which are imported or exported by products, bulk or waste.

- In the sectoral approach, sector- or even plant-specific net calorific values are taken to calculate the energy consumption, whereas in the reference approach, average (country specific) calorific values are applied.

3.2.1.2 Comparison of energy consumption

Table 25 shows the energy consumption of the two approaches. For the reference approach, non-energy consumption according to the energy balance is subtracted. The comparison shown in Table 25 is equal to CRF table 1.A(c). Please note that positive numbers indicate that the RA shows higher energy consumption than the SA.

Table 25: Energy consumption of sectoral and reference approach in [PJ].

Year	Reference Approach excluding non energy use and reductants					Sectoral Approach				
	Liquid	Solid	Gaseous	Waste	Total	Liquid	Solid	Gaseous	Waste	Total
1990	374.7	118.0	204.0	8.1	704.8	368.4	113.5	204.0	7.7	693.5
1995	407.6	87.3	258.8	9.4	763.1	393.9	79.9	258.4	8.9	741.0
2000	423.2	85.9	262.5	10.5	782.1	417.2	74.7	265.3	9.8	767.0
2005	515.7	92.9	325.2	16.7	950.4	508.7	84.9	327.7	14.8	936.1
2010	449.6	64.4	324.2	25.0	863.2	439.6	53.7	328.7	22.5	844.5
2011	423.6	67.0	307.0	27.5	825.2	418.6	57.2	309.5	24.2	809.5
2012	406.1	58.7	293.5	26.7	785.0	408.2	49.0	295.7	24.0	777.0
2013	419.5	58.1	283.1	26.0	786.6	420.3	48.2	285.6	23.8	777.9
2014	404.2	46.5	256.3	26.2	733.1	404.5	36.1	258.6	24.4	723.5
2015	412.8	48.0	275.2	27.3	763.4	411.6	37.4	277.4	24.6	751.0
2016	419.2	42.3	288.9	29.3	779.7	423.4	31.1	290.8	26.2	771.5
2017	429.2	41.0	311.6	28.1	809.9	431.0	30.5	314.2	25.2	800.9
2018	424.0	39.5	296.6	26.9	787.0	426.0	29.9	299.1	24.9	779.9

Year	Reference Approach excluding non energy use and reductants					Sectoral Approach				
	Liquid	Solid	Gaseous	Waste	Total	Liquid	Solid	Gaseous	Waste	Total
2019	427.4	35.1	306.4	26.0	794.9	427.5	27.6	309.0	23.7	787.7
2020	383.0	26.0	292.1	27.3	728.5	383.2	19.3	294.6	23.7	720.7
2021	402.2	16.0	309.8	27.1	755.2	400.8	14.1	311.8	23.9	750.6
2022	388.4	14.7	276.1	28.4	707.6	381.6	13.8	278.1	25.3	698.8

Table 26: Difference of energy consumption by type of fuel in percent.

Year	Liquid	Solid	Gaseous	Waste	Total
1990	1.7%	4.0%	0.0%	4.6%	1.6%
1995	3.5%	9.3%	0.2%	6.5%	3.0%
2000	1.4%	15.0%	-1.0%	7.0%	2.0%
2005	1.4%	9.4%	-0.8%	12.6%	1.5%
2010	2.3%	19.8%	-1.4%	10.9%	2.2%
2011	1.2%	17.2%	-0.8%	13.5%	1.9%
2012	-0.5%	19.9%	-0.8%	11.1%	1.0%
2013	-0.2%	20.5%	-0.9%	9.2%	1.1%
2014	-0.1%	28.8%	-0.9%	7.6%	1.3%
2015	0.3%	28.3%	-0.8%	11.2%	1.7%
2016	-1.0%	35.9%	-0.7%	12.0%	1.1%
2017	-0.4%	34.5%	-0.8%	11.6%	1.1%
2018	-0.5%	32.4%	-0.8%	7.9%	0.9%
2019	0.0%	27.1%	-0.8%	9.7%	0.9%
2020	0.0%	35.1%	-0.8%	15.5%	1.1%
2021	0.4%	13.6%	-0.6%	13.3%	0.6%
2022	1.8%	6.8%	-0.7%	12.2%	1.3%

Energy consumption is different between the two approaches because

- Transformation and distribution losses are not considered in the sectoral approach.
- The sectoral approach uses sector-specific NCVs.
- The methodology of the approaches is not comparable at fuel type level.

Changed methodologies

Since submission 2021, the reference approach considers energy balance data of pure fossil diesel and gasoline while in previous submissions blended biofuels were included in those fuel data. Furthermore, double counting of coal tar in the reference approach has been removed and some double counting of liquid fuels is removed in the sectoral approach. In addition, the carbon content of waste non-biomass fraction in the reference approach has been harmonized with the sectoral approach.

Recalculations

Recalculations follow the revisions of the energy balance.

Following a recommendation from the UNFCCC review 2023, total apparent consumption (excluding NEU, reductants and feedstocks) for liquid fuels has been revised by subtracting the non-energy use of naphtha, which is about 37 PJ for 2022.

3.2.2 International bunker fuels

3.2.2.1 International aviation

In 2022, the share of international aviation in the total fuel consumption in the aviation sector in Austria represents 98.5% (defined on energy content). Greenhouse gas emissions and activity data from aviation assigned to international bunkers include the transport modes international airport traffic (LTO-cycles) and international cruise traffic for IFR-flights (International Flight Rules) as shown in the following Table 27.

Table 27: Greenhouse gas emissions and activity from international bunkers-aviation 1990–2022.

	CO ₂ [kt]		CH ₄ [kt]		N ₂ O [kt]		Activity [TJ]
	int. LTO	int. cruise	int. LTO	Int. cruise	int. LTO	int. cruise	int. LTO + int. cruise
Year	Kerosene						
1990	116	764	0.01	NA	0.005	0.02	12 097
1995	176	1 157	0.02	NA	0.008	0.04	18 315
2000	210	1 485	0.03	NA	0.010	0.05	23 296
2005	270	1 689	0.04	NA	0.012	0.05	26 927
2010	276	1 773	0.04	NA	0.012	0.06	28 159
2011	314	1 854	0.05	NA	0.014	0.06	29 793
2012	302	1 771	0.04	NA	0.014	0.06	28 477
2013	294	1 682	0.04	NA	0.013	0.05	27 141
2014	297	1 680	0.04	NA	0.013	0.05	27 177
2015	313	1 814	0.05	NA	0.013	0.06	29 243
2016	321	2 004	0.02	NA	0.009	0.06	31 957
2017	310	1 936	0.01	NA	0.009	0.05	30 873
2018	338	2 192	0.02	NA	0.009	0.06	34 777
2019	381	2 525	0.02	NA	0.010	0.07	40 032
2020	148	896	0.01	NA	0.004	0.02	14 381
2021	173	1 055	0.01	NA	0.005	0.03	16 913
2022	279	1 688	0.01	NA	0.008	0.05	27 039
1990–2022	139%	121%	-7%		44%	88%	124%

Methodological Issues

Emissions have been calculated using the methodology and emission factors as described in 1.A.3.a Civil Aviation.

Recalculations

No category specific recalculations have been carried out.

Planned Improvements

The emission factor spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2019' (EEA 2019) has been updated in autumn 2023 (EEA 2023a). Austria will update its aviation calculation tool for the next submission.

3.2.2.2 International navigation

In 2022, the share of international navigation in the total fuel consumption in the navigation sector in Austria represented 41% (defined on energy content).

Methodological Issues

Since 2010, greenhouse gas emissions from water-borne navigation (inland navigation on the River Danube) have been reported separately for the national and the international share of navigation from 1990 onwards.

For this purpose Austria uses a bottom-up method to calculate the international fuel consumption in navigation which is based on freight transport activities on the River Danube. As domestic navigation on the River Danube is navigation between Danube harbours located within Austria, international navigation is navigation across national boundaries and transit navigation, expressed in:

tons x kilometers → (GWh/tkm*tkm; CO₂/tkm*tkm etc.)

As inland tkm on the Danube are used to calculate bottom-up domestic navigation, tkm from import, export and transit-activities on the Danube are used to calculate the international share of navigation on the Danube.

Statistical data (tkm) for freight activities (split up into inland, import, export and transit tkm) on the River Danube were obtained from (VIA DONAU 2023). For detailed methodological issues concerning factors like kg diesel/tkm and emissions factors see the results of the model GEORG as described in 1.A.2 g.vii.

Activity Data & Emission Factors

Activity data and implied emission factors from navigation assigned to international bunkers are presented in the following table.

Table 28: Emission factors and activity data for international bunkers-marine 1990–2022.

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	619	74.2	4.8	33.3
1995	770	74.2	4.7	33.5
2000	905	74.2	4.5	33.9
2005	1 005	74.2	3.8	33.0
2010	882	74.2	2.6	27.5
2011	779	74.2	2.4	26.4
2012	794	74.2	2.3	25.8
2013	849	74.2	2.3	25.3

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
2014	785	74.4	2.2	24.8
2015	645	74.4	2.1	24.2
2016	704	74.4	2.1	23.7
2017	728	74.4	2.0	23.2
2018	530	74.4	2.0	22.9
2019	610	74.4	1.9	22.7
2020	572	74.4	1.9	22.4
2021	523	74.4	1.9	22.2
2022	434	74.4	1.9	21.9

Recalculations

For 2021 a linking error in the 'Danube Shipping' module of the off-road transport model GEORG has been corrected resulting in a revised energy consumption of 523.06 TJ (instead of 823.24 TJ).

Planned Improvements

No category-specific improvements are planned.

3.2.3 Feedstocks and non-energy use of fuels

Non-energy use of fuels is considered in the national energy balance. This chapter presents explanations for the reported non-energy use together with information on where CO₂ emissions due to the manufacture, use and disposal of carbon containing products are considered.

Lubricants

manufacture: emissions are assumed to be included in total emissions from category 1.A.1.b petroleum refinery.

use: VOC emissions from lubricants used in rolling mills are considered in category 2.C.1. It is assumed that other uses of lubricants do not result in VOC or CO₂ emissions due to the low vapour pressure of lubricants.

CO₂ from lubricants which are used in engines are considered in category 2.D.1.

disposal: In case that waste oil is used as fuel, emissions from incineration of lubricants (waste oil) are included in categories 1.A.1.a and 1.A.2. In case that energy is not recovered, incineration of waste oil is reported under category 5.C.

Bitumen

manufacture: emissions from the production of bitumen are assumed to be included in total emissions of category 1.A.1.b petroleum refinery.

use: GHG emissions from the use of bitumen for road paving and roofing are considered as not applicable/negligible.

disposal: CO₂ emissions from the disposal from bitumen are assumed to be negligible. Recycling is not considered.

Naphtha

manufacture: Naphta is produced in the oil refinery and transferred to a petrochemical plant. Residues from the petrochemical plants are transferred back to the oil refinery steam cracker.

use: Naphta is used for plastics production (e.g. ethylene).

Petroleum coke

In IEA JQ (2023), non energy use is reported for the manufacture of electrodes.

manufacture: No information about emissions from manufacture of electrodes is currently available.

use: Emissions from the use of electrodes are considered in category 2.B.4 carbide production and 2.C metal production.

Residual fuel oil

use: Considerable amounts of residual fuel are used in blast furnaces until the year 2015. Emissions are considered in 2.C.1.

Coking coal, Bituminous coal, Coke oven coke, Coal Tar

manufacture: emissions from the production of coke are considered in category 1.A.2.a.

use: CO₂ emissions from coal, coke and coal tar used in iron and steel industry are reported under 2.C. The use of coal tar as a reductant in blast furnaces is considered under category 2.C.1 and is relevant for the years 2010-2014 only.

Natural Gas

use: emissions from the use of natural gas as a feedstock in ammonia production are accounted for in the industrial processes sector (category 2.B.1).

Plastics waste

manufacture: Emissions from manufacture of plastics are considered in category 2.B.

use: plastics waste is used as a reductant in blast furnaces since the year 2006. Emissions are considered in 2.C.1.

disposal: Any emissions from waste disposal are considered in category 5.A. Waste incineration with energy use is considered in 1.A – *other fossil fuels* and – to a minor degree – waste incineration without energy recovery is considered in category 5.C.

Solvents

manufacture: emissions from the production of solvents are considered in sector 2.D.3

use: Indirect CO₂ emissions from solvent use are considered in sector 2.D.3. Incineration of waste solvents is considered under category 1.A – *other fossil fuels*.

disposal: emissions from the disposal of solvents are considered in 5.A.

Paraffin wax

use: CO₂ emissions from paraffin wax use are considered in sector 2.D.2.

Lubricants

use: CO₂ emissions from lubricants use are considered in sector 2.D.1.

3.2.4 CO₂ capture from flue gases and subsequent CO₂ storage, if applicable

CO₂ capture from flue gases and CO₂ storage is not occurring in Austria.

3.2.5 Country-specific issues

With regard to country-specific issues, it can be referred to Chapter 3.2.9, where point source emissions as well as the CO₂ emission trading system (ETS) are considered.

3.2.6 Source Category Description

Transport (1.A.3)

In 2022, the most important source of GHGs was the category *1.A.3 Transport* with a share of 28% in total national GHG emissions. 16.4% of national GHG emissions were released by passenger cars, 2.4% by light duty vehicles, 9% by heavy-duty vehicles and 0.2% by mopeds and motorcycles. Austria's railway system is mainly driven by electricity, only 0.1% of overall GHGs originate from this category. Fuels used by ships on inland waterways have a share of 0.1% in total GHG emissions. Because Austria is a landlocked country, there is no occurrence of maritime activities. However, emissions from international transport at inland waterways are excluded from the national total and reported as marine bunkers. About 0.04% of national GHG arise from domestic aviation. Gas pipeline compressors contribute 0.2% to national GHG emissions.

Manufacturing Industries (1.A.2)

Combustion in *manufacturing industries and construction* was the second largest sub-category with a share of 15% in 2022 national total GHG emissions. This category also includes mobile machinery mainly used in the construction sector. Considerably large amounts of CO₂-emissions from non-energy fuel use, such as reducing agents used in iron and steel industries and natural gas used for ammonia production, are reported as emissions from industrial processes (CRF Category 2).

Energy Industries (1.A.1)

The third largest GHG source of the energy sector in 2022 with a share of 12% total GHG emissions was *energy industries*, where fossil fuels are used for electrical power and district heating production. In the year 2022, overall gross public electricity production was 61 781 GWh⁴⁶, of which 38 952 GWh (63%) were generated by hydro plants, 11 803 GWh (19%) by thermal power plants and 11 021 GWh (18%) by wind, solar and geothermal power plants. Industrial auto producers generated 11 206 GWh of electricity in the year 2022. There are no operating nuclear plants in Austria. Due to the importance of hydropower, the seasonal water situation in Austria has a high influence on the need for electric power generation by fossil fuels. In energy industries, biomass is mainly

⁴⁶ Source: IEA Questionnaire December/2021 by STATISTIK AUSTRIA.

used by smaller district heating plants. The oil refining industry, which consists of only one plant in Austria, is also included in this category (sub-category *1.A.1.b Petroleum refining*). Crude oil input of the oil refinery was 5.6 Mt in 2022. Furthermore, this category includes emissions from other energy industries, which is mainly natural gas consumption of the oil/gas exploration sector and of gas refining industries (sub-category *1.A.1.c Manufacture of Solid Fuels and Other Energy Industries*).

Other Sectors (1.A.4)

Fossil fuels, mainly used for space and water heating in the commercial, agricultural and household sector (sub-category *1.A.4 Other Sectors* or “small combustion” sector), formed the fourth largest category within sector energy, with a share of 11% in 2022 total national GHG emissions. Emissions of this category are very dependent on the climatic circumstances and on the economic trend. E.g. a “cold winter” in combination with a low heating oil price may increase emissions from space heating significantly. In Austria a large share of solid biomass consumption is used for space and water heating. Category *1.A.4* also includes emissions from mobile machinery mainly used in agriculture and forestry.

Military (1.A.5)

Category *1.A.5 Other* includes emissions from military air and road transport as well as from other mobile machinery. It contributes 0.04% to total GHG emissions in 2022.

3.2.7 Key Categories

The methodology and results of the key category analysis is presented in Chapter 1.5.

3.2.8 Completeness

Table 29 provides an overview of the IPCC 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. “NO” indicates that the Austrian energy balance does not quote any energy consumption for the relevant sector and fuel category.

Emissions of all sources of category *1.A Fuel Combustion* have been estimated; the status of emission estimates of this category is complete.

Table 29: Overview of subcategories of Category 1.A Fuel Combustion: transformation into SNAP Codes and status of estimation for the year 2022.

IPCC Category	SNAP	Status		
		CO ₂	CH ₄	N ₂ O
1.A.1.a Public Electricity and Heat Production	0101 Public power 0102 District heating plants			
1.A.1.a Liquid Fuels		✓	✓	✓
1.A.1.a Solid Fuels		✓	✓	✓
1.A.1.a Gaseous Fuels		✓	✓	✓
1.A.1.a Biomass		✓	✓	✓
1.A.1.a Other Fuels		✓	✓	✓

IPCC Category	SNAP	Status		
		CO ₂	CH ₄	N ₂ O
1.A.1.b Petroleum refining	0103 Petroleum refining plants			
1.A.1.b Liquid Fuels		✓	✓	✓
1.A.1.b Solid Fuels		NO	NO	NO
1.A.1.b Gaseous Fuels		✓	✓	✓
1.A.1.b Biomass		NO	NO	NO
1.A.1.b Other Fuels		NO	NO	NO
1.A.1.c Manufacture of Solid fuels and Other Energy Industries	010503 Oil/Gas Extraction plants			
1.A.1.c Liquid Fuels		✓	✓	✓
1.A.1.c Solid Fuels		IE ⁽¹⁾	IE ⁽¹⁾	IE ⁽¹⁾
1.A.1.c Gaseous Fuels		✓	✓	✓
1.A.1.c Biomass		NO	NO	NO
1.A.1.c Other Fuels		NO	NO	NO
1.A.2.a Iron and Steel	0301 Comb. In boilers, gas turbines and stationary engines (Iron and Steel Industry) 030326 Processes with Contact-Other(Iron and Steel Industry)			
1.A.2.a Liquid Fuels		✓	✓	✓
1.A.2.a Solid Fuels		✓	✓	✓
1.A.2.a Gaseous Fuels		✓	✓	✓
1.A.2.a Biomass		✓	✓	✓
1.A.2.a Other Fuels		NO	NO	NO
1.A.2.b Non-ferrous Metals	0301 Comb. In boilers, gas turbines and stationary engines (Non-ferrous Metals Industry)			
1.A.2.b Liquid Fuels		✓	✓	✓
1.A.2.b Solid Fuels		✓	✓	✓
1.A.2.b Gaseous Fuels		✓	✓	✓
1.A.2.b Biomass		✓	✓	✓
1.A.2.b Other Fuels		✓	✓	✓
1.A.2.c Chemicals	0301 Comb. in boilers, gas turbines and stationary engines (Chemical Industry)			
1.A.2.c Liquid Fuels		✓	✓	✓
1.A.2.c Solid Fuels		✓	✓	✓
1.A.2.c Gaseous Fuels		✓	✓	✓
1.A.2.c Biomass		✓	✓	✓
1.A.2.c Other Fuels		✓	✓	✓
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.d Liquid Fuels		✓	✓	✓
1.A.2.d Solid Fuels		✓	✓	✓
1.A.2.d Gaseous Fuels		✓	✓	✓
1.A.2.d Biomass		✓	✓	✓
1.A.2.d Other Fuels		✓	✓	✓
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.e Liquid Fuels		✓	✓	✓
1.A.2.e Solid Fuels		✓	✓	✓
1.A.2.e Gaseous Fuels		✓	✓	✓

IPCC Category	SNAP	Status		
		CO ₂	CH ₄	N ₂ O
1.A.2.e Biomass		✓	✓	✓
1.A.2.e Other Fuels		✓	✓	✓
1.A.2.f Non-Metallic Minerals	030311 Cement 030317 Glass 030312 Lime 030319 Bricks and Tiles 030323 Magnesia production (dolomite treatment)			
1.A.2.f Liquid Fuels		✓	✓	✓
1.A.2.f Solid Fuels		✓	✓	✓
1.A.2.f Gaseous Fuels		✓	✓	✓
1.A.2.f Biomass		✓	✓	✓
1.A.2.f Other Fuels		✓	✓	✓
1.A.2.g Other	0301 Comb. in boilers, gas turbines and stationary engines 0808 Other Mobile Sources and Machinery-Industry			
1.A.2.g Liquid Fuels		✓	✓	✓
1.A.2.g Solid Fuels		✓	✓	✓
1.A.2.g Gaseous Fuels		✓	✓	✓
1.A.2.g Biomass		✓	✓	✓
1.A.2.g Other Fuels		✓	✓	✓
1.A.3.a Civil Aviation	080501 Domestic airport traffic (LTO cycles – < 1 000 m) 080503 Domestic cruise traffic (> 1 000 m)			
1.A.3.a Aviation Gasoline		✓	✓	✓
1.A.3.a Jet Kerosene		✓	✓	✓
1.A.3.b Road Transportation	0701 Passenger cars 0702 Light duty vehicles < 3.5 t 0703 Heavy duty vehicles > 3.5 t and buses 0704 Mopeds and Motorcycles < 50 cm³ 0705 Motorcycles > 50 cm³ 0706 Gasoline evaporation from vehicles			
1.A.3.b Gasoline		✓	✓	✓
1.A.3.b Diesel Oil		✓	✓	✓
1.A.3.b LPG		✓	✓	✓
1.A.3.b Gaseous Fuels		✓	✓	✓
1.A.3.b Biomass		✓	✓	✓
1.A.3.b Other Fuels		✓	IE ⁽²⁾	IE ⁽²⁾
1.A.3.c Railways	0802 Other Mobile Sources and Machinery-Railways			
1.A.3.c Liquid Fuels		✓	✓	✓
1.A.3.c Solid Fuels		✓	✓	✓
1.A.3.c Gaseous		NO	NO	NO
1.A.3.c Biomass		✓	✓	✓
1.A.3.c Other Fuels		✓	IE ⁽²⁾	IE ⁽²⁾
1.A.3.d Navigation	0803 Other Mobile Sources and Machinery-Inland waterways			
1.A.3.d Residual Oil		NO	NO	NO
1.A.3.d Gas/Diesel oil		✓	✓	✓
1.A.3.d Gasoline		✓	✓	✓
1.A.3.d Gaseous		NO	NO	NO
1.A.3.d Biomass		✓	✓	✓
1.A.3.d Other Fuels		✓	IE ⁽²⁾	IE ⁽²⁾

IPCC Category	SNAP	Status		
		CO ₂	CH ₄	N ₂ O
1.A.3.e.i Pipeline Transport	010506 Pipeline Compressors			
1.A.3.e.i Gaseous Fuels		✓	✓	✓
1.A.3.e.ii Other - Airport Ground activities	0810 Other off-road (Airport Ground Activities)			
1.A.3.e.ii Liquid Fuels		✓	✓	✓
1.A.3.e.ii Gaseous Fuels		✓	✓	✓
1.A.3.e.ii Other Fuels		✓	IE ⁽²⁾	IE ⁽²⁾
1.A.3.e.ii Biomass		✓	✓	✓
1.A.4.a Commercial/Institutional	0201 Commercial and institutional plants			
1.A.4.a Liquid Fuels		✓	✓	✓
1.A.4.a Solid Fuels		✓	✓	✓
1.A.4.a Gaseous Fuels		✓	✓	✓
1.A.4.a Biomass		✓	✓	✓
1.A.4.a Other Fuels		✓	✓	✓
1.A.4.b Residential	0202 Residential plants 0809 Other Mobile Sources and Machinery-Household and gardening			
1.A.4.b Liquid Fuels		✓	✓	✓
1.A.4.b Solid Fuels		✓	✓	✓
1.A.4.b Gaseous Fuels		✓	✓	✓
1.A.4.b Biomass		✓	✓	✓
1.A.4.b Other Fuels		✓	IE ⁽²⁾	IE ⁽²⁾
1.A.4.b Peat		✓	✓	✓
1.A.4.c Agriculture/Forestry/Fisheries	0203 Plants in agriculture, forestry and aquaculture 0806 Other Mobile Sources and Machinery-Agriculture 0807 Other Mobile Sources and Machinery-Forestry			
1.A.4.c Liquid Fuels		✓	✓	✓
1.A.4.c Solid Fuels		✓	✓	✓
1.A.4.c Gaseous Fuels		✓	✓	✓
1.A.4.c Biomass		✓	✓	✓
1.A.4.c Other Fuels		✓	IE ⁽²⁾	IE ⁽²⁾
1.A.5 Other	0801 Other Mobile Sources and Machinery-Military			
1.A.5 Liquid Fuels		✓	✓	✓
1.A.5 Solid Fuels		NO	NO	NO
1.A.5 Gaseous Fuels		NO	NO	NO
1.A.5 Biomass		✓	✓	✓
1.A.5 Other Fuels		✓	IE ⁽²⁾	IE ⁽²⁾
Marine Bunkers	080404 International sea traffic (international bunkers)			
Gasoline		NO	NO	NO
Gas/Diesel oil		✓	✓	✓
Residual Fuel Oil		NO	NO	NO
Lubricants		NO	NO	NO
Coal		NO	NO	NO
Other Fuels		NO	NO	NO
Aviation Bunkers	080502 International airport traffic (LTO cycles - < 1 000 m) 080504 International cruise traffic (> 1 000 m)			
Jet Kerosene		✓	✓	✓

IPCC Category	SNAP	Status		
		CO ₂	CH ₄	N ₂ O
Gasoline		NO	NO	NO
Multilateral Operations		NO	NO	NO

⁽¹⁾ Emissions from coke ovens are included in 1.A.2.a iron and steel industries

⁽²⁾ Other fuels include the share of fossil methanol in FAME (biodiesel). CH₄ and N₂O emissions of this share are reported under biomass.

3.2.9 Methodology Overview

Stationary combustion

For stationary combustion the IPCC Tier 1 and Tier 2 methodologies have been applied. Activity data are taken either from national statistics or from the IEA/EUROSTAT joint questionnaires. Calorific values used for conversion of fuel activity data from [tonnes] and [cubic metres] into [Terajoule] are country specific. Country specific emission factors are fuel and technology dependent.

Mobile sources

For mobile sources either Tier 3 or country specific methods (Tier 2) have been applied, where technology dependent activity data are calculated by means of a bottom up model and adjusted to top down activity data. Bottom up activity data are calculated by means of vehicle-kilometres, vehicle stock statistics and operating condition dependant fuel consumption per vehicle kilometre. Bottom up fuel consumption of civil aviation is calculated by aircraft specific LTO-cycle and cruise-kilometre consumption. Top down activity data are based on fuel sales taken from the national energy balance.

Table 30: Overview of applied 1.A Methodologies by source and gas.

	Method			Emission factor		
	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
1 A 1 a liquid	T2	T1	T1	CS	D	D
1 A 1 a solid	T2	T1	T1	CS	D	D
1 A 1 a gaseous	T2	T1	T1	CS	D	D
1 A 1 a other	T2	T2	T1	CS	CS	D
1 A 1 a biomass	T1	T1,T2	T1	D	CS,D	D
1 A 1 b liquid	T2	T1	T1	CS	D	D
1 A 1 b gaseous	T2	T1	T1	CS	D	D
1 A 1 c 2 gaseous	T2	T1	T1	CS	D	D
1 A 1 c 3 gaseous	T2	T1	T1	CS	D	D
1 A 1 c 3 biomass	NA	T1	NA	NA	D	NA
1 A 2 a liquid	T2	T1	T1	CS	D	D
1 A 2 a solid	T2	T1	T1	CS	D	D
1 A 2 a gaseous	T2	T1	T1	CS	D	D
1 A 2 a biomass	T1	T2	T1	D	CS	D
1 A 2 b liquid	T2	T1	T1	CS	D	D
1 A 2 b solid	T2	T1	T1	CS	D	D
1 A 2 b gaseous	T2	T1	T1	CS	D	D
1 A 2 b other	T2	T2	T1	CS	CS	D

	Method			Emission factor		
	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
1 A 2 b biomass	T1	T2	T1	D	CS	D
1 A 2 c liquid	T2	T1	T1	CS	D	D
1 A 2 c solid	T2	T1	T1	CS	D	D
1 A 2 c gaseous	T2	T1	T1	CS	D	D
1 A 2 c other	T2	T2	T1	CS	CS	D
1 A 2 c biomass	T1	T1,T2	T1	D	CS,D	D
1 A 2 d liquid	T2	T1	T1	CS	D	D
1 A 2 d solid	T2	T1	T1	CS	D	D
1 A 2 d gaseous	T2	T1	T1	CS	D	D
1 A 2 d other	T2	T2	T1	CS	CS	D
1 A 2 d biomass	T1	T1,T2	T1	D	CS,D	D
1 A 2 e liquid	T2	T1	T1	CS	D	D
1 A 2 e solid	T2	T1	T1	CS	D	D
1 A 2 e gaseous	T2	T1	T1	CS	D	D
1 A 2 e other	T2	T2	T1	CS	CS	D
1 A 2 e biomass	T1	T1,T2	T1	D	CS,D	D
1 A 2 f liquid	T2	T1	T1	CS	D	D
1 A 2 f solid	T2	T1	T1	CS	D	D
1 A 2 f gaseous	T2	T1	T1	CS	D	D
1 A 2 f other	T2	T2	T1	CS	CS	D
1 A 2 f biomass	T1	T2	T1	D	CS	D
1 A 2 g 7 liquid	T3	T3	T3	CS	CS	CS
1 A 2 g 7 biomass	T1	T3	T3	D	CS	CS
1 A 2 g 8 liquid	T2	T1	T1	CS	D	D
1 A 2 g 8 solid	T2	T1	T1	CS	D	D
1 A 2 g 8 gaseous	T2	T1	T1	CS	D	D
1 A 2 g 8 other	T2	T2	T1	CS	CS	D
1 A 2 g 8 biomass	T1	T1,T2	T1	D	CS,D	D
1 A 3 a aviation gasoline	T2	T2	T2	CS	CS	CS
1 A 3 a jet kerosene	T3	T3	T3	CS	CS	CS
1 A 3 b 1 gasoline	T2	T3	T3	CS	CS	CS
1 A 3 b 1 diesel oil	T2	T3	T3	CS	CS	CS
1 A 3 b 1 LPG	T2	T3	T3	CS	CS	CS
1 A 3 b 1 gaseous	T2	T3	T3	CS	CS	CS
1 A 3 b 1 biomass	T1	T3	T3	D	CS	CS
1 A 3 b 1 other	T2	-	-	CS	-	-
1 A 3 b 2 gasoline	T2	T3	T3	CS	CS	CS
1 A 3 b 2 diesel oil	T2	T3	T3	CS	CS	CS
1 A 3 b 2 LPG	T2	T3	T3	CS	CS	CS
1 A 3 b 2 gaseous	T2	T3	T3	CS	CS	CS
1 A 3 b 2 biomass	T1	T3	T3	D	CS	CS
1 A 3 b 2 other	T2	-	-	CS	-	-
1 A 3 b 3 gasoline	T2	T3	T3	CS	CS	CS
1 A 3 b 3 diesel oil	T2	T3	T3	CS	CS	CS
1 A 3 b 3 LPG	T2	T3	T3	CS	CS	CS
1 A 3 b 3 gaseous	T2	T3	T3	CS	CS	CS
1 A 3 b 3 biomass	T1	T3	T3	D	CS	CS

	Method			Emission factor		
	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
1 A 3 b 4 gasoline	T2	T3	T3	CS	CS	CS
1 A 3 b 4 biomass	T1	T3	T3	D	CS	CS
1 A 3 c liquid	T2	T3	T3	CS	CS	CS
1 A 3 c solid	T2	T3	T3	CS	CS	CS
1 A 3 c biomass	T1	T3	T3	D	CS	CS
1 A 3 c other	T2	-	-	CS	-	-
1 A 3 d gas/diesel oil	T2	T3	T3	CS	CS	CS
1 A 3 d gasoline	T2	T3	T3	CS	CS	CS
1 A 3 d biomass	T1	T3	T3	D	CS	CS
1 A 3 d other	T2	-	-	CS	-	-
1 A 3 e 1 gaseous	T2	T1	T1	CS	D	D
1 A 3 e 2 liquid	T2	T2	T2	CS	CS	CS
1 A 3 e 2 gaseous	T2	T2	T2	CS	CS	CS
1 A 3 e 2 other	T2	-	-	CS	-	-
1 A 4 a 1 liquid	T2	T1,T2	T1	CS	CS,D	D
1 A 4 a 1 solid	T2	T1	T1	CS	D	D
1 A 4 a 1 gaseous	T2	T1	T1	CS	D	D
1 A 4 a 1 other	T2	T2	T1	CS	CS	D
1 A 4 a 1 biomass	T1	T1,T2	T1	D	CS,D	D
1 A 4 b 1 liquid	T2	T1,T2	T1	CS	CS,D	D
1 A 4 b 1 solid	T2	T1	T1	CS	D	D
1 A 4 b 1 gaseous	T2	T1	T1	CS	D	D
1 A 4 b 1 peat	T1	T1	T1	D	D	D
1 A 4 b 1 biomass	T1	T1,T2	T1	D	CS,D	D
1 A 4 b 2 liquid	T2	T3	T3	CS	CS	CS
1 A 4 b 2 biomass	T1	T3	T3	D	CS	CS
1 A 4 b 2 other	T2	-	-	CS	-	-
1 A 4 c 1 liquid	T2	T1,T2	T1	CS	CS,D	D
1 A 4 c 1 solid	T2	T1	T1	CS	D	D
1 A 4 c 1 gaseous	T2	T1	T1	CS	D	D
1 A 4 c 1 biomass	T1	T2	T1	D	CS	D
1 A 4 c 2 gasoline	T3	T3	T3	CS	CS	CS
1 A 4 c 2 diesel oil	T3	T3	T3	CS	CS	CS
1 A 4 c 2 biomass	D	T3	T3	D	CS	CS
1 A 4 c 2 other	T2	-	-	CS	-	-
1 A 5 b liquid	T2	T3	T3	CS	CS	CS
1 A 5 b biomass	T1	T3	T3	D	CS	CS
1 A 5 b other	T2	-	-	CS	-	-

Consideration of point source emissions

For the following categories and pollutants, plant or boiler specific emission declarations are considered each year.

- 1.A.1.a Public Electricity and Heat Production (about 130 boilers): CO, SO₂, NO_x
- 1.A.1.b Petroleum Refining (1 plant): SO₂, NO_x, CO, VOC ("IE": reported under 1 B)
- 1.A.2.a Iron and Steel (2 integrated iron & steel plants): CO₂, CO, VOC, SO₂, NO_x

- 1.A.2.f Non-Metallic Minerals – Cement production (10 plants): CO₂, SO₂, NO_x, CO, VOC

To avoid double counting of point source emissions with area sources (data from the national energy balance), the consistency of reported activity by plant operators with activity data from energy statistics is checked. Reported data must not be greater than data from energy statistics for the respective category (the correspondence of a plant to the specific energy balance sector is determined by identical NACE or ISIC-Codes). Only consistent and complete point source data are used for inventory preparation. If point source data are not consistent, then data from the national energy balance are used.

Activity data and emissions of point source emissions declarations are checked by comparing implied emission factors against IPCC default values or by comparing emissions to those of a simple Tier 1 approach.

3.2.9.1 Consistency with the EU emission trading system (EU-ETS)

Currently the following industrial branches are fully covered by the national ETS:

- 1.A.1.b Oil refineries
- 1.A.2.a+2.C.1 Iron and steel manufacturing industries
- 1.A.2.f Non-metallic mineral industries (cement, glass, lime, bricks and tiles, other ceramic materials)

Combustion plants of other industrial branches (including power plants) are considered, if their thermal plant capacity exceeds 20 MW_{th} (excluding boilers < 3 MW, biomass-boilers and hazardous and municipal waste incineration boilers).

The following branches have a high coverage of ETS installations:

- 1.A.1.a Public electricity and heat production (about 80 %). Coverage of about 95% for fuels (except waste)
- 1.A.2.d Pulp, paper and print (around 75 %)
- 1.A.2.c Chemicals (around 75 %)

Description of received ETS data

ETS data is submitted by means of a standard calculation sheet, which includes numerical data about multiple fuels, processes and material flows. Additionally, a written QA/QC report has to be submitted. National legislation (Emissionszertifikatengesetz §7) allows the use of detailed ETS data for reasons of inventory compilation.

For fuel combustion and industrial processes, the following numerical data is reported:

- Activity data: mass or volume of fuel consumption/process input material
- Net calorific value of fuel
- Oxidation factor of fuel/conversion factor of process material
- CO₂ emission factor of fuel or process material
- Share of non-fossil CO₂ (biomass) in case of “non-traded fuels”

For sites with complex material flows (e.g. refineries, iron and steel plants, chemical plants), carbon mass balance data is reported alternatively:

- Activity data: mass or volume of material flow (may have a negative sign)
- Net calorific value of material
- Carbon content of material
- Direct CO₂ measurements

The ETS reports include data about “traded-fuels” (e.g. different types of coal and fuel oils, natural gas) as well as “non-traded fuels” (e.g. industrial wastes, biomass). For each of the “traded fuels”, a national default NCV and a national default CO₂ emission factor may be selected for emission calculation. For “non-traded fuels” (industrial waste, mostly used in cement industry), plant operators have to make their own estimate of the carbon content and the NCV. However, carbon contents (t C/t waste) and oxidation factors of common waste fuels (tyres, waste oil, plastics waste) used in the cement industry are widely harmonized between different operators.

Methodology of ETS data consideration

ETS “bottom up” data since 2005 are used for calculation of emission data in categories 1.A.1, 1.A.2, 1.A.3.e and 1.A.4.a. About 200 plants report 800 fuel and material flows yearly, which are considered in the inventory. From the year 2013 onwards, the scope of ETS has been expanded by natural gas compressors used in energy industries (CRF 1.A.1.c and 1.A.3.e), smaller steel-works (CRF 1.A.2.a and 2.C), magnesite sinter plants (CRF 1.A.2.f and 2.A) and chemical industries (CRF 1.A.2.c and 2.B).

- In accordance with STATISTIK AUSTRIA, each plant is allocated to a NACE category of the energy balance.
- In accordance with STATISTIK AUSTRIA, each reported fuel is allocated to a fuel type according to the energy statistics system. For “non-traded fuels”, systematic errors of allocation have to be avoided as far as possible.
- ETS fuel masses/volumes and NCVs are used for activity data calculation. The remaining activity data is calculated by means of remaining fuel masses/volumes and averaged NCVs from the energy balance:

$$\text{Activity}_{\text{category, fuel}} = (\text{Energy\_Balance\_Activity}_{\text{category, fuel}} - \sum_i (\text{ETS\_Activity}_{\text{plant } i, \text{fuel}})) \times \text{Energy\_Balance\_NCV}_{\text{fuel}} + \sum_i (\text{ETS\_Activity}_{\text{plant } i, \text{fuel}} \times \text{ETS\_NCV}_{\text{plant } i, \text{fuel}}).$$

- ETS CO₂ emissions are considered by fuel. The remaining CO₂ emissions are calculated by remaining activity data and “national default” emission factors:

$$\text{CO}_{2\text{category, fuel}} = (\text{Energy\_Balance\_Activity}_{\text{category, fuel}} - \sum_i (\text{ETS\_Activity}_{\text{plant } i, \text{fuel}})) \times \text{Energy\_Balance\_NCV}_{\text{fuel}} \times \text{Default\_EF}_{\text{fuel}} + \sum_i (\text{ETS\_CO}_{2\text{plant } i, \text{fuel}}).$$

3.2.9.2 Choice of emission factors for stationary combustion

Emission factors for combustion plants are expressed as kg/GJ for CO₂ and as g/GJ for CH₄ and g/GJ for N₂O. Please note that emission factors sometimes are different for different sectors because of the different share of fuel combusted. E.g., the CO₂ emission factor for “hard coal” used in the energy industries is different from the factor used for manufacturing industry because different hard coal types with different origin are used; “hard coal” is actually a group of different hard coal types.

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, carbon content of coal, CH₄ content of natural gas.

- The mix of fuels in the 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.
- The technical equipment of a combustion plant, which burns a specific fuel, changes over time.
- Changes in technologies (rather relevant for air pollutants such as NO_x, VOC or PM_{2.5})

References for country specific CO₂ and CH₄ default emission factors are included in national studies (BMWA 1990, 1996, 2003, UMWELTBUNDESAMT 2001a, UMWELTBUNDESAMT 2004a). Detailed figures are included in the relevant chapters.

CO₂ emission factors for stationary sources per fuel type

Natural Gas (fossil)

For all sources of natural gas combustion, a CO₂ emission factor of 55.4 t CO₂/TJ (UMWELTBUNDESAMT 2001a) is applied for 1990–2018. For the year 2019 onwards, a factor of 55.6 t CO₂/TJ is applied.

In 2016, national gas supplier companies provided detailed data about natural gas composition and heating values for the years 2013–2015 and a CO₂ emission factor of 55.4 t/TJ and a net calorific value of 36.4 MJ/Nm³ has been calculated. The emission factor is in line with the emission factor used so far for emission calculations and valid until the inventory year 2018.

The CO₂ emission factor and the calorific value have been used as default values for ETS reporting since 2016 and have been first published by the ministry of environment in January 2017. Updates are planned to be published every three years.

In the year 2020, an updated (slightly higher) natural gas CO₂ emission factor (55.6 t CO₂/TJ) has been published (BMNT 2020), which is applied for the years 2019 to 2021. In the follow up report (BMK 2022), the CO₂ emission factor to be applied from 2022 to 2024 remains unchanged.

Table 31 shows the typical composition of natural gas as reported by the main national natural gas supplier for 2021.

Table 31: Typical natural gas composition of Austrian main supplier 2021 (NCV = 36.68 MJ/Nm³)

Component	% Volume
CH ₄	95.64
C ₂ H ₆	2.86
C ₃ H ₈	0.34
n-C ₄ H ₁₀	0.05
i-C ₄ H ₁₀	0.06
n-C ₅ H ₁₂	0.01
i-C ₅ H ₁₂	0.01
C ₆ H ₁₄ ⁺	0.02
CO ₂	0.47
N ₂	0.52
O ₂	0.75

Liquid fuels (fossil)

Fuel oil: Depending on the sulphur content three fuel oil categories are considered in the inventory. CO₂ emission factors are taken from (BMWA 1996).

Gasoil, Diesel Oil: CO₂ emission factors are taken from (BMWA 1996).

Liquid Petroleum Gas, LPG: CO₂ emission factors are taken from (BMWA 1996).

Refinery Gas: The CO₂ emission factor is based on plant specific measurements.

Solid fuels (fossil)

Coal: (BMWA 1996): CO₂ emission factors are based on elemental analysis with the assumption that 100% of carbon is released as CO₂ (values originate from the study (HACKL & MAUSCHITZ 1996), where the EF are based on the elemental analysis for different coal types).

Peat (fossil)

A default emission factor of 106 t/TJ for peat is taken from (IPCC 2006).

Municipal Solid Waste, MSW (partly fossil)

For the years 1990 to 2004, the fossil carbon content for MSW is taken from (ABFALLWIRTSCHAFT 2003). A fraction analysis of the typical wet MSW for Vienna⁴⁷ was performed by the local waste authority of Vienna (MA 48) in 1997/1998.

The fossil and non fossil carbon content of each fraction is taken from (ÖKOINSTITUT 2002). This leads to a fossil share of 45% of the overall carbon content of 261 kg C/t MSW_{wet matter}. The CO₂ emission factor was converted into t CO₂/TJ by means of a net calorific heating value of 8.81 GJ/t. The calculated CO₂ emission factor for MSW is 48.88 t/TJ. The emissions factor has been applied for the years 1990 to 2004.

From the year 2005 onwards, an updated MSW CO₂ emission factor of 43.45 t CO₂/TJ is applied for the sum of renewable and non-renewable MSW. The updated emission factor is based on a new study (UMWELTBUNDESAMT AND TU VIENNA 2019). Emission factors were derived from a methodology worked out by the Technical University of Vienna (TU 2015) and available MSW fraction analyses. The methodology of TU Vienna uses CO₂ stack measurements as well as available input and output process measurement parameters of the plants. These plant specific measurements have been used to validate a methodology based on MSW fraction analysis (manual sorting of fractions such as paper, kitchen and garden waste, packaging plastics, packaging glass, metals) to calculate the total carbon content and the fossil share of carbon. The resulting emission factor was derived from MSW sorting analysis of several years.

Activity data is taken from the energy balance, where the fossil (non renewable) part together with CO₂, N₂O and CH₄ emissions is allocated to *1.A.1.a-other fossil fuels* and the biogenic (renewable) part together with CO₂ from biomass, N₂O and CH₄ emissions is allocated to *1.A.1.a-biomass*. The sum of both parts is consistent with the sum of renewable and non-renewable energy consumption as reported in the energy balance. However, the shares of the non-renewable (fossil) and renewable (biomass) parts of energy consumption used within the inventory are not consistent with

⁴⁷ Until 1998 incineration of MSW in Vienna took place only at the one plant where the analysis was performed; in 2003 73% of total MSW in Austria was combusted in this plant, the value was applied to total MSW combustion in Austria.

the energy balance but are calculated by the heating values of the different MSW fractions as provided in the study (UMWELTBUNDESAMT AND TU VIENNA 2019). The calculated share of the non-renewable part used for the inventory results to 52.1% while the calculated share of the energy balance lies between 56% and 65% (e.g. about 60.2% for the years 2021 to 2022, 65.3% for the year 2005, 62% for the year 1990). Because the selected CH₄ and N₂O emission factors for both parts are identical, the selected share does not affect total emissions of both parts.

Industrial Waste (partly fossil)

The main share of industrial waste is used in cement and chemical industry for the purpose of energy recovery. For cement industry emission factors are based on the studies (HACKL & MAUSCHITZ 1995, 1997, 2001, 2003, 2007) and (MAUSCHITZ 2004) which include information about fractions and carbon contents. Details about emissions from cement industry are given in Chapter 3.2.11.2.

The fractions and the specific carbon contents of waste incinerated in hazardous waste incineration plants (rotation kilns), chemical industry, pulp and paper industry and wood products manufacturing industry are not reported within the ETS and therefore are unknown.

Until the submission 2019, a CO₂ emission factor of 104.17 t/TJ had been applied for those unknown waste fractions. Within (UMWELTBUNDESAMT AND TU VIENNA 2019) the Technical University of Vienna (TU Vienna) presented an emission factor, which better reflects actual known dependencies of heating value, water content and carbon content of waste fuels. TU Vienna also carried out stack measurements and input analysis of a hazardous waste incineration plant, which shows that the factor represents a “conservative approach” (high certainty that under-estimation does not occur). The proposed CO₂ emission factor is 75 t/TJ and has been applied for the whole time series since 1990.

Sewage Sludge (non fossil)

Sewage sludge is incinerated in one waste incineration plant and a couple of public power plants. The default CO₂ emission factor of 112 t/TJ has been selected from the IPCC 2006 Guidelines.

Black Liquor (non fossil)

Black liquor is incinerated in pulp and paper industry and in wood products manufacturing industry. The default CO₂ emission factor of 95.3 t/TJ has been selected from the IPCC 2006 Guidelines.

Biogas, Sewage Sludge Gas, Landfill Gas (non fossil)

Biogas reported by (IEA JQ 2023) is used for energy recovery in all subcategories of Category 1.A. The default CO₂ emission factor of 54.6 t/TJ has been selected from the IPCC 2006 Guidelines. Biogas is also fed into the public natural gas network or local biogas networks but reported separately in the energy balance. The biogas fed into the public gas network must meet special requirements with regard to purity and calorific value.
(see <http://www.biogas-netzeinspeisung.at/rechtliche-planung/index.html>).

3.2.9.3 CO₂ emissions reported by the EU-ETS

The following Table 32 shows certificated CO₂ emissions from the ETS (UMWELTBUNDESAMT 2023a) and their allocation to IPCC categories. The allocation does not always follow the category

reported by plant operators but is harmonized by means of reported NACE-codes and therefore harmonized with energy statistics. Minor process related emissions which could not be allocated to a specific category (e.g. carburisation material, pyrolysis material) have been allocated to category 1.A.2.g.8

Table 32: 2005–2022 CO₂ emissions [kt] as reported under the EU-ETS.

Category	2005	2010	2017	2018	2019	2020	2021	2022
Total ETS¹⁾	33 373	30 855	30 516	28 345	29 482	26 982	28 662	26 603
1.A FUEL COMBUSTION ACTIVITIES	20 760	17 836	16 071	15 586	15 740	14 109	14 068	12 942
1.A.1.a Public Electricity and Heat Production	11 482	9 335	6 019	5 420	5 667	4 386	4 379	4 445
1.A.1.b Petroleum refining	2 827	2 724	2 739	2 824	2 791	2 732	2 750	2 255
1.A.1.c Manufacture of Solid fuels and Other Energy Industries	43	47	194	175	180	159	163	180
1.A.2.a Iron and Steel	1 163	893	1 374	1 501	1 513	1 493	1 550	1 572
1.A.2.b Non-ferrous Metals	0	0	62	50	50	51	52	50
1.A.2.c Chemicals	665	654	1 181	1 109	1 188	1 112	1 065	955
1.A.2.d Pulp, Paper and Print	2 245	2 044	1 444	1 474	1 417	1 377	1 378	1 094
1.A.2.e Food Processing, Beverages and Tobacco	316	352	320	280	257	249	237	263
1.A.2.f Non-metallic minerals	1 656	1 528	1 637	1 694	1 664	1 654	1 682	1 579
1.A.2.g.8 Other: Stationary	340	245	418	425	417	372	399	366
1.A.3.e Pipeline compressors	0	0	634	587	547	475	378	152
1.A.4.a Commercial/Institutional	22	15	49	47	49	48	36	31
2 INDUSTRIAL PROCESSES	12 613	13 020	14 445	12 760	13 742	12 873	14 594	13 661
2.A.1 Cement Production	1 797	1 622	1 710	1 827	1 771	1 821	1 889	1 832
2.A.2 Lime Production	579	574	549	511	544	521	585	548
2.A.3 Glass Production	35	40	38	38	41	39	36	35
2.A.4 Other Process Uses of Carbonates	438	395	446	478	402	392	457	422
2.B.1 Ammonia Production	0	0	467	357	520	491	500	418
2.B.10 Other Chemical Industry	0	0	120	114	122	124	121	122
2.C.1 Steel	9 764	10 388	11 109	9 431	10 339	9 482	11 002	10 280
2.C.3 Aluminium Production	0	0	4	4	4	4	5	4

¹⁾ Source: UMWELTBUNDESAMT (2023a). These data do not include N₂O emissions from nitric acid production.

CO₂ emission factors reported within the ETS

Table 33 and Table 34 show the implied CO₂ emission factors reported within the ETS by fuel and SNAP category for the recent reported year. In some cases, rather small fuel consumption was reported for specific categories. This may lead to significant errors in implied emission factor calculation (e.g. diesel, gasoil) because within the ETS CO₂ emissions are rounded to the nearest ton whereas reported fuel consumption is not rounded.

Table 33: 2022 CO₂ implied emission factors calculated from ETS data. Coal, Petrol Coke, Waste and Natural Gas.

SNAP	102A Hard Coal	105A Brown Coal	107A Coke Oven Coke	110A Petrol Coke	115A Ind. Waste	301A Natural Gas
Weighted average	93.21	97.27	112.18	93.54	81.47	55.60
010101 Public Power plants ≥ 300 MW _{th}	-	-	-	-	-	55.60
010102 Public Power plants ≥ 50 MW _{th} < 300 MW _{th}	-	-	-	-	106.07	55.60
010103 Public Power plants ≤ 50 MW _{th}	-	-	-	-	-	-

SNAP	102A Hard Coal	105A Brown Coal	107A Coke Oven Coke	110A Petrol Coke	115A Ind. Waste	301A Natural Gas
010201 Public District Heating plants $\geq 300 \text{ MW}_{\text{th}}$	-	-	-	-	-	55.60
010202 Public District Heating plants $\geq 50 \text{ MW}_{\text{th}} < 300 \text{ MW}_{\text{th}}$	-	-	-	-	-	55.60
010203 Public District Heating plants $< 50 \text{ MW}_{\text{th}}$	-	-	-	-	-	55.60
010301 Refinery	-	-	-	129.93	-	55.60
010504 Other Energy Industries – Gas Turbines	-	-	-	-	-	55.60
010506 Pipeline Compressors	-	-	-	-	-	55.60
020103 Commercial plants $< 50 \text{ MW}_{\text{th}}$	-	-	-	-	62.16	55.60
0301 Industry – Steel	-	-	-	-	-	55.60
0301 Industry – Non ferrous metals	94.00	-	104.00	-	75.17	55.60
0301 Industry – Chemicals	94.51	-	-	-	100.18	55.60
0301 Industry – Pulp and Paper	88.85	-	-	-	118.37	55.60
0301 Industry – Food and Beverages	-	-	108.09	-	68.65	55.60
03010 Industry – Other	-	-	-	-	98.18	55.60
030311 Cement kilns	93.59	97.07	-	93.83	79.96	55.60
030312 Lime kilns	-	98.12	-	93.64	-	55.60
030317 Glass	128.42	-	104.00	-	-	55.60
030319 Bricks and Tiles	95.87	97.57	-	-	55.65	55.60
030323 Dolomite Treatment	-	-	104.00	93.33	74.49	55.60
030326 Integrated Iron & Steel works	93.29	-	112.29	-	82.73	56.42

Table 34: 2022 CO₂ implied emission factors calculated from ETS data. Oil products.

SNAP	203B light fuel oil	203D Heavy fuel oil	204A Gasoil	2050 Diesel	224A other liquid	303A LPG
Weighted average	77.98	79.33	75.00	73.70	69.55	67.86
010101 Public Power plants $\geq 300 \text{ MW}_{\text{th}}$	-	80.00	75.00	73.70	-	-
010102 Public Power plants $\geq 50 \text{ MW}_{\text{th}} < 300 \text{ MW}_{\text{th}}$	-	-	75.00	73.70	-	-
010103 Public Power plants $\leq 50 \text{ MW}_{\text{th}}$	-	-	-	-	-	-
010201 Public District Heating plants $\geq 300 \text{ MW}_{\text{th}}$	-	-	75.00	73.70	-	-
010202 Public District Heating plants $\geq 50 \text{ MW}_{\text{th}} < 300 \text{ MW}_{\text{th}}$	77.00	80.04	75.00	73.70	-	-
010203 Public District Heating plants $< 50 \text{ MW}_{\text{th}}$	77.00	-	75.00	73.70	-	-
010301 Refinery	-	79.30	-	73.70	-	67.86
010504 Other Energy Industries – Gas Turbines	-	-	-	73.70	-	-
010506 Pipeline Compressors	-	-	-	73.70	-	-
020103 Commercial plants $< 50 \text{ MW}_{\text{th}}$	-	-	-	-	70.89	-
0301 Industry – Steel	-	-	-	73.73	-	-
0301 Industry – Non ferrous metals	-	-	-	73.70	-	-
0301 Industry – Chemicals	-	80.52	75.00	73.70	68.36	-

SNAP	203B light fuel oil	203D Heavy fuel oil	204A Gasoil	2050 Diesel	224A other liquid	303A LPG
0301 Industry – Pulp and Paper	78.00	78.00	75.00	73.70	-	-
0301 Industry – Food and Beverages	-	-	75.00	73.70	-	-
03010 Industry – Other	-	-	75.00	73.70	-	64.00
030311 Cement kilns	78.00	78.00	74.89	-	-	-
030312 Lime kilns	-	78.00	75.00	-	-	-
030317 Glass	78.00	-	-	73.70	-	-
030319 Bricks and Tiles	78.00	78.00	75.00	73.70	-	-
030323 Dolomite Treatment	78.00	78.00	75.00	73.70	-	64.00
030326 Integrated Iron & Steel works	78.00	-	75.00	-	-	-

3.2.9.4 Choice of activity data for stationary sources

Activity data used for estimating emissions in the sectoral approach is taken from the energy balance as well as information on the last revision of the national energy balance.

The national energy balance is provided by Statistik Austria (STATISTIK AUSTRIA 2023a, IEA JQ 2023). The net calorific values (NCV) used for converting mass or volume units of the fuel quantities into energy units [TJ] are provided by Statistik Austria.

In the sectoral approach of Category 1.A, only the fuel quantities that are combusted are relevant and thus considered for emission calculation. Quantities not considered are: non-energy and feedstock use, international bunker fuels, transformation and distribution losses, transformations of fuels to other fuels like hard coal to coke oven coke and internal refinery processes which have been added to the transformation sector of the energy balance.

Potential emissions from non-energy and feedstock fuel use are considered in the corresponding IPCC categories as described in chapter 3.2.3.

3.2.10 1.A.1 Energy Industries

3.2.10.1 1.A.1.a Public Electricity and Heat Production

Key Sources: CO₂ from 1.A.1.a gaseous, liquid, solid and other fossil fuels

Category 1.A.1.a *Public Electricity and Heat Production* covers emissions from fuel combustion in public power and heat plants. The share in total GHG emissions from sector 1.A is 21.4% for the year 1990 and 12.2% for the year 2022. The increased CH₄ and N₂O emissions are mainly due to increased biomass combustion in plants smaller than 50 MW_{th}.

Methodology

For the years 1990 to 2004, the IPCC Tier 2 methodology is applied by using activity data from energy balance and national CO₂ default emission factors.

For the years 2005–2022, CO₂ emissions from plants having a total boiler capacity of ≥ 20 MW_{th} are taken from ETS reports and CO₂ emissions from plants < 20 MW_{th} are calculated by means of national default emission factors and the remaining fuel consumption of the energy balance. Coal consumption is fully covered by the ETS. The general methodology is described in chapter 3.2.1.2.

Emission factors

National CO₂ emission factors are taken from (BMWA 1990, 1996), (UMWELTBUNDESAMT 2001a) and (UMWELTBUNDESAMT 2002). The selected emissions factors for 2022 as well as the national default emission factors are listed in the following table. The CO₂ emission factor for municipal solid waste for the years 1990 to 2004 is taken from (ABFALLWIRTSCHAFT 2003), for the years 2005 onwards it is taken from (UMWELTBUNDESAMT AND TU VIENNA 2019). The CO₂ emission factor for industrial waste is also taken from (UMWELTBUNDESAMT AND TU VIENNA 2019).

Table 35: Default emission factors of Category 1.A.1.a for the year 2022.

Fuel	Default CO ₂ [t/TJ]	CH ₄ [kg/TJ]	N ₂ O [kg/TJ]
Light Fuel Oil in plants ≥ 50 MW _{th}	77.00	3.00	0.60
Heavy Fuel Oil in plants ≥ 50 MW _{th}	80.00	3.00	0.60
Fuel Oil in plants ≤ 50 MW _{th}	78.00	3.00	0.60
Gasoil	75.00	3.00	0.60
Diesel oil	75.00	3.00	0.60
Liquified Petroleum Gas	64.00	1.00	0.10
Hard coal in power and CHP plants	95.00	1.00	1.50
Hard coal in district heating plants.	93.00	1.00	1.50
Lignite and brown coal in power and CHP plants ≥ 50 MW _{th}	110.00	1.00	1.50
Lignite and brown coal in district heating plants ≥ 50 MW _{th}	108.00	1.00	1.50
Lignite, brown coal and brown coal briquettes in plants < 50 MW _{th}	97.00	1.00	1.50
Natural Gas	55.60	1.00	0.10
Fuel Wood	112.00 ¹⁾	30.00	4.00
Wood Waste	112.00 ¹⁾	10.00	4.00
Sewage Sludge	112.00 ¹⁾	12.00	4.00
Biogas, Sewage Sludge Gas, Landfill Gas	54.60 ¹⁾	1.00	0.10
Municipal Solid Waste 1990–2004: renewable and non-renewable	48.88	12.00	4.00
Municipal Solid Waste 2005 onwards: renewable and non-renewable	43.45	12.00	4.00
Municipal Solid Waste implied emission factor: non renewable	83.46	12.00	4.00
Municipal Solid Waste 2005 onwards: renewable	108.58 ¹⁾	12.00	4.00
Industrial Waste	75.00	12.00	4.00

¹⁾ Reported as CO₂ emissions from biomass.

1.A.1.a – Biomass – implied emission factors for CO₂, N₂O and CH₄

Following a recommendation of the 2023 UNFCCC review, the fluctuations in the trends of 1.A.1.a biomass CO₂, CH₄ and N₂O implied emission factors are explained in ANNEX 3.1.

Activity data

Total fuel consumption of Category 1.A.1.a is taken from (IEA JQ 2023) prepared by Statistik Austria (STATISTIK AUSTRIA 2023a).

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 36 presents 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 electricity production from fuel combustion. In the year 2012 electricity production from hydro plants reached a historic maximum of 47.2 TWh and contributed to 74% of total production. District heat production in 2022 was 11% lower than in 2021 because of a 12.8% lower heating demand (heating degree days).

Table 36: Public gross electricity and heat production.

Year	Public gross electricity production [GWh]						Public Heat Production [TJ] by Combustible Fuels
	Total	Hydro ¹⁾	Combustible Fuels	Geothermal	Solar	Wind	
1990	43 403	30 111	13 292	0.0	0	0	24 427
1995	47 580	35 431	12 147	0.000	1	1	34 426
2000	52 810	41 131	11 609	0.000	3	67	42 197
2005	58 518	38 205	18 958	2.302	21	1 331	54 424
2010	61 571	40 500	18 916	1.398	89	2 064	70 415
2011	56 270	36 815	17 344	1.053	174	1 936	70 399
2012	64 030	47 204	14 025	0.677	337	2 463	74 061
2013	60 239	45 226	11 234	0.306	626	3 152	75 274
2014	57 742	44 270	8 840	0.384	785	3 846	69 707
2015	57 455	40 102	11 575	0.061	937	4 840	72 314
2016	60 429	42 482	11 617	0.021	1 096	5 235	74 159
2017	63 114	41 697	13 576	0.091	1 269	6 572	76 620
2018	60 631	40 745	12 400	0.239	1 455	6 030	74 087
2019	66 268	43 669	13 446	0.200	1 702	7 450	73 573
2020	64 721	44 888	10 997	0.073	2 043	6 792	73 971
2021	62 669	42 133	11 009	0.031	2 783	6 740	80 992
2022	61 781	38 952	11 803	0.002	3 776	7 245	72 187

¹⁾ including pumped storage; Source: IEA/JQ 2023

As shown in Table 37 electricity supply increased by 13.6 TWh since 2000 of which approx. 80% has been supplied by additional imports until 2008. The year 2009 shows falling electricity consumption (supply) but an increase of production, mainly by hydropower. The year 2015 shows an historical maximum of net imports which contributed to 15% of total electricity supply.

Table 37: Electricity supply, gross production, imports, exports and net imports [GWh].

Year	Electricity [GWh]				
	Supply ¹⁾	Gross production ²⁾	Imports	Exports	Net Imports
1990	46 489	50 294	6 839	7 298	-459
1995	50 979	56 225	7 287	9 757	-2 470
2000	55 750	61 257	13 824	15 192	-1 368

Year	Electricity [GWh]				
	Supply ¹⁾	Gross production ²⁾	Imports	Exports	Net Imports
2005	62 948	66 833	20 355	17 732	2 623
2010	65 523	71 128	19 909	17 472	2 437
2011	65 702	65 813	24 977	16 777	8 199
2012	66 690	72 603	23 430	20 627	2 803
2013	67 048	68 357	24 960	17 689	7 270
2014	65 977	65 439	26 712	17 437	9 275
2015	67 021	65 299	29 389	19 328	10 062
2016	67 866	68 308	26 366	19 207	7 159
2017	69 029	71 324	29 362	22 817	6 546
2018	69 192	68 618	28 076	19 129	8 947
2019	69 332	74 234	26 047	22 918	3 129
2020	66 936	72 558	24 522	22 327	2 196
2021	70 108	73 644	26 436	18 893	7 543
2022	69 384	72 987	28 595	19 890	8 705

Source: IEQ JQ 2023

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

²⁾ Public and autoproducer gross production

Recalculations

Recalculations of activity data are following the revisions of the energy balance as described in Annex 4.

Following a recommendation of the 2023 UNFCCC review, the non renewable part of MSW has been allocated to *1.A.1.a other fossil fuels* and the renewable part to *1.A.1.a biomass* (see chapter 3.2.9.2). This changes do not affect total GHG emissions.

Sector specific QA/QC procedures

Large point source data are used for validation of energy consumption. Until the year 2007 the Umweltbundesamt operates a database to store boiler specific data, which is called „Dampfkesseldatenbank“ (DKDB, UMWELTBUNDESAMT 2007) which includes fuel consumption, CO, NO_x, SO_x and dust emissions from boilers with a thermal capacity greater than 20 MW which data is used for the years 1990 to 2007. These data are used to generate a sectoral split of the categories *Public Power* and *District Heating* each into the two categories ≥ 300 MW and ≥ 10 MW to 300 MW of thermal capacity. Currently about 65 boilers between 10 and 950 MW_{th} are considered in this approach. Large point source activity data from 2005 onwards is considered from ETS reporting.

The remaining fuel consumption (= total consumption minus consumption of large point sources) is the activity data for boilers smaller than 10 MW_{th}.

3.2.10.2 1.A.1.b Petroleum Refining

Key Sources: CO₂ from 1.A.1.b gaseous and liquid fuels

Category *1.A.1.b Petroleum Refining* enfold emissions from fuel combustion, flaring and thermal cracking of the only petroleum refining plant in Austria. Fugitive CH₄ emissions are included in category *1.B.2.a Fugitive Emissions from Fuels – Oil – Refining/storage*. Since 2003 the plant has been up-graded which increases CO₂ emissions from bitumen blowing and hydrogen production.

The share in total GHG emissions from sector 1.A is 4.6% for the year 1990 and 4.7% for the year 2022. Crude oil input was 8 megatons in 1990 and 5.6 megatons in 2022.

Methodology

The IPCC Tier 2 methodology is used. For calculation of CO₂ emissions, plant specific emission factors are used. For calculation of N₂O and CH₄ emissions, the default emission factors from the IPCC 2006 Guidelines have been selected.

The carbon contents of *gaseous*, *liquid* and *solid* fuel types are reported by the plant operator. The fuel groups do not correspond with IPCC definitions, e.g. gaseous fuels include refinery gas which is, according to IPCC definition, a liquid fuel.

Table 38: Carbon content per fuel group for petroleum refining.

Fuel-type	Carbon Content	
	[t CO ₂ /t fuel]	Associated IEA-Fuels
Gaseous	2.683	Natural Gas, Refinery Gas
Liquid	3.047	Residual Fuel Oil, Gas Oil, Diesel, Petroleum, Jet Gasoline, Other Oil Products, LPG
Solid	3.430	Petrol coke (FCC-coke)

For 1990 to 2001, CO₂ emissions are calculated by multiplying activity data from the energy balance by the emission factors in Table 38. CO₂ emissions 2002 to 2005 are reported by the Austrian Association of Mineral Oil Industries and are consistent with ETS 2005 data. From the year 2006 onwards, reported ETS data is used.

To be consistent with IPCC fuel group definition, total CO₂ emissions are disaggregated to the IEA fuel types (see column "Associated IEA-fuels") by using default emission factors for industrial boilers, subtracting the calculated CO₂ emissions from total CO₂ emissions, and associating remaining CO₂ emissions to refinery gas. The resulting IEF for refinery gas is presented in Table 39. The IEF fluctuations reflect changes in refinery gas composition.

Table 39: Implied emission factors for refinery gas.

Year(s)	t CO ₂ /TJ
1990	65.8
1995	82.3
2000	60.5
2001	54.0
2002–2022	64.0

For corresponding crude oil input data which may be used as an indicator over time series refer to description of category 1.B.2.a Oil.

Table 40: Emission factors of Category 1.A.1.b.

Fuel	CO ₂ [t/TJ]	N ₂ O [kg/TJ]	CH ₄ [kg/TJ]
Residual Fuel Oil	80.00	0.60	3.00
Gas oil	75.00	0.60	3.00
Diesel	78.00	0.60	3.00

Fuel	CO ₂ [t/TJ]	N ₂ O [kg/TJ]	CH ₄ [kg/TJ]
Other Oil Products	78.00	0.60	3.00
Petrol Coke	100.88	0.60	3.00
Refinery gas	64.00	0.10	1.00
LPG	64.00	0.10	1.00
Natural Gas	55.60	0.10	1.00

Activity data

Fuel consumption is taken from (IEA JQ 2023) except for the years 1999 to 2005, where petrol coke is additionally counted in *other oil products* (1999: +63 kt, 2004: +59 kt) to obtain consistency with plant specific activity data reported in (DKDB, UMWELTBUNDESAMT 2007).

Sector specific QA/QC procedures

A simple mass balanced input/output validation of energy balance data has been performed which shows a plausible and time series consistent correlation of the input and output material flows as shown in the following table. The last line shows the difference between input and output. Natural gas consumption is not considered in this approach.

Table 41: Refinery input/output mass balance.

Material flow [kt]	1990	1995	2000	2005	2010	2016	2017	2018	2019	2020	2021	2022
Total Input	9 062	9 259	8 887	9 233	8 457	9 030	8 948	9 576	9 952	8 871	8 832	6 502
Crude oil	7 952	8 619	8 240	8 743	7 719	8 184	8 064	8 970	9 124	8 168	8 243	5 617
NGL	41	43	107	78	134	6	37	18	16	14	11	11
Feedstocks	1 069	597	540	362	325	531	552	293	501	421	268	658
Biofuel (blending)	0	0	0	50	279	309	294	294	311	267	309	215
Total Output	8 864	9 013	8 620	9 086	8 335	8 861	8 791	9 460	9 842	8 706	8 676	6 377
Fuel oil	1 913	1 596	1 075	1 360	934	898	839	710	735	737	645	778
Gas oil	1 239	1 454	1 062	997	795	635	662	581	476	592	387	261
Diesel	1 531	1 920	2 662	2 931	2 741	3 166	3 319	3 472	3 703	3 202	3 329	1 883
Other Kerosene	31	8	1	1	3	21	15	26	15	13	9	27
Aviation kerosene	291	420	544	592	476	651	613	760	893	362	344	404
Aviation gasoline	0	0	0	0	0	1	1	1	1	1	1	1
Motor gasoline	2 631	2 276	1 815	1 798	1 589	1 759	1 782	2 030	2 075	1 805	1 870	1 389
White spirit	0	5	0	0	70	0	0	0	0	0	0	0
Bitumen	269	254	343	366	292	333	306	369	395	424	440	236
Other petroleum products	7	29	15	87	172	26	27	21	23	45	46	26
Naphtha	475	621	710	472	720	961	804	1 028	1 006	1 051	1 087	822
LPG	47	60	34	107	87	122	102	111	137	117	150	106
Refinery gas	373	305	312	309	392	218	262	281	316	284	296	389
Petroleum Coke (FCC)	57	66	48	66	62	71	59	71	67	73	74	56
Input-Output	198	246	267	147	123	169	157	115	111	165	156	124

Recalculations

No recalculations have been carried out in this year's submission.

Planned improvements

No improvements are planned.

3.2.10.3 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries

Key Source: CO₂ from 1.A.1.c gaseous fuels

Category *1.A.1.c Manufacture of Solid Fuels and Other Energy Industries* enfold emissions from fuel combustion in the oil and gas extraction sector (reported by companies as 'own use'), compressors used for natural gas storage tanks and fuel use of gas processing facilities ('gas refineries'). For 1990 to 1995 transformation losses/own use in gas works are included too. The share in sector 1.A overall GHG emissions is 1% for the year 1990 and 0.7% for the year 2022.

Methodology

Calculation of CO₂ emissions are following a Tier 2 methodology and calculation of CH₄ and N₂O emissions are following a Tier 1 methodology.

For 2005 onwards, CO₂ emissions and activity data of natural gas storage compressors are taken from ETS data.

Emission factors

CO₂ emission factors are taken from studies (BMWA 1990, 1996).

For calculation of N₂O and CH₄ emissions the default emission factors from the IPCC 2006 Guidelines have been selected.

Table 42: *Emission factors of Category 1.A.1.c.*

Fuel	CO ₂ [t/TJ]	CH ₄ [kg/TJ]	N ₂ O [kg/TJ]
Natural Gas	55.60	1.00	0.10
Heavy Fuel Oil	78.00	3.00	0.60

Activity data

Fuel consumption is taken from (IEA JQ 2023).

Transformation losses in gas works are calculated by subtracting final energy use from transformation input. Since the energy balance (IEA JQ 2023) does not report gas works gas, activity data is taken from the 'Austrian Energy Balance' provided by STATISTIK AUSTRIA (STATISTIK AUSTRIA 2023a), which is structured differently but consistent with (IEA JQ 2023).

Recalculations

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

3.2.10.4 1.A.1.c.iii Other energy industries – charcoal production

CH₄ emissions from Charcoal production are included in *1.A.1.c.iii Other energy industries – biomass*.

Methodology

Calculation of CH₄ emissions from charcoal production is following a Tier 2 methodology.

For the most recent years (2005 to latest inventory year) Austria uses the data from the National Energy Balance to calculate emissions from charcoal production

For the years 1990–2004 an average production amount of 1 000 t was assumed, as the National Energy Balance only provides data for this fuel category starting from 2005. Although the IEA Joint Questionnaire figures also do not show indigenous production for the years prior to 2001, it is unlikely that there was no traditional charcoal production based on wood as feedstock at all as charcoal is produced within small communities for many decades mainly to keep this old tradition in rural areas as a cultural heritage. Hence, it is reasonable to assume a constant charcoal production for the years before 2001. In Table 43 the activity data of charcoal production is presented.

Table 43: Activity data (charcoal produced) and CH₄ emissions for Fugitive Emissions from Solid Fuel Transformation 1990–2022.

Year	Charcoal production (in t)	Charcoal [TJ]	CH ₄ emissions [kt]
1990	1 000	31	0.031
1995	1 000	31	0.031
2000	1 000	31	0.031
2005	1 101	34	0.034
2010	1 181	37	0.037
2011	1 130	35	0.035
2012	1 377	43	0.043
2013	1 269	38	0.038
2014	1 263	36	0.036
2015	1 447	41	0.041
2016	1 382	41	0.041
2017	1 222	35	0.035
2018	1 379	39	0.039
2019	1 425	40	0.041
2020	1 442	41	0.041
2021	1 463	42	0.042
2022	1 091	32	0.032

For calculating the emissions, Austria is using a constant country specific NCV of 30 MJ/kg from its National Energy Balance. Due to the absence of measurements which are needed to derive a country specific emission factor, the default emission factor of the revised IPCC 1996 Guidelines (Table 1-14) has been applied for CH₄ (1 000 kg/TJ).

3.2.11 1.A.2 Manufacturing Industries and Construction

3.2.11.1 1.A.2.a Iron and Steel

Key Sources: CO₂ from 1.A.2.a gaseous and solid fuels

Category *1.A.2.a Iron and Steel* enfold emissions from fuel combustion in iron and steel industry. CO₂ emissions from ore reduction in blast furnaces are included in category *2.C.1.b Pig Iron*. The share in total GHG emissions from Sector 1.A is 3.5% for the year 1990 and 4% for the year 2022.

Methodology

Two iron and steel production sites (the only operating blast furnaces in Austria) are considered as point sources. For 1990 to 2002, CO₂ emissions and fuel consumption from these two plants were reported by the plant operator. The reported fuel consumption of the two plants is subtracted from total fuel consumption for iron and steel production in Austria and the resulting fuel consumption is considered as area source. For the area sources an IPCC Tier 2 methodology was applied for all GHGs.

CO₂, NMVOC, CO, NO_x and SO₂ emissions are reported by the two Austrian iron and steel plants, together with their coal, fuel oil and natural gas fuel consumption. The emissions declaration includes emissions from natural gas consumption not included in the ETS.

The methodology of separating process CO₂ emissions from total integrated steel plants' CO₂ emissions is also explained in the methodology chapter of category *2.C.1*. 100% of natural gas consumption and a share of coke oven gas consumption are considered within category *1.A.2.a* while 100% of solid, liquid and other fuels and a share of coke oven gas are considered as reducing agents in blast furnaces and therefore CO₂ emissions are reported under category *2.C.1*. Activity data of natural gas is taken from plant operator emission reports and includes fuel consumption which is not considered under the ETS. CO₂ emissions from coke oven gas are calculated by subtracting emissions from reducing agents and emissions from natural gas from total CO₂ emissions. The methodology of calculating CO₂ emissions from reducing agents is partly a tier 1 method using default emission factors and reported consumption data as well as data from the energy balance while EU-ETS reporting is based on a detailed mass balance. The resulting methodological uncertainty between the two approaches is therefore fully reflected in the CO₂ emissions from coke oven gas which is the main reason of the fluctuating trend of *1.A.2.a solid fuels*.

The CO₂ emission factor for natural gas is taken from (BMWA 1996). For coke oven coke, a default emission factor of 25.8 t C/TJ (94.6 t CO₂/TJ) has been selected.

CO₂ emissions of integrated steel plants 1990 to 2002 and 2005 onwards are reported by plant operators.

N₂O and CH₄ emissions are calculated by means of a Tier 1 methodology.

Point source CO₂ emissions 2003 and 2004

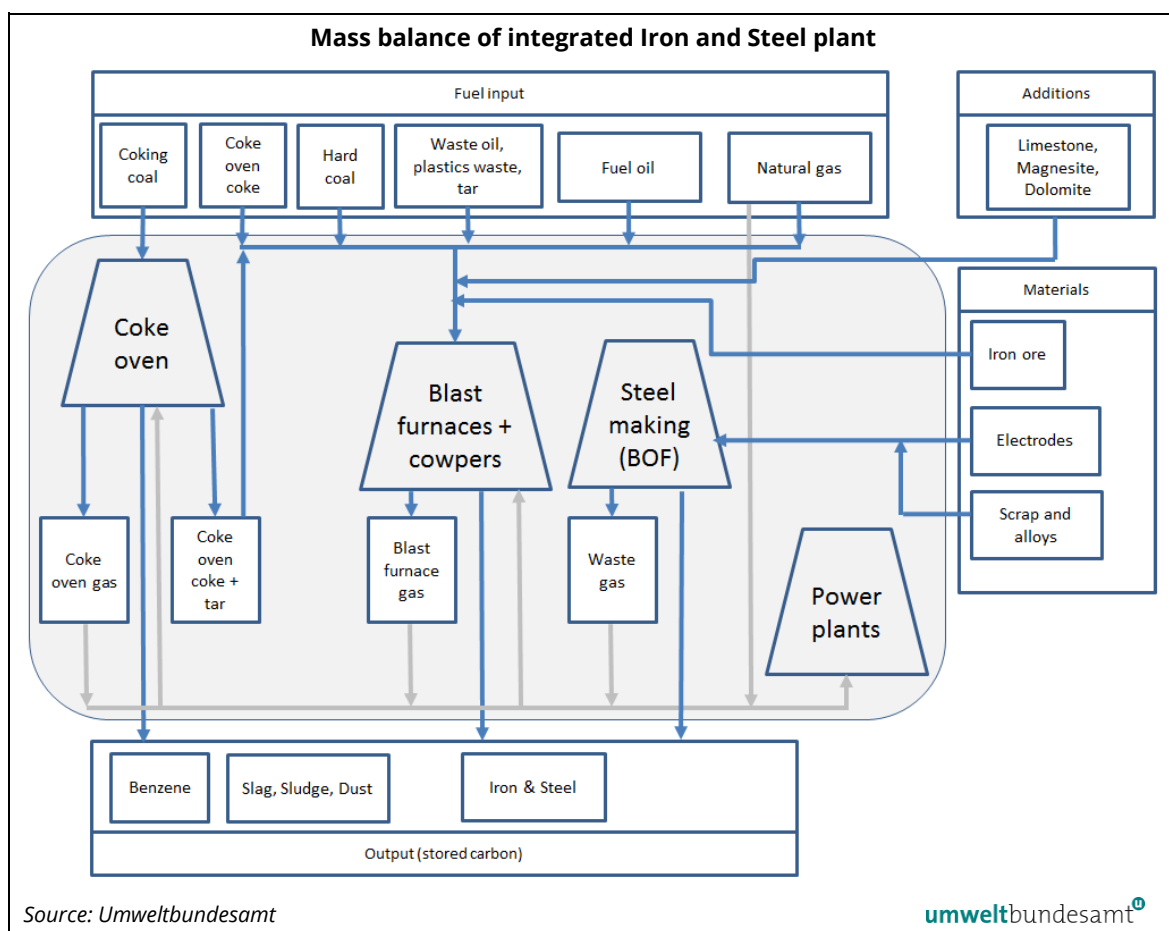
Since for the years 2003 and 2004 no point source CO₂ emissions have been reported by plant operators, the Umweltbundesamt performed calculations on the basis of 2000 to 2002 data by means of a simple approach: Activity data reported by plant operators are multiplied by national default emission factors. The resulting emissions are those from blast furnaces and autoproducer power plants. CO₂ emissions from coke ovens (2004: 285 kt) are estimated by means of coke oven output and an emission factor of 0.2 t CO₂/t coke which is equal to 5% transformation losses.

Mass balance of integrated iron and steel plant

The following Figure 10 shows a flow chart of a integrated iron and steel plant representing the mass balance which is used for reporting under the ETS. The grey shaded area illustrates the most

important facilities and the interior fluxes between them, although the real conditions are even more complex. The outside parts of the figure shows the carbon containing inputs and outputs of fuels and materials as reported under the ETS. The fuel Input and the internal transformation processes between fuels (e.g. coke oven coke, blast furnace gas, coke oven gas, blast furnace gas, waste gas from basic oxygen furnaces) are reported in the energy balance. CO₂ emissions from reducing agents (coke oven coke, hard coal, fuel oil, waste oil, plastics waste, tar) which are used in the blast furnace as well as the net CO₂ emissions from carbon containing material input such as iron ore, scrap and electrodes as well as output material such as steel and pig iron are reported under CRF category 2.C.1. CO₂ Emissions from natural gas and coke oven gas are reported under CRF category 1.A.2.a.

Figure 10: Mass balance of integrated Iron and Steel plant.



Emissions

The following table lists the results of the two approaches. Please note that process related CO₂ emissions from blast furnaces are reported under category 2.C.1.

Table 44: Greenhouse gas emissions from Category 1.A.2.a by sub sources.

Year	other sources			integrated steel plants		
	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]
1990	193	0.005	0.001	1 640	0.021	0.002
1995	293	0.009	0.001	1 045	0.015	0.002

Year	other sources			integrated steel plants		
	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]
2000	457	0.010	0.001	819	0.013	0.001
2005	366	0.010	0.001	1 478	0.022	0.002
2010	345	0.008	0.001	931	0.016	0.002
2011	345	0.007	0.001	1 101	0.019	0.002
2012	353	0.007	0.001	1 130	0.019	0.002
2013	332	0.007	0.001	1 274	0.021	0.002
2014	307	0.006	0.001	1 189	0.020	0.002
2015	358	0.007	0.001	1 047	0.017	0.002
2016	396	0.008	0.001	1 181	0.018	0.002
2017	374	0.008	0.001	1 284	0.019	0.002
2018	366	0.008	0.001	1 406	0.021	0.002
2019	389	0.008	0.001	1 415	0.021	0.002
2020	395	0.008	0.001	1 408	0.020	0.002
2021	331	0.007	0.001	1 452	0.021	0.002
2022	511	0.011	0.001	1 425	0.019	0.002

Emission factors

CO₂ emission factors are taken from studies (BMWA 1990, 1996) and (UMWELTBUNDESAMT 2002). The selected and calculated emission factors for 2022 are presented in Table 45 and Table 46.

Activity data

Total fuel consumption is taken from (IEA JQ 2023).

Point source activity data are reported by plant operators which are widely consistent with (IEA JQ 2023).

Table 45: Emission factors of Category 1.A.2.a for area sources.

Fuel	CO ₂ [t/TJ]	CH ₄ [kg/TJ]	N ₂ O [kg/TJ]
Light Fuel Oil	78.00	3.00	0.60
Heavy Fuel Oil	78.00	3.00	0.60
Gas oil	75.00	3.00	0.60
Petroleum	78.00	3.00	0.60
LPG	64.00	1.00	0.10
Hard Coal	94.00	10.00	1.50
Lignite and brown coal	97.00	10.00	1.50
Coke	104.00	10.00	1.50
Natural Gas	55.60	1.00	0.10
Wood Waste	112.00 ¹⁾	10.00	4.00

¹⁾ Reported as CO₂ emissions from biomass.

Table 46: Emission factors of Category 1.A.2.a for point sources.

Fuel	CO ₂ [t/TJ]	CH ₄ [kg/TJ]	N ₂ O [kg/TJ]
Coke Oven Coke	94.60	1.00	0.10
Natural Gas	55.60	0.10	0.10

Fugitive emissions and losses

An analysis of ETS data shows that the amount of carbon stored in slag, dust, sludge and steel was 71 kt CO₂ equivalents in 2022 (2021: 78 kt; 2020: 65 kt; 2019: 71 kt; 2018: 70 kt, 2017: 73 kt, 2016: 83 kt, 2015: 87 kt, 2014: 91 kt, 2013: 83 kt, 2012: 76 kt, 2011: 71 kt, 2010: 66 kt, 2009: 55 kt, 2008: 91 kt). This amount should be considered in the quantification of the difference between the sectoral and the reference approach.

Recalculations

Recalculations for the year 2021 follow the revisions of the national energy balance.

3.2.11.2 1.A.2.b Non-Ferrous Metals

Key Source: CO₂ from 1.A.2.b gaseous fuels

Category *1.A.2.b Non-Ferrous Metals* enfolds emissions from fuel combustion in non ferrous metal industry. The share in total GHG emissions from sector *1.A* is 0.3% for the year 1990 and 0.6% for the year 2022.

Methodology

CO₂ emissions are calculated by means of a Tier 2 method while N₂O and CH₄ emissions are calculated by means of a Tier 1 method. From the year 2013 onwards, CO₂ ETS data are considered.

CO₂ emission factors are taken from studies (BMWA 1990, 1996) and (UMWELTBUNDESAMT 2002).

Emission factors for 2022 are presented in the following table.

Table 47: Emission factors of Category 1.A.2.b

Fuel	CO ₂ [t/TJ]	CH ₄ [kg/TJ]	N ₂ O [kg/TJ]
Residual Fuel Oil	78.00	3.00	0.60
Gas oil	75.00	3.00	0.60
Petroleum	78.00	3.00	0.60
LPG	64.00	1.00	0.10
Hard Coal	94.00	10.00	1.50
Coke	104.00	10.00	1.50
Natural Gas	55.60	1.00	0.10
Industrial waste	75.17 ¹⁾	12.00	4.00

¹⁾ Implied emission factor

Activity data

Fuel consumption is taken from (IEA JQ 2023) and ETS.

Recalculations

Changes of activity data 2020 follow the revision of the national energy balance.

3.2.11.3 1.A.2.c Chemicals

Key Sources: CO₂ from 1.A.2.c gaseous and other fuels

Category 1.A.2.c *Chemicals* enfold emissions from fuel combustion in chemical industry. The share in total GHG emissions from sector 1.A is 1.6% for the year 1990 and 2.9% for the year 2022.

Methodology

CO₂ emissions are calculated by means of a Tier 2 method while N₂O and CH₄ emissions are calculated by means of a Tier 1 method. From the year 2013 onwards, CO₂ ETS data are considered.

CO₂ emissions from industrial waste: Table 48 shows the composition of the implied emissions factor for industrial waste. One plant with a capacity of 250 kt solid waste/year is considered with a NCV of 10 TJ/kt waste and a CO₂ emission factor of 75 t/TJ. From 2005 on ETS data is considered with plant specific emissions and energy consumption. The remaining energy use (other waste) is considered with a CO₂ emission factor of 37.50 t/TJ. 'Other waste' is considered as 50% waste gas (with a high share of hydrogen) and chemical reaction heat (which is not relevant for GHG emissions). Therefore, an emission factor of 50% of the default emission factor is selected.

Table 48: Composition of 1.A.2.c Chemical industries – industrial waste – CO₂ IEF for the years 2000 to 2022.

Year	Total energy use	Solid waste		ETS		Other waste		CO ₂ IEF [t/TJ]
	[TJ]	[TJ]	CO ₂ EF	[TJ]	CO ₂ IEF	[TJ]	CO ₂ EF	
2000	2 258	1 500	75.00	378 ¹⁾	70.62	380	37.50	67.96
2005	1 431	1 052	75.00	378	70.62	0	37.50	73.84
2010	4 190	3 914	75.00	378	77.47	0	37.50	75.16
2011	3 690	3 479	75.00	276	75.10	0	37.50	75.01
2012	3 776	3 517	75.00	210	82.92	0	37.50	75.54
2013	2 858	2 441	75.00	259	83.31	0	37.50	76.21
2014	3 249	2 661	75.00	417	58.28	0	37.50	71.98
2015	3 057	2 466	75.00	588	61.86	0	37.50	72.46
2016	3 363	2 906	75.00	591	77.87	0	37.50	75.39
2017	3 023	2 638	75.00	457	71.98	0	37.50	74.62
2018	2 776	2 327	75.00	385	68.78	0	37.50	74.00
2019	2 479	1 920	75.00	448	65.50	0	37.50	72.86
2020	3 241	2 710	75.00	559	77.92	0	37.50	75.48
2021	3 017	2 600	75.00	530	86.18	0	37.50	76.55
2022	4 100	3 684	75.00	418	76.82	0	37.50	75.18

¹⁾ For 2000 to 2004 the value of 2005 has been selected.

Emission factors

CO₂ emission factors are taken from studies (BMWA 1990, 1996) and (UMWELTBUNDESAMT 2002).

Table 49: Emission factors of Category 1.A.2.c for 2022.

Fuel	CO ₂ [t/TJ]	CH ₄ [kg/TJ]	N ₂ O [kg/TJ]
Residual Fuel Oil	78.00	3.00	0.60
Gas oil	75.00	3.00	0.60
LPG	64.00	1.00	0.10
Other liquid fuels (flaring)	67.27 ³⁾	3.00	0.60
Hard Coal	94.00	10.00	1.50
Lignite, Brown Coal Briquettes	97.00	10.00	1.50

Fuel	CO ₂ [t/TJ]	CH ₄ [kg/TJ]	N ₂ O [kg/TJ]
Coke	104.00	10.00	1.50
Natural Gas	55.60	1.00	0.10
Fuel Wood	112.00 ¹⁾	30.00	4.00
Wood Waste	112.00 ¹⁾	10.00	4.00
Black Liquor	95.30 ¹⁾	3.00	2.00
Biogas	54.60 ¹⁾	1.00	0.10
Industrial Waste	75.18 ²⁾	12.00	4.00

¹⁾ Reported as CO₂ emissions from biomass; ²⁾ For the years 1990 to 1999: 75 t/TJ; ³⁾ IEF derived from ETS data

Activity data

Fuel consumption is taken from (IEA JQ 2023) and from the ETS.

Recalculations

Changes of activity data 2021 follow the revision of the energy balance. Recalculations of CO₂ emissions 2020 (+67 kt CO₂) are mainly due to improved allocation of ETS industrial waste data.

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

Key Source: CO₂ from 1.A.2.d gaseous, solid and liquid fuels

Category *1.A.2.d Pulp, Paper and Print* includes emissions from fuel combustion in pulp, paper and print industry. The share in total GHG emissions from sector 1.A is 4.3% for the year 1990 and 3.2% for the year 2022.

Methodology

CO₂ emissions are calculated by means of a Tier 2 method while N₂O and CH₄ emissions are calculated by means of a Tier 1 method. For the years 2005 onwards, CO₂ emissions from ETS reports are considered.

CO₂ emissions from industrial waste: The following Table 50 shows the composition of the implied emissions factor 2000–2022 for industrial waste. From 2005 onwards, ETS data is considered with plant specific emissions and energy consumption. From 1990 to 2004, energy consumption of the energy balance is taken and considered with a CO₂ emission factor of 75 t/TJ. Table 50 shows fuel waste consumption as provided by energy statistics together with fuel waste consumption, CO₂ emissions and the calculated IEF from ETS.

Table 50: Composition of 1.A.2.d Pulp, Paper and Print – industrial waste – CO₂ IEF for the years 2000 to 2022.

Year	Total energy use (energy balance)	ETS		CO ₂ IEF	CO ₂
	[TJ]	[TJ]	CO ₂ IEF	[t/TJ]	[kt]
2000	0	-	-	75.00	-
2005	90	111	64.29	64.29	7.15
2010	166	79	100.85	100.85	7.93
2011	164	91	87.79	87.79	7.99
2012	81	60	116.27	116.27	6.98
2013	153	170	128.46	128.46	21.83

Year	Total energy use (energy balance)	ETS		CO ₂ IEF	CO ₂
	[TJ]	[TJ]	CO ₂ IEF	[t/TJ]	[kt]
2014	258	180	129.09	129.09	23.20
2015	237	180	140.21	140.21	25.23
2016	268	151	134.22	134.22	20.21
2017	248	178	125.66	125.66	22.36
2018	212	289	73.69	73.69	21.29
2019	231	74	91.13	91.13	6.71
2020	205	94	99.33	99.33	9.38
2021	125	14	124.93	124.93	1.74
2022	988	18	118.37	118.37	

Emission factors

CO₂ emission factors are taken from studies (BMWA 1990, 1996) and (UMWELTBUNDESAMT 2002). Emission factors for 2022 are presented in the following table.

Table 51: Emission factors of Category 1.A.2.d.

Fuel	CO ₂ [t/TJ]	CH ₄ [kg/TJ]	N ₂ O [kg/TJ]
Hard Coal	94.00	10.00	1.50
Lignite, Brown Coal Briquettes	97.00	10.00	1.50
Coke	104.00	10.00	1.50
Residual Fuel Oil	78.00	3.00	0.60
Diesel and Gasoil	75.00	3.00	0.60
Petroleum	78.00	3.00	0.60
LPG	64.00	1.00	0.10
Natural Gas	55.60	1.00	0.10
Fuel Wood and Sewage Sludge	112.00 ¹⁾	30.00	4.00
Wood Waste	112.00 ¹⁾	12.00	4.00
Black Liquor	95.30 ¹⁾	3.00	2.00
Biogas and Landfill Gas	54.60 ¹⁾	1.00	0.10
Industrial Waste	118.37	12.00	4.00

¹⁾ Reported as CO₂ emissions from biomass

Activity data

Fuel consumption is taken from (IEA JQ 2023) as presented in Annex 4, and from the ETS.

Recalculations

Recalculations of activity data 2021 are following the revision of the energy balance as described in Annex 4.

3.2.11.5 1.A.2.e Food Processing, Beverages and Tobacco

Key Source: CO₂ from 1.A.2.e gaseous and liquid fuels

Category 1.A.2.e Food Processing, Beverages and Tobacco enfold emissions from fuel combustion in food processing, beverages and tobacco industry. The share in total GHG emissions from sector 1.A is 1.7% for the year 1990 and 1.8% for the year 2022.

Methodology

CO₂ emissions are calculated by means of a Tier 2 method while N₂O and CH₄ emissions are calculated by means of a Tier 1 method. For the years 2005 onwards, ETS data are considered.

Emission factors

CO₂ emission factors are taken from studies (BMWA 1990, 1996) and (UMWELTBUNDESAMT 2002). Emission factors for 2022 are presented in the following table.

Table 52: Emission factors of Category 1.A.2.e.

Fuel	CO ₂ [t/TJ]	CH ₄ [kg/TJ]	N ₂ O [kg/TJ]
Residual Fuel Oil	78.00	3.00	0.60
Diesel and Gas oil	75.00	3.00	0.60
Petroleum	78.00	3.00	0.60
LPG	64.00	1.00	0.10
Hard Coal	94.00	10.00	1.50
Lignite, Brown Coal Briquettes	97.00	10.00	1.50
Coke	104.00	10.00	1.50
Natural Gas	55.60	1.00	0.10
Fuel Wood	112.00 ¹⁾	30.00	4.00
Wood Waste	112.00 ¹⁾	10.00	4.00
Biogas	54.60 ¹⁾	1.00	0.10
Industrial Waste	75.00	12.00	4.00

¹⁾ Reported as CO₂ emissions from biomass

Activity data

Fuel consumption is taken from (IEA JQ 2023) as presented in Annex 4.

Recalculations

Changes in activity data 2021 are based on a revision of the energy balance as described in Annex 4.

3.2.11.6 1.A.2.f Non-Metallic Minerals

Key Source: CO₂ from 1.A.2.f gaseous, solid, liquid and other fuels

Category 1.A.2.f *Non-Metallic Minerals* enfold emissions from fuel combustion in cement, lime, magnesia, glass and bricks & tiles industries. Fuel use of limekilns, which are operated by sugar industries, is reported under category 1.A.2.e *food processing, Beverages and Tobacco*. The share in total GHG emissions from Sector 1.A is 3.2% for the year 1990 and 3.3% for the year 2022.

Cement Clinker Production (NACE 26.51)

This category enfold emissions from fuel combustion in cement clinker kilns. The yearly production capacity of the 9 Austrian plants is about 4.3 Mt cement clinker. Yearly clinker production is 80% to 90% of total capacity. Further information about yearly clinker production is provided in the methodology chapter of category 2.A.1 *Cement production*. Between 2008 and 2014, clinker production was falling by 21% from 4 Mt to 3.1 Mt and has increased to 3.6 Mt in 2022.

Methodology

Information about CO₂ emissions due to fuel combustion for cement production is taken from four studies of the Austrian cement industry (HACKL & MAUSCHITZ, 1995, 1997, 2001, 2003, 2007) and (MAUSCHITZ 2004, 2009, 2010–2023). The data presented in these studies include fuel consumption and emission data for emissions from combustion processes and from calcination processes (process specific emissions, see category 2.A.1) separately. The studies cover the years 1988 to 2022.

For the studies mentioned above, CO₂ emissions from all cement production plants in Austria were investigated. The determination of the emission data took place by inspection of every single plant, recording and evaluation of plant specific records, and plant specific measurements and analysis carried out by independent scientific institutes. Using this data (single measurement data or half-hourly mean values from continuous measurements), yearly mean values for concentration of CO₂ in the waste gas flow were calculated. With the average flow of dry waste gas, the plant specific CO₂ emission mass stream and consequently the plant specific emission factors (normalized to ton clinker and/or ton cement) were calculated.

CO₂ emissions

CO₂ emissions for the years 1990 to 2003 are taken from industry (HACKL & MAUSCHITZ, 1995, 1997, 2001, 2003, 2007) and (MAUSCHITZ 2004).

For solid, liquid and gaseous fuels, CO₂ emissions are calculated by multiplying activity data by national default emission factors (for sources of emission factors see relating chapter). The remaining CO₂ emissions are allocated to industrial waste.

CO₂ emissions from 2004 onwards are taken from the ETS allocation plan survey and from ETS reports.

CH₄ and N₂O emissions are calculated by means of the IPCC Tier 1 methodology.

Activity data

Calculated thermal energy intake of cement kilns is between 3.45 GJ/t clinker in 1990 and 3.86 GJ/t clinker in 2022.

Hard Coal, Brown Coal, Petrol Coke and Industrial Waste

In (IEA JQ 2023) the category *Non-metallic Mineral Products* enfolds fuel consumption of NACE Division 26. As within this NACE division, industrial branches other than cement industry do not use coal and industrial waste for fuel combustion but 100% of those fuels are allocated to the cement industry. The same is for petrol coke until 2001, but from 2002 onwards, a share of petrol coke is allocated to magnesia production from dolomite by using ETS data. The following Table 53 shows the amount, NVCs and CO₂ IEFs of industrial waste, which is used as a fuel in cement kilns. After 2005, the share of non-fossil waste has been taken from ETS data. The overall IEF is between 79.0 to 88.5 t CO₂/TJ, which is reasonable because most of the waste origins from oil products. From 1990 to 2004, the mass of fractions with 100% biomass is not explicitly known. The biogenic C-content of the diverse waste fractions is e.g.: 0% for waste oil and solvents, 3–24% for plastics, 27–30% for scrap tyres, 36–42% for high heat value fraction of MSW and 56% for paper reject. Examples of non-fossil waste fractions: glycerine, carcass meal, animal fat, sewage sludge, paper fibre residue and sawdust.

Table 53: Industrial waste used as fuel in cement kilns 1990–2022.

Year	solid waste [kt]		NCV ¹⁾ [MJ/kg]	fossil ¹⁾ CO ₂ IEF [t/TJ]	biomass ¹⁾ CO ₂ IEF [t/TJ]	Fossil + ¹⁾ biomass CO ₂ IEF [t/TJ]
	100% biomass	Fractions with fossil C-content				
1990	–	59	22.07	55.42	–	–
1995	–	87	22.71	68.92	–	–
2000	–	170	20.94	83.20	–	–
2005	58	204	23.28	68.92	10.32	79.25
2010	129	227	22.19	65.23	18.59	83.82
2011	136	240	21.53	64.06	21.81	85.86
2012	152	263	20.92	63.23	25.30	88.52
2013	146	280	19.90	64.26	20.04	84.30
2014	143	302	21.01	63.50	20.32	83.82
2015	164	307	19.93	59.87	24.06	83.93
2016	158	333	20.73	60.28	20.41	80.70
2017	158	341	21.15	61.03	20.01	81.04
2018	182	366	20.59	60.54	21.42	81.96
2019	169	359	19.82	59.40	20.62	80.02
2020	177	319	19.61	58.79	21.83	80.63
2021	212	348	20.03	55.55	23.48	79.03
2022	224	355	19.18	55.54	25.91	81.45

¹⁾ Of solid waste with fossil and non-fossil C-content.

Natural Gas and Fuel Oil

For the period 1990 to 2004 natural gas and fuel oil consumption is taken from (HACKL & MAUSCHITZ 1995, 1997, 2001, 2003, 2007) and (MAUSCHITZ 2004) and converted into the unit TJ by applying the calorific values reported in (IEA JQ 2023).

Activity data 2005–2021

For the years 2005 onwards, ETS data are taken which covers 100% of cement plants.

Emission factors

CO₂ default emission factors are taken from studies (BMWA 1990, 1996).

Recalculations

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

3.2.11.7 1.A.2.g Other Manufacturing Industries and Construction

Key Source: CO₂ from 1.A.2.g.vii liquid fuels
CO₂ from 1.A.2.g.viii gaseous, liquid and solid fuels

This category enfolds emissions due to fuel combustion of the industrial branches as specified in Table 54. The share in total GHG emissions from Sector 1.A is 3.9% for the year 1990 and 6.1% for the year 2022.

Table 54: 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

Methodology

CO₂ emissions are calculated by means of a Tier 2 method while N₂O and CH₄ emissions are calculated by means of a Tier 1 method. For the years 2005 onwards, CO₂ ETS data are considered.

Activity data

Fuel consumption is taken from (IEA JQ 2023) as presented in Annex 4.

Since the energy balance (IEA JQ 2023) does not report gas works gas the activity data is taken from the 'Austrian Energy Balance' provided by STATISTIK AUSTRIA (STATISTIK AUSTRIA 2023a), which is in a different structure but consistent with IEA JQ 2023).

Emission factors

CO₂ emission factors are taken from studies (BMWA 1990, 1996) and (UMWELTBUNDESAMT 2002). The emission factors for 2022 are presented in the following table.

Table 55: Emission factors 2022 of category 1.A.2.g.viii Other Manufacturing Industries and Construction.

Fuel	CO ₂ [t/TJ]	CH ₄ [kg/TJ]	N ₂ O [kg/TJ]
Hard Coal	94.00	10.00	1.50
Lignite and Brown Coal Briquettes	97.00	10.00	1.50
Coke	104.00	10.00	1.50
Residual Fuel Oil	78.00	3.00	0.60
Diesel and Gasoil	75.00	3.00	0.60
Petroleum	78.00	3.00	0.60
LPG and Gas Works gas	64.00	1.00	0.10
Natural Gas	55.60	1.00	0.10
Fuel Wood	112.00 ¹⁾	30.00	4.00
Wood Waste	112.00 ¹⁾	10.00	4.00
Biogas, Sewage Sludge Gas, Landfill gas	54.60 ¹⁾	1.00	0.10
Industrial Waste – fossil (1990–2004)	75.00	12.00	4.00
Industrial Waste – IEF	25.01 ¹⁾	12.00	4.00

¹⁾ Reported as CO₂ emissions from biomass; ²⁾ Implied emission factor

Recalculations

Changes of activity data 2021 are based on a revision of the energy balance as described in Annex 4.

1.A.2.g.vii Off-road vehicles and other machinery (industry)

Key Source: yes (liquid, CO₂)

In this chapter the methodology of estimating emissions from mobile sources of CRF 1.A.2.g.vii is described. The share in total GHG emissions from CRF 1.A is 0.5% for the year 1990 and 3.1% for the year 2022.

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 3 methodology.

Energy consumption and emissions of off-road traffic in Austria are calculated with the model GEORG (**G**razer **E**missionsmodell für **O**ff-**R**oad **G**eräte). This model was 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 CRFs were taken into account:

- 1.A.2.g.vii 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 (ground activities)

Activities of mobile machinery in CRF 1.A.2.g.vii Industry also contain commercially/institutionally used machinery. Austria does not report emissions from these machines separately under CRF 1.A.4.a.2 as the split into commercial/institutional and non-commercial/non-institutional use is not possible due to a lack of data.

Input data to the model are:

- Machinery stock data (obtained from data on licences, through inquiries and statistical extrapolation);
- Assumptions on drop-out rates of machinery (broken down machinery will be replaced);
- Operating time (obtained through inquiries), related to age of machinery.

From machinery stock data and drop-out rates an age structure of the off-road machinery was obtained by GEORG. Four categories of engine types were considered. Depending on the fuel consumption of the engine the ratio power of the engine was calculated. Emissions were calculated by multiplying an engine specific emission factor (expressed in g/kWh) by the average engine power, the operating time and the number of vehicles.

With this method national fuel consumption and national emissions are calculated (bottom-up). Calculated fuel consumption of off-road traffic is then summed up with total fuel consumption of inland road transport and is compared with total fuel sold in Austria according to the national energy balance. The difference is allocated to fuel export (for details concerning fuel export see CRF

1.A.3.b). The emissions reported for Austria also include the emissions from the fuel exports assuming that the fuel export fleet (mainly travelling on highways) is similar to the Austrian fleet on highways.

Activity Data

Activity data, vehicle stock and specific fuel consumption for vehicles and machinery (e.g. leaders, diggers etc.) were taken from:

- Statistik Austria (national energy balance),
- Questionnaire to vehicle and machinery users (HAUSBERGER 2000),
- Interviews with experts and expert judgment validating the questionnaire results (HAUSBERGER 2000) and
- Information from vehicle and machinery manufacturers (HAUSBERGER 2000).

An allocation of pure biofuels in the off-road sector has not been performed due to lack of data.

Activities used for estimating emissions of CRF 1.A.2.g.vii as well as the implied emission factors are presented below. Combustion of liquid fossil fuels is the only mobile source of CO₂ emissions from category CRF 1.A.2.g.vii.

The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards.

Table 56: Implied emission factors and activities from industrial mobile off-road sources 1990–2022.

Year	Activity	Implied Emission Factors		
	TJ	CO ₂ t/TJ	CH ₄ kg/TJ	N ₂ O kg/TJ
1990	3 448	74.19	3.79	26.12
1995	4 821	74.19	3.60	27.11
2000	7 426	74.19	3.15	29.82
2005	11 016	73.52	1.73	21.33
2010	15 324	70.30	0.75	12.59
2011	15 401	70.25	0.71	12.09
2012	15 960	70.09	0.64	11.37
2013	16 051	70.29	0.58	10.74
2014	15 722	70.12	0.54	10.43
2015	15 318	69.71	0.50	10.10
2016	15 424	70.18	0.45	9.64
2017	16 193	70.55	0.39	9.11
2018	17 343	70.46	0.33	8.63
2019	18 264	70.56	0.30	8.26
2020	17 535	70.58	0.28	8.06
2021	19 303	70.46	0.25	7.87
2022	20 692	70.46	0.23	7.72

Emission Factors

Based on a new study (SCHWINGSHACKL/REXEIS/WELLER 2020) emission factors for a set of recently measured NRMM were updated as well as the implementation periods of the corresponding emission standards (so called “stages”) were taken into account.

The following emission factors for different engine types (average motor capacity) depending on the year of construction and emission standards are used in the GEORG model. They represent emissions according to the engine power output and fuel consumption.

Table 57: Emission factors for diesel engines < 80 kW.

Emission Standard		Fuel	CO ₂	CH ₄	N ₂ O
	Years		[g/kwh]		
AG1	1990–1993	285.005	898.622	0.045	0.316
AG2	1994–2001	268.445	846.406	0.035	0.350
Stage 1	2002–2003	274.294	864.848	0.005	0.224
Stage 2	2004–2006	274.294	864.848	0.004	0.120
Stage 3a	2007–2011	274.294	864.848	0.002	0.084
Stage 3b	2012–2017	274.294	864.848	0.001	0.084
Stage 4 SCR	2014–2020	274.294	864.848	0.001	0.084
Stage 5	2020–2022	274.294	864.848	0.00002	0.084

Table 58: Emission factors for diesel engines > 80 kW.

Emission Standard		Fuel	CO ₂	CH ₄	N ₂ O
	Years		[g/kwh]		
AG1	1990–1993	277.543	875.092	0.038	0.316
AG2	1994–2001	263.231	829.968	0.029	0.350
Stage 1	2002–2003	258.120	813.852	0.005	0.224
Stage 2	2004–2006	268.550	846.740	0.003	0.120
Stage 3a	2007–2011	268.550	846.740	0.002	0.084
Stage 3b	2012–2017	268.550	846.740	0.001	0.084
Stage 4 SCR	2014–2020	268.550	846.740	0.001	0.084
Stage 5	2020–2022	268.550	846.740	0.00002	0.084

Table 59: Emission factors for 2-stroke-petrol engines.

Emission Standard	Fuel		CO ₂	CH ₄	N ₂ O
	Years		[g/kwh]		
AG1	1990–1993	739.000	2 330.067	2.503	0.015
AG2	1994–2001	671.650	2 117.712	1.761	0.015
Stage 1	2002–2003	653.150	2 059.382	1.663	0.015
Stage 2	2004–2006	500.000	1 576.500	0.510	0.014
Stage 3a	2007–2011	482.143	1 520.196	0.510	0.012
Stage 3b	2012–2022	482.143	1 520.196	0.510	0.012

Table 60: Emission factors for 4-stroke-petrol engines.

Emission Standard		Fuel	CO ₂	CH ₄	N ₂ O
	Years		[g/kwh]		
AG1	1990–1993	561.100	1 769.148	0.554	0.038
AG2	1994–2001	540.000	1 702.620	0.440	0.041
Stage 1	2002–2003	469.400	1 480.018	0.420	0.041
Stage 2	2004–2006	469.400	1 480.018	0.407	0.041
Stage 3a	2007–2011	456.361	1 438.907	0.375	0.030
Stage 3b	2012–2022	456.361	1 438.907	0.375	0.030

Recalculations

Energy consumption for category “liquid” (blended diesel) has been revised for 2021 due to an update of the industrial production index. Instead of 19,148,55 TJ the revised value for energy consumption is 19,302.87 TJ. This has also implications on the fuel categories “biomass” and “Other” (FAME fossil part). The corresponding changes in CO₂, CH₄ and N₂O emissions affect all of the three mentioned fuel categories of 1.A.3.c except for CO₂ of biomass, as it is zero per se.

Planned Improvements

No category-specific improvements are planned.

3.2.12 QA/QC of 1.A.1 and 1.A.2 stationary sources

For general QA/QC see Chapter 1.2.3.

In 2016 STATISTIK AUSTRIA provided an updated documentation for the national energy balance and a document which covers a more actual quantification of uncertainties.

Concerning activity data for sectors 1.A.1 and 1.A.2 there are specific regulations in the Austrian legislation:

- BGBl II No. 1997/331 Feuerungsanlagen-Verordnung,
- BGBl 1989/19 Luftreinhalteverordnung für Kesselanlagen,
- BGBl 1988/380 Luftreinhaltegesetz für Kesselanlagen,
- BGBl 150/2004 Emissionsschutzgesetz für Kesselanlagen – EG K,
- BGBl 84/2006 Emissionsschutzgesetz für Kesselanlagen – EG K,
- BGBl II No. 2007/292 Emissionserklärungsverordnung – EEV.

Additionally the following sector specific QA/QC procedures have been carried out:

- activity data check
 - Survey for the “National Emission Trading Allocation Plan” 1 (NAP1) 1990 to 2002 with almost complete data for 1998 to 2002,
 - 1.A.1.a: public report: fuel consumption and energy production by plant (1990),
 - discussion of activity data with Refinery (incl. methodology of CO₂ emission calculation) and Iron and Steel Industry,
 - check of gas consumption with data from E-Control,
 - check of oil consumption with data from Mineral Oil Association.
- indicators and analysis (activity data and CO₂ emissions)
 - Public “Kyoto Progress” Reports until 2007. Public “Climate Protection” Reports since 2008,
 - energy intensity indicators: Iron and Steel, Cement industry, Refinery, Households.
- external review
 - Federal provinces air emission inventory,
 - Check of methodology and CO₂ emissions by WIFO.
- emission factors check

- check of IEF (time series),
- NAP1 survey: Country specific CO₂ emission factors used in the inventory were widely accepted,
- comparison with IPCC.
- time series consistency
 - plausibility checks of dips and jumps,
 - yearly published emission trends report,
 - repeated values.
- recalculations check of activity data (energy balance), implied emissions factors and emissions.
- Method Documentation with Standard Operation Procedure (SOP);
- “Quick-calculation” of 1.A activity,
- improvement list (external and internal findings);
- link to STATISTIK AUSTRIA, Industrial associations;
- calculation by spreadsheets
 - consistent use of energy balance data (central file),
 - documented sources,
 - use of units,
 - strictly defined interfaces between spreadsheets/calculation modules,
 - unique structure of sheets which do the same,
 - use of coding systems (SNAP, SPLIT, NAPFUE),
 - record keeping, use of write protection,
 - unique use of formulas, special cases are documented/highlighted,
 - quick-control checks for data consistency through all steps of calculation.

3.2.13 1.A.3 Transport

3.2.13.1 1.A.3.a Civil Aviation

Key Source: No

CRF 1.A.3.a *Civil Aviation* covers domestic LTO (landing/take off) and domestic cruise.

For methodological reason it is distinguished between flights according to

- Visual Flight Rules (VFR) which include all flights using aviation gasoline
- Instrumental Flight Rules (IFR) which cover all flights using kerosene

International LTO and international cruise is considered in CRF 1.D.1.a *International Bunkers Aviation*. Military Aviation is allocated to CRF 1.A.5 *Other*.

Greenhouse gas emissions from domestic aviation are very low related to total emissions from the transport sector 1.A.3 and amounted to 0.3% in 1990 and 0.1% of GHG emissions of 1.A.3 in 2022.

Table 61: Greenhouse gas emissions from 1.A.3.a domestic Civil Aviation by subcategories 1990–2022.

Year	CO ₂ [kt]			CH ₄ [kt]			N ₂ O [kt]		
	dom. LTO (VFR)	dom. LTO (IFR)	dom. cruise (IFR)	dom. LTO (VFR)	dom. LTO (IFR)	dom. Cruise (IFR)	dom. LTO (VFR)	dom. LTO (IFR)	dom. Cruise (IFR)
	Gasoline	Kerosene	Kerosene	Gasoline	Kerosene	Kerosene	Gasoline	Kerosene	Kerosene
1990	7.8	9.3	21.3	0.0001	0.0020	NA	0.0002	0.001	0.001
1995	7.1	14.0	32.2	0.0000	0.0026	NA	0.0002	0.002	0.001
2000	6.3	19.3	41.6	0.0000	0.0048	NA	0.0002	0.002	0.001
2005	8.6	16.4	41.6	0.0001	0.0041	NA	0.0002	0.002	0.001
2010	9.1	19.4	34.9	0.0001	0.0048	NA	0.0003	0.002	0.001
2011	13.6	16.8	31.2	0.0001	0.0042	NA	0.0004	0.002	0.001
2012	7.9	16.9	29.7	0.0001	0.0042	NA	0.0002	0.002	0.001
2013	8.1	16.9	29.5	0.0001	0.0042	NA	0.0002	0.002	0.001
2014	7.4	15.4	27.0	0.0001	0.0038	NA	0.0002	0.001	0.001
2015	8.2	14.9	26.6	0.0001	0.0037	NA	0.0002	0.001	0.001
2016	10.2	14.8	22.5	0.0001	0.0009	NA	0.0003	0.0004	0.001
2017	7.4	13.8	21.3	0.0001	0.0008	NA	0.0002	0.0004	0.001
2018	7.1	16.1	22.8	0.0001	0.0013	NA	0.0002	0.0004	0.001
2019	6.8	16.4	22.8	0.00005	0.0014	NA	0.0002	0.0005	0.001
2020	5.7	7.7	9.9	0.00004	0.0009	NA	0.0002	0.0002	0.0003
2021	6.3	8.0	9.6	0.00004	0.0010	NA	0.0002	0.0002	0.000
2022	5.4	10.4	13.9	0.00004	0.0010	NA	0.0002	0.0003	0.0004
1990–2022	-31%	12%	-35%	-29%	-48%		-29%	-76%	-45%

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 3A (IFR flights) and Tier 1 (VFR flights) methodology.

IFR – Instrument Flight Rules

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

- Tier 3B: For the years 1990–1999 a country-specific methodology was applied. The calculations were based on a study commissioned by the Umweltbundesamt finished in 2002 (KALIVODA & KUDRNA 2002). This methodology was consistent with the very detailed IPCC 2006 GL Tier 3B methodology (advanced version based on the MEET model (KALIVODA & KUDRNA 1997). For emission calculation air traffic movement data⁴⁸ (flight distance and destination per aircraft type) and aircraft/engine performances data were used.
- Tier 3A: For the years from 2000 onwards the IPCC 2006 GL Tier 3A methodology has been applied. Tier 3A takes into account average fuel consumption and emission data for LTO phases and various flight lengths, for an array of representative aircraft categories.

⁴⁸ This data is also used for the split between domestic and international aviation.

Based on a recommendation of the 2020 UNFCCC inventory review, Austria improved time series consistency by using the Tier 3A methodology as described above for the years from 2000 onwards and a trend extrapolation (as described in the IPCC 2006 GL volume 1 chapter 5.3.3) for 1990-1999.

Due to the lack of consistent data Austria was not able to use overlap or surrogate techniques. While the total amount of kerosene used in each year during the period 1990-1999 is out of question (KALIVODA & KUDRNA 2002), for the trend extrapolation it was necessary to determine the yearly ratios of kerosene used for domestic LTO, domestic cruise, international LTO and international cruise based on average shares of kerosene consumption over the three years 2000, 2001 and 2002. As a result four fixed average ratios were used for determining the new kerosene consumption and emissions for the years 1990-1999 for domestic LTO and domestic cruise as well as international LTO and international cruise.

VFR – Visual Flight Rules

The IPCC 2006 GL simple methodology (Tier 1 – fuel-based methodology) is applied.

Activity Data

Kerosene and gasoline consumption are reported under CRF 1.A.3.a, whereas airport ground handling activities are reported under CRF 1.A.3.e.2 *Other (Airport Ground Activities)*.

IFR flights

For details of fuel consumption in the years 1990–1999 please refer to ‘**Methodological Issues**’ above.

For the years from 2000 onwards fuel consumption for the different transport modes IFR national LTO, IFR international LTO, IFR national cruise and IFR international cruise was calculated according to the IPCC 2006 GL Tier 3A method, with average consumption data per aircraft types and flight distances. The fuel consumption of IFR international cruise was adjusted as explained below.

IFR flight movements are taken from Austro Control (AUSTRO CONTROL 2023), fuel consumption data from the national energy balance (STATISTIK AUSTRIA 2023a).

Bottom up Methodology – fuel consumed

Based on the number of flight movements per aircraft type and airport (national and international) departing Austria, the distances for each airport pair and the specific fuel consumption per aircraft type and distance class, FC (kerosene) and emissions are calculated bottom up.

For the inventory years 2000-2015 flight movements were obtained from special analyses by Statistik Austria (STATISTIK AUSTRIA 2008⁴⁹, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016). In addition, domestic flight movements were compared with a second data source for flight movements, provided by Austro Control (AUSTRO CONTROL 2007⁵⁰, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016) and reconciled to meet these number of flight movements. Distances between airport pairs have been extracted based on IATA codes from single queries on the internet.⁵¹

⁴⁹ For the years 2000-2007

⁵⁰ For the years 2000-2006

⁵¹ www.world-airport-codes.com

Beginning with the inventory year 2016 flight movements have only been taken from Austrocontrol (AUSTRO CONTROL 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023), as they seemed to be more representative compared with international data. Since then distances between departure and arrival aerodromes have been calculated by an automatic distance generator using following formula:

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

D ... Distance between aerodromes

φ(B) ... Geographical latitude of arrival aerodrome B

r ... Average radius of the earth (6371 km)

λ(A) ... Geographical longitude of departure aerodrome A

φ(A) ... Geographical latitude of departure aerodrome A

λ(B) ... Geographical longitude of arrival aerodrome B

Therefore, 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 is being compared to the total fuel sold reported by the national energy balance:

- For the inventory years 2000-2015 the delta was fully allocated to international cruise, as the data reconciliation of domestic flight movements (see above) had already resulted in increased numbers in line with Austrocontrol.
- Beginning with the inventory year 2016 any delta between the bottom up result and the official amount of kerosene sold has been allocated to domestic LTO, international LTO, national cruise and international cruise depending on their relative shares in total kerosene consumption.

The following table shows the fuel consumption for IFR flights and the numbers of national LTO (IFR).

Table 62: Fuel consumption for IFR flights and number of IFR LTO cycles, 1990–2022.

Year	Activity		
	Dom. LTO (IFR) Kerosene [kt]	Dom. Cruise (IFR) Kerosene [kt]	Dom. LTO (IFR) [no. of flights]
1990	2.94	6.75	-
1995	4.45	10.23	-
2000	6.11	13.18	22 611
2005	5.20	13.19	20 179
2010	6.16	11.07	20 532
2011	5.32	9.89	16 185
2012	5.37	9.43	16 405
2013	5.35	9.36	15 741
2014	4.87	8.56	14 776
2015	4.73	8.43	13 282
2016	4.70	7.15	15 515
2017	4.37	6.76	14 781
2018	5.11	7.24	19 735
2019	5.22	7.25	19 679
2020	2.45	3.13	14 196

Year	Activity		
	Dom. LTO (IFR) Kerosene [kt]	Dom. Cruise (IFR) Kerosene [kt]	Dom. LTO (IFR) [no. of flights]
2021	2.54	3.06	12 917
2022	3.30	4.40	13 294
1990–2022	12%	-35%	-41%⁵²

FR flights

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

Table 63: Fuel consumption for VFR flights, 1990–2022.

Year	Activity	
	Dom. LTO (VFR) Gasoline [kt]	
1990	2.49	
1995	2.24	
2000	2.04	
2005	2.79	
2010	2.92	
2011	4.40	
2012	2.54	
2013	2.61	
2014	2.38	
2015	2.65	
2016	3.28	
2017	2.39	
2018	2.30	
2019	2.20	
2020	1.83	
2021	2.03	
2022	1.73	
1990–2022	-30%	

Emission Factors

The following tables give an overview of the emission factors used for IFR and VFR flights.

Table 64: Comparison of emission factors for 1.A.3.a Civil Aviation – IFR flights

	Inventory years 1990-2015	Inventory years 2016-2022
IFR - CO ₂	3.15 kg/kg fuel	3.15 kg/kg fuel
IFR - CH ₄	9.6% of HC_LTO	10.0% of HC_LTO
IFR - N ₂ O	0.1 kg/LTO 0.1 kg/t fuel for cruise	2.0 kg/TJ fuel

⁵² Trend 2000 - onwards

Table 65: Comparison of emission factors for 1.A.3.a Civil Aviation – VFR flights

	Inventory years 1990-2015	Inventory years 2016-2022
VFR – CO ₂	3.15 kg/kg fuel	70.000 kg/TJ fuel
VFR – CH ₄	0.5 kg/TJ fuel	0.5 kg/TJ fuel
VFR – N ₂ O	2.0 kg/TJ fuel	2.0 kg/TJ fuel

CO₂ (Tier 1)

CO₂ emissions for IFR flights are calculated in line with the factor provided by the emission factor spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2019' (EEA 2019). The factor used is 3.15 kg/kg fuel.

CH₄ (Tier 1)

CH₄ emission factors are not included in the spreadsheet accompanying the EMEP/EEA 2019 Guidebook (Annex 5). According to the IPCC 2006 Guidelines, the Tier 1 approach assumes that all aircrafts have the same emission factors for CH₄ based on the rate of fuel consumption.

CH₄ emissions for all flights (IFR-LTO) can be estimated with the Tier 1 default value of 0.5 kg/TJ fuel (IPCC 2006) or 10% of total VOC (HC) emissions (IPCC 2006, Chapter Mobile Combustion, Table 3.6.5). For inventory years 1990–2015 a percentage of 9.6% of HC_LTO, for inventory years 2016–2019 10% of total VOC (HC) has been used.

HC emission factors were not included in the old CORINAIR 1996 emission factor spreadsheet for all aircraft types. Therefore, HC emissions for inventory years 1990-2015 were reported based on a calculation with HC IEFs from KALIVODA/KUDRNA (2002). For inventory years 2016 onwards HC emissions are not reported based on the KALIVODA/KUDRNA (2002) study any more, but based on the HC emission factors which are part of the emission factors spreadsheet (EEA 2019) for the different aircraft types.

According to the IPCC 2006 Guidelines, CH₄ emissions are assumed to be negligible in the cruise mode⁵³. Therefore CH₄ emissions for domestic and international cruise are reported as 'NA'.

N₂O (Tier 1)

According to the IPCC Guidelines (IPCC 2006), the Tier 1 approach assumes that all aircrafts have the same emission factors for N₂O based on the rate of fuel consumption.

N₂O emissions for all flights are estimated with the Tier 1 default value of 2.0 kg N₂O/TJ fuel (IPCC 2006, Chapter Mobile Combustion, Table 3.6.5).

Fuel consumption

The specific fuel consumption per distance class is provided in the spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2019' – Annex 5 (EEA 2019) for a huge number of aircraft types.

As in reality there are always flight movements with aircrafts which are not listed in the spreadsheet, an allocation of unknown aircrafts to listed aircrafts in the spreadsheet has to be undertaken based on research about engine type, number of engines, production series etc. If the unknown

⁵³ This is assumed to be valid for domestic and international cruise mode.

aircraft cannot be allocated, the aircraft is being labelled as UNKNOWN. The specific fuel consumption and emission factors are separately calculated on the basis of the national and international LTO and cruise averages of each year. This means the calculation distinguishes between:

- Unknown aircraft type for national flights – LTO
- Unknown aircraft type for national flights – cruise
- Unknown aircraft type for international flights – LTO
- Unknown aircraft type for international flights – cruise

For LTO_{unknown} the equation is:

$$FC/LTO = \text{Sum } FC\_LTO_{\text{unknown}} / \text{Sum flights movements}_{\text{unknown}}$$

For Cruise_{unknown} the equation is:

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

125 nm (nautical miles) is the shortest distance class. For the other distance classes >125 nm the values are being extrapolated.

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 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.

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.

Comparison IEA (military jet kerosene data)

In 2014, the ERT noted a significant difference in jet kerosene consumption (civil aviation) between IEA data and CRF Table 1.C. In response to the draft ARR 2014, Austria explained that the IEA value also includes military jet kerosene data and that this is the reason for the difference.

Completeness

In response to a question raised by the ERT (ICR, 2013) and based on a recommendation made by the UNFCCC in the course of the 2020 Review, fuel consumption and emissions of mobile sources used for aircraft handling at Austrian airports are now reported under CRF 1.A.3.e.2.

Recalculations

No category specific recalculations have been carried out.

Planned improvements

The emission factor spreadsheet accompanying the 'EMEP/EEA air pollutant emission inventory guidebook 2019' (EEA 2019) has been updated in autumn 2023 (EEA 2023a). Austria will update its aviation calculation tool accordingly for the next submission.

3.2.13.2 1.A.3.b Road Transport

Key Source: Yes (diesel oil CO₂/N₂O and gasoline CO₂)

CRF 1.A.3.b shows a strong increase in GHG emissions since 1990 (+51%) mainly due to an increase of road performance (mileage) of diesel cars and freight transport. In addition to the increase of road performance **within** Austria, the amount of fuel sold in Austria **but used elsewhere** – an effect called **fuel export** mainly caused by a lower fuel tax compared to Austria's neighbouring countries – has increased considerably since 1990. Between 2005 and 2012 total GHG emissions decreased due to lower amounts of fuel sold together with an increased use of biofuels for blending and the gradual replacement with newer vehicles with lower specific fuel consumption. Since then GHG emissions from transport have been **gradually increasing** with rising traffic volumes. In the pandemic year 2020 a sharp decrease of emissions was observed followed by an increase due to a slight economic recovery. **From 2021 to 2022** emissions from sub-category 1.A.3.b *Road Transportation* declined by 4.8% due to a drop in diesel sales especially in fuel exports with heavy duty vehicles, attributable to the dynamic fuel prices due to stabilizing measures in some neighbouring countries and the geo-political situation.

In 2022, 59% of the total greenhouse gas emissions from CRF 1.A.3.b are caused by passenger cars, 8% by light duty vehicles, 32% by heavy duty vehicles and buses and around 1% by mopeds and motorcycles.

In the following table total greenhouse gas emissions in CO₂e 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 added to get the total emissions for each vehicle category. The phenomenon of fuel export is explained in the subchapter Methodological Issues.

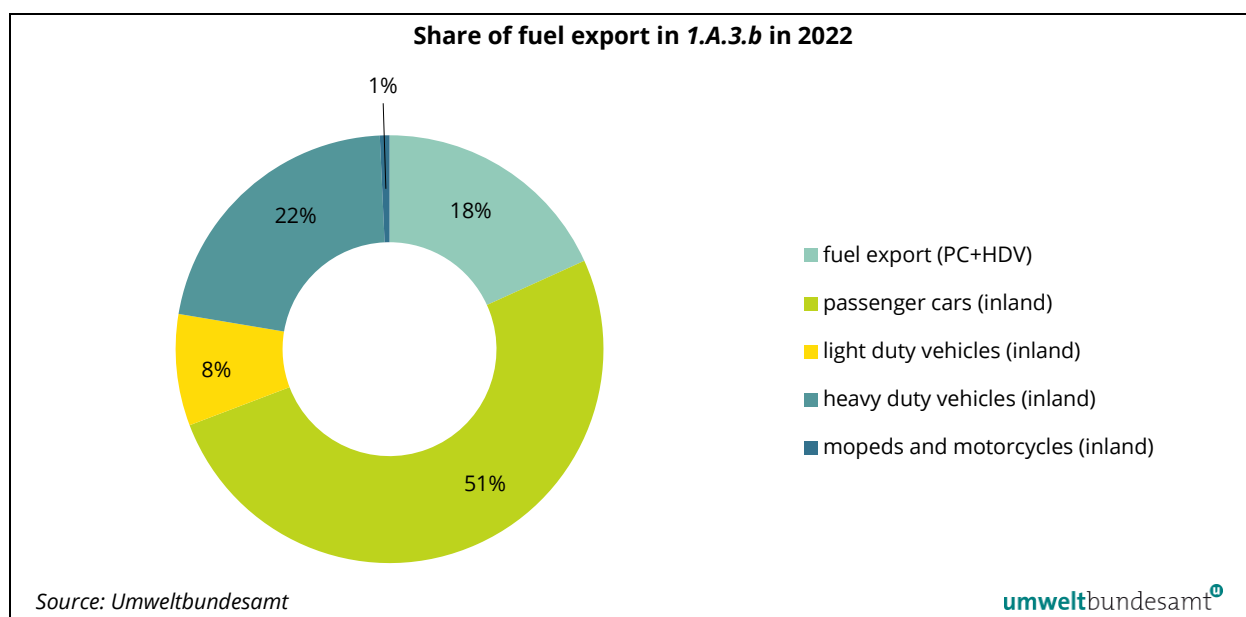
Table 66: Greenhouse gas emissions from 1.A.3.b Road Transport differentiated by means of transportation 1990–2022.

Year	Passenger cars		light duty vehicles	heavy duty vehicles		mopeds & motorcycles
	inland	fuel export	inland	inland	fuel export	inland
CO ₂ e [kt]						
1990	8 505	518	1 024	2 492	850	69
1995	9 174	486	1 179	3 131	1 312	83
2000	9 781	283	1 340	3 649	3 028	110
2005	12 220	1 926	1 436	3 992	4 566	125
2010	11 183	2 072	1 349	3 568	3 517	143
2011	11 123	1 963	1 367	3 657	2 838	147

Year	Passenger cars		light duty vehicles	heavy duty vehicles		mopeds & motorcycles
	inland	fuel export	inland	inland	fuel export	inland
CO ₂ e [kt]						
2012	10 949	1 918	1 359	3 657	2 998	152
2013	10 989	1 829	1 379	3 661	4 066	158
2014	11 086	1 799	1 400	3 547	3 493	163
2015	11 351	2 001	1 428	3 542	3 424	167
2016	11 727	2 166	1 490	3 941	3 290	173
2017	11 922	2 314	1 536	4 169	3 342	176
2018	11 794	2 428	1 549	4 294	3 382	174
2019	11 507	2 391	1 596	4 339	3 701	173
2020	10 079	1 298	1 611	4 191	3 230	157
2021	10 201	1 586	1 737	4 512	3 232	150
2022	10 394	1 588	1 717	4 410	2 126	148
1990–2022	22%	206%	68%	77%	150%	114%

In 2022, the total share of fuel export in CRF 1.A.3.b amounted to 18% or 3 714 kt CO₂ equivalents of which 43% are attributed to passenger road transport and 57% to road freight transport.

Figure 11: Share of fuel export in 1.A.3.b Road Transport in 2022.



Methodological Issues

The used methodology for estimating CO₂ emissions conforms to the requirements of the IPCC 2006 GL: Tier 2 for CO₂ and Tier 3 for CH₄ und N₂O. Details on EFs are given below.

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 IPCC 2006 GL 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 by national statistics.

Vehicle registrations are being updated yearly (STATISTIK AUTRIA 2023b). The last update of the specific yearly mileage of passenger cars, light duty vehicles, busses and motorcycles has been done for the year 2021 and 2022 according to data of the annual inspection of traffic and operational safety (according to §57a of the 1967 Motor Vehicle Act (KFG)) for the submission 2024.

For heavy duty vehicles the current traffic volumes up to 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 is calculated from the growth rates according to the final results of the automatic traffic counting stations and the toll data (ASFINAG 2023; BMK 2023d). For passenger cars, light duty vehicles, buses and motorcycles mileage data from the periodical inspection database was used as described above.

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). Emissions reported for Austria also include the emissions from the fuel exports.

According to the bottom-up / top-down methodology 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.

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 (Non-Road Mobile Machinery), because the amount of total fuel sold in Austria taken from the energy balance is the value which determines the GHG emissions of transport.

Fuel export

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 neighboring countries). Meaning that to a greater extent fuel is filled up in Austria and consumed abroad. This assumption is underpinned by two national studies (MOLITOR & HAUSBERGER et al. 2004; MOLITOR & SCHÖNFELDER et al. 2009).

It is assumed that the fuel export fleet (mainly travelling on highways) is similar to the Austrian fleet on highways, which means that no different efficiency rates are assumed for the fuel export fleet. It is assumed that fuel export is assigned to three vehicles groups: gasoline PC, diesel PC and diesel trucks.

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

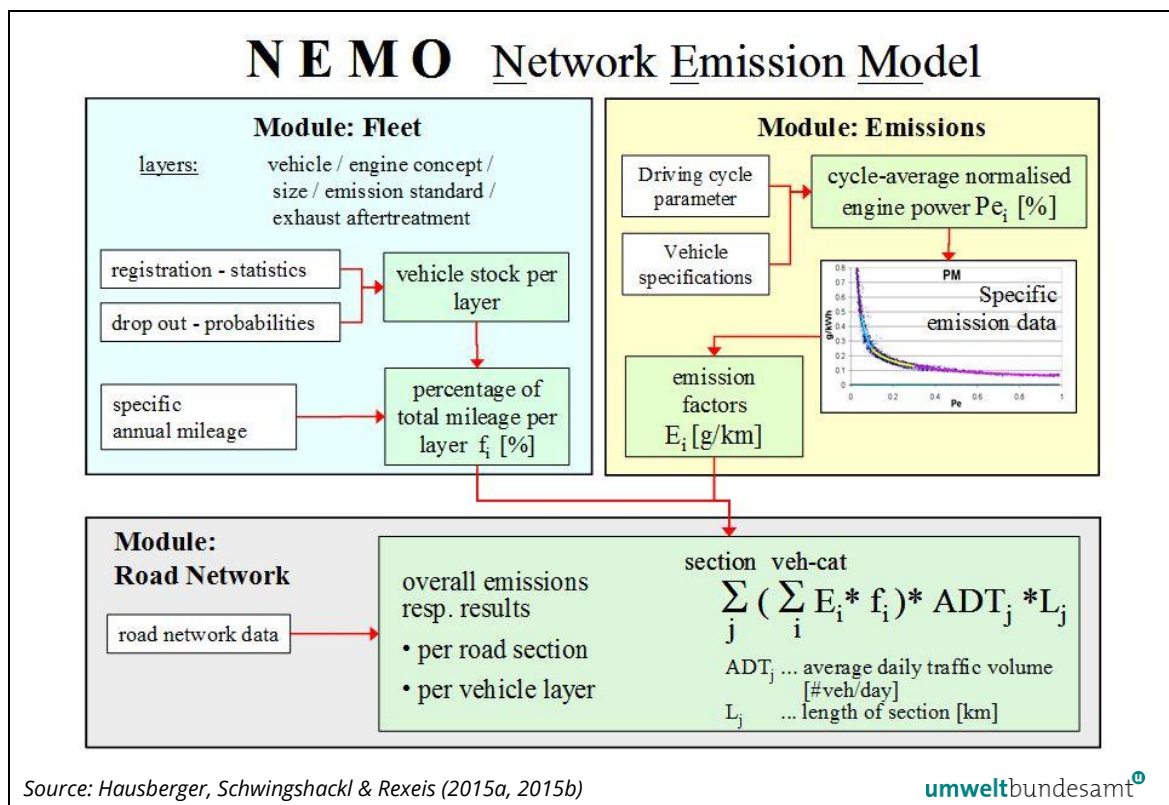
NEMO – Network Emission Model

From the submission in 2015 onwards calculations are based on the model NEMO – Network Emission Model (DIPPOLD, REXEIS & HAUSBERGER 2012; HAUSBERGER, SCHWINGSHACKL & REXEIS 2015a, 2015b; SCHWINGSHACKL & REXEIS 2022). NEMO combines a detailed calculation of the fleet composition with the simulation of energy consumption and emission output on 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, H₂ ...).

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, PM₁₀, PM_{2.5}, PM₁ and PM_{0.1} exhaust and non-exhaust emissions of road traffic.

Figure 12 shows a schematic picture of the methodology of NEMO.

Figure 12: Schematic picture of the NEMO model.



Model input

1. Yearly vehicle registrations (STATAT) and an algorithm for drop-out probabilities form the vehicle stock of each vehicle category split into layers according to the propulsion system (SI, CI,...), cylinder capacity classes or vehicle mass;
2. Emission factors of the vehicles according to the year of first registration and the layers from 1);
3. Yearly specific mileages of PCs, LDVs, mopeds and motorcycles (BMK)
4. Yearly growth rates of kilometres driven by PCs and HDVs separated for the federal street network (motorways) and the federal county network (urban, rural) (AUSTRIA TECH)
5. Yearly absolute number of vehicle kilometres (trucks and busses) on Austrian motorways (BMK)
6. Number of passengers per vehicle and tons payload per vehicle;
7. Optional either/or
 - a. total gasoline and diesel consumption of the area under consideration,
 - b. average km per vehicle and year.

Model output

- a. Km driven per vehicle and year,
- b. Total fuel consumption of road traffic,
- c. Total vehicle mileages,
- d. Total passenger-km and ton-km,

- e. Specific emission values for the vehicle fleets [g/km], [g/tkm], [g/pkm],
- f. Total emissions (evaporative emissions and suspended TSP, PM₁₀, PM_{2.5}, PM₁ and PM_{0.1} exhaust and non-exhaust emissions, CO, HC, NO_x, CO₂, SO₂ and several unregulated pollutants among them CH₄ and N₂O) of road traffic.

The calculation is done according to the following method for each year

1. Assessment of the vehicle stock split into layers according to the propulsion system (SI, CI,...), cylinder capacity classes (or vehicle mass for HDV) and year of first registration using the vehicle survival probabilities and the vehicle stock of the year before.

$$stock_{Jg_i, year\ i} = stock_{Jg_i, year\ i-1} \times survival\ probability_{Jg_i}$$

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)

$$total\ mileage_{E_i} = \sum_{Jg=start.}^{end} (stock_{Jg, year\ i} \times km/vehicle_{Jg, year\ i})$$

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

$$Emission_{E_i} = total\ mileage_{E_i} \times emission\ factor_{K_j, E_i}$$

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

$$Emission_{veh. category} = \sum_{E_i=1}^{end} Emission_{E_i}$$

6. Calculation of the total passenger-km and ton-km

$$transport\ volumes_{veh. category} = \sum_{E_i=1}^{end} (vehicle\ mileage_{E_i} \times loading_{E_i})$$

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)

Module: Fleet

The composition of the vehicle fleet in NEMO is being simulated based on annual Austrian registration statistics per vehicle category and propulsion system as well as age-dependent survival (drop-out) probabilities. Vehicle technologies (exhaust standards or “EURO classes”) are assigned to vehicle registrations based on the year of registration.

NEMO combines both detailed calculation of the vehicle fleet composition and simulation of emission factors on a vehicle level. NEMO calculates the percentages of different vehicle layers on the overall traffic volume as a function of year and considered road type based on data on vehicle

stock, composition of new registrations and vehicle usage. The simulation of the emissions of the different vehicle layers is based on the correlation of the specific engine emission behaviour (emissions in grams per kilowatt-hour engine work) with the cycle average engine power in a normalised format. The calculation of the required engine power is based on average speed and additional kinematic parameters for the description of the cycle dynamics for a given road section.

Module: Road Network

Starting point for the road network files currently used in the inventory for the three road categories “urban”, “rural” and “motorway” are the mileage distributions stored in HBEFA for Austria according to different traffic situations. Within the road categories the average speed is a product of x different driving patterns per vehicle category (dependant on y road types in each of the three road categories with specific inclinations, speed limits, actual traffic flows, average measured speeds, etc.). The resulting average speeds for Austrian “urban”, “rural” and “motorway” road category weighted by traffic volume in the attachment can be found in the following table.

Table 67: Resulting average speeds per vehicle category in NEMO (based on traffic situations taken from HBEFA V4.2)

Vehicle category	Speed [km/h] per road category		
	urban	rural	motorway
Passenger Car	32.6	71.2	116.3
Light Duty Vehicle	32.6	71.2	116.2
Heavy Duty Vehicle-Road Truck	29.5	63.5	79.9
Heavy Duty Vehicle-Tow Truck	29.5	63.5	79.9
Coach	29.5	64.3	90.5
Urban Bus	23.7	49.8	-
Motorcycle-2 cylinders	33.7	68.3	-
Motorcycle-4 cylinders	33.7	68.3	-
Moped	33.7	48.8	-

Activity Data

From 2021 to 2022 fuel consumption of road transport in TJ (gasoline, diesel and alternative fuels including liquid biomass) decreased by 5.0%. Specific consumption per average vehicle kilometer and vehicle category did not improve for light duty vehicles; it declined by 0.1% for diesel passenger cars, by 1.1% for gasoline passenger cars, and by 1% for heavy duty vehicles.

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%⁵⁴*
- *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:

⁵⁴ An allocation to agriculture is not possible at the moment, because of the technical model framework.

- LPG is assigned to PC, HDV and LDV (only otto-motorised) according to their road performance.
- Natural gas (CNG) is distributed to PC, HDV and LDV (only otto-motorised) according to their road performance.

Biofuels

Since 2005 biogenic fuel (biodiesel, bioethanol, plant oil) has been used in the Austrian road transport sector. Biodiesel and bioethanol are mainly used for blending fossil fuels, whereas plant oil is distributed in pure form. In 2022 the energetic substitution by biofuels amounted to 5.8% in the road transport sector (BMK, 2024).⁵⁵ 2005, the first year of blending biofuels, the substitution amounted to only 0.8% (UMWELTBUNDESAMT, 2006).

The following data is used as direct input data in the calculation models based on NEMO and GEORG (see 1.A.2.g.vii).

Based on the calculation of the substitution target according to the Austrian Fuel Ordinance, in 2022 an amount of 5 816 134 tonnes of fossil diesel was sold. Based on data from the national bio-fuel register *e/Na* (electronic sustainability certificates), 391 265 tonnes of biodiesel and 7 093 tonnes of hydrotreated vegetable oil (HVO) were **added by blending**. In addition, 28 349 tonnes of biodiesel and 132 tonnes of HVO were put on the market in their **pure form** or as fuel with a higher percentage of biogenic admixture in diesel. In addition, 1 414 600 tonnes of fossil gasoline were sold. A total of 78 995 tonnes of sustainable bioethanol were added to these fuels, of which 6 135 tonnes were biogenic ethyl tertiary butyl ether (ETBE). As in previous years, accounting for 209 tonnes, vegetable oil was used in agriculture. In addition, 527 tonnes of bio-methane (bio-gas) were sold to the transport sector in the year 2022 (BMK, 2024). The table below shows total absolute numbers of biofuels used in Austria for mobile sources. The table below shows total absolute numbers of biofuels used in Austria for mobile sources.

Table 68: Use of biofuels in absolute figures 2005–2022.

Year	Pure [t]			Blended [t]	
	Biofuels	Biogas	Vegetable oil	Biodiesel+HVO	Bioethanol
2005	17 000	-	-	75 000	-
2010	74 984	2	17 393	427 000	105 872
2011	85 093	6	16 731	422 072	102 744
2012	58 160	9	16 823	440 938	105 366
2013	62 694	15	17 842	443 389	88 833
2014	143 125	463	16 028	474 692	87 676
2015	158 267	350	15 988	528 944	89 541
2016	65 280	344	15 595	495 764	86 893
2017	31 052	214	15 561	459 032	85 208
2018	62 914	306	263	462 396	88 186
2019	58 502	349	135	448 328	86 290
2020	34 542	278	107	390 273	82 019
2021	26 145	213	149	416 461	75 511

⁵⁵ The required substitution target amounts to 5.75%, measured by energy content.

Year	Pure [t]			Blended [t]	
	Biofuels	Biogas	Vegetable oil	Biodiesel+HVO	Bioethanol
2022	28 482	527	209	398 358	78 995
2005–2022	68%	29 713%⁵⁶	-99%	431%	-25%⁵⁷

Emission Factors

CO₂ emissions are calculated on the basis of tons of fuel. In NEMO a country-specific CO₂ EF is applied assuming a carbon content of 86% for diesel and gasoline resulting in a value of 3.153 kg/kg fossil fuel.

As responded to the ERT's questions during the 2016, 2020 and 2022 UNFCCC Reviews the high CO₂ IEF for gasoline (75.94 t/TJ in 2022) is above the upper IPCC default values (73.00 t/TJ) due to the application of the comparatively low NCV from the national energy balance, which is 41.5 TJ/kt Gasoline for the year 2022. The application of the IPCC default NCV (44.3 TJ/kt) would increase activity data and thus reduce the CO₂-IEF and bring it into the range. Austria therefore does not assume that emissions from Gasoline are over-estimated.

As responded to the ERT's question during the UNFCCC Review 2016 on an update on the progress of separate reporting of CH₄ and N₂O emissions associated with biomass (also raised in ARR 2014 para 30) it should be noted that Austria has implemented this improvement in its submission 2018.

CH₄ and N₂O EFs used in NEMO 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. As planned in the last NIR emission factors have been updated in the 2023 submission according to the HBEFA version V4.2 (INFRAS 2022) published in January 2022 and replacing version V4.1 (MATZER/WELLER et al., 2019).

Software updates

Besides other general updates in HBEFA V4.2, it contains a detailed mapping of the emission development of diesel vehicles with and without a software update in addition to the emission factors for diesel PCs with EA 189 engines, which have already been integrated in HBEFA V4.1. There the effect of the mandatory software update of VW vehicles with the EA189 engine ("Diesel Gate") on the average EURO 5 emission factor has been analysed in several measurement series.

The development of the emission factors and temperature dependencies for the additional software update vehicle layers can be read in a study by TU Graz (DIPPOLD/HAUSBERGER 2021) and is also integrated in HBEFA V4.2.

Ambient temperature influence

Ambient temperature influences on NO_x emission factors have been checked, but there have been no changes compared to HBEFA V4.1. Therefore, it is still valid to say that the lower the ambient temperature, the worse NO_x exhaust-aftertreatment systems work.

⁵⁶ Trend 2010–onwards

⁵⁷ Trend 2010–onwards

Moreover, specific yearly CO₂ emission and fuel consumption factors per vehicle kilometre of newly registered passenger cars and light duty vehicles have been implemented according to the national CO₂ monitoring data for the Austrian fleet (BMK 2023b, BMK 2023c).

Cold-start emissions

The cold-start emission module has been checked and there have been no changes compared to HBEFA V4.1.

Cold-start emissions according to IPCC 2006 GL are calculated as separate emissions in addition to 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:

$$\text{Additional impact per start [g / km]} = \text{cold-start surcharge [g / start]} / \text{average trip length per cold start [km / start]}$$

The cold start influence is in NEMO included in the calculation of fuel consumption and emissions of CO₂, NO_x, CO, hydrocarbons and PM. For N₂O and NH₃ no cold start emission factors were found in the literature. Thus, the cold-start influence on the greenhouse effects of N₂O emissions could not be taken into account.

The values used for cold-start surcharges come from:

- *PC and LDV*: cold-start model (updated in HBEFA V4.1)
- *HDV*: cold-start study commissioned by Umweltbundesamt (REXEIS et al. 2013)
- *2-wheelers*: derived from cold-start emissions of PC gasoline

Relative factors on top of commercial fuels incl. blending of biofuels (=reference fuels)

All emission factors of alternative and pure biofuels used in NEMO are considered in the model by relative factors compared to commercial fuels. This allows to include any other fuels in the NEMO calculations.

The following table provides the used relative factors compared to the reference fuels. The reference fuels are blended gasoline and blended diesel, because these fuels are commercially launched by fuelling stations on the market. The relative factors are multiplied with the EFs (in g/km) of every EURO-class and vehicle category per year. The relative factors are kept constant for the whole time series, but the final EFs change over time, because the basic EFs per EURO class improve as a consequence of the vehicles' advanced exhaust gas technologies. The relative factors are derived from literature research (e.g. EMEP Guidebook) or exhaust measurements.

Table 69: Relative factors used for bioethanol E85, LPG, CNG and biogas.

Gasoline	blended gasoline	bioethanol E85	LPG	CNG	biogas
FC	1.00	1.00	1.00	0.84	0.84
NO _x	1.00	1.51	1.22	0.67	0.67
HC	1.00	1.37	0.85	0.44	0.44
CO	1.00	0.88	1.25	0.70	0.70

Gasoline	blended gasoline	bioethanol E85	LPG	CNG	biogas
PM exhaust	1.00	1.00	1.00	0.71	0.71
Nox_raw	1.00	1.51	1.22	0.67	0.67
N ₂ O	1.00	0.64	1.00	0.34	0.34
NO ₂	1.00	1.51	1.22	1.11	1.11
NH ₃	1.00	1.00	1.00	0.68	0.68
CH ₄	1.00	1.94	1.00	2.94	2.94
Benzol	1.00	1.00	1.00	1.00	1.00
C22H12	1.00	1.00	0.03	1.00	1.00
C20H12 (k)	1.00	1.00	0.04	1.00	1.00
C20H12 (b)	1.00	1.00	0.00	1.00	1.00
C20H12 (a)	1.00	1.00	0.03	1.00	1.00

Table 70: Relative factors used for biodiesel, plant oil and diesel B20.

diesel	blended diesel	biodiesel (RME⁵⁸)	plant oil	diesel B20
FC	1.00	1.00	1.00	1.00
NO _x	1.00	1.20	1.20	1.04
HC	1.00	1.00	1.00	1.00
CO	1.00	0.74	0.74	0.95
PM exhaust	1.00	0.61	0.61	0.92
NO _x _raw	1.00	1.20	1.20	1.04
N ₂ O	1.00	1.20	1.20	1.04
NO ₂	1.00	1.00	1.00	1.00
NH ₃	1.00	1.00	1.00	1.00
CH ₄	1.00	1.15	1.15	1.03
Benzol	1.00	1.00	1.00	1.00
C22H12	1.00	1.00	1.00	1.00
C20H12 (k)	1.00	1.00	1.00	1.00
C20H12 (b)	1.00	1.00	1.00	1.00
C20H12 (a)	1.00	1.00	1.00	1.00

Implied emission factors for the different means of road transportation are listed in the following tables. In contrast to the CRF tables, Activity data shown in Table 71 to Table 74 include all energy sources (i.e. fossil and bio fuels) used in each vehicle category in order to show the increasing substitution of fossil fuels with biofuels from 2005 onwards. For this reason data provided in these tables do not correspond to the IEFs given in the CRF where they are separately shown for each energy source (e.g. IEF for fossil diesel, fossil gasoline, biomass etc.).

⁵⁸ rapeseed oil methyl ester

Table 71: Implied emission factors of passenger cars 1990–2022.

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	116 875	75.9	21.30	2.65
1995	125 617	75.7	12.67	3.07
2000	131 912	75.3	6.64	2.69
2005	187 595	74.7	4.11	2.21
2010	184 559	71.2	2.64	1.87
2011	182 393	71.1	2.49	1.87
2012	179 772	71.0	2.42	1.88
2013	178 384	71.2	2.38	1.92
2014	180 115	70.9	2.32	1.96
2015	187 336	70.6	2.39	2.05
2016	193 208	71.2	2.58	2.18
2017	197 109	71.5	2.80	2.33
2018	197 691	71.2	2.99	2.39
2019	192 746	71.3	3.09	2.43
2020	157 880	71.2	3.22	2.64
2021	163 352	71.3	3.25	2.62
2022	165 691	71.5	3.26	2.59

Table 72: Implied emission factors of light duty vehicles 1990–2022.

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	13 637	74.7	7.0	0.9
1995	15 764	74.4	3.6	0.8
2000	17 937	74.3	1.8	1.3
2005	19 394	73.6	1.0	1.6
2010	19 032	70.3	0.7	1.8
2011	19 299	70.3	0.7	1.8
2012	19 214	70.1	0.8	1.9
2013	19 429	70.3	0.9	2.1
2014	19 763	70.2	1.1	2.2
2015	20 252	69.8	1.3	2.4
2016	20 967	70.3	1.5	2.5
2017	21 471	70.7	1.8	2.7
2018	21 642	70.6	2.2	2.9
2019	22 228	70.8	2.5	3.1
2020	22 396	70.9	2.8	3.4
2021	24 158	70.8	3.3	3.5
2022	23 883	70.8	3.5	3.5

Table 73: Implied emission factors of heavy duty vehicles 1990–2022.

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	44 843	74.3	2.7	0.7
1995	59 659	74.2	2.0	0.7
2000	89 746	74.2	1.1	0.6
2005	116 205	73.5	0.7	0.5
2010	100 293	70.1	0.4	1.8
2011	91 903	70.0	0.4	2.1
2012	94 328	69.9	0.3	2.3
2013	109 141	70.0	0.3	2.5
2014	99 578	69.8	0.3	2.8
2015	99 045	69.4	0.3	3.0
2016	102 182	69.9	0.2	2.8
2017	105 511	70.3	0.2	2.8
2018	107 799	70.3	0.2	2.9
2019	112 633	70.5	0.2	2.9
2020	103 907	70.6	0.2	2.9
2021	108 579	70.5	0.1	2.9
2022	91 603	70.5	0.2	3.0

Table 74: Implied emission factors of mopeds and motorcycles 1990–2022.

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	836	76.3	254.0	1.3
1995	1 024	76.3	185.7	1.2
2000	1 372	76.3	142.8	1.2
2005	1 570	76.3	120.9	1.2
2010	1 892	72.8	92.9	1.2
2011	1 954	72.8	88.5	1.2
2012	2 031	72.6	83.7	1.2
2013	2 099	73.0	79.0	1.2
2014	2 177	72.5	74.4	1.2
2015	2 243	72.5	70.7	1.2
2016	2 288	73.4	67.9	1.2
2017	2 337	73.4	64.8	1.2
2018	2 348	72.4	57.1	1.2
2019	2 323	72.4	61.7	1.2
2020	2 132	72.0	60.0	1.2
2021	2 015	72.4	57.1	1.3
2022	1 990	72.8	52.2	1.3

Taking into account the carbon part of biofuels (and the associated CO₂ emissions)

According to the 2006 IPCC GLs (volume 2, chapter 3, section 'CO₂ emissions from biofuels' in page 3.17) *"it is important to assess the biofuel origin so as to identify and separate fossil from biogenic feedstocks"*. In other words, a part of the carbon of biofuels (and the associated CO₂ emissions) may have a fossil origin. In Austria this is the case. Consequently, the CO₂ from fossil methanol in the production of biodiesel (FAME⁵⁹) has been accounted for the time series 2005-2019 resulting in increased emissions for every vehicle sub-category, where blended or pure biodiesel is used.

Calculations were done based on SEMPOS (2018) who published together with a group of experts an accorded point of view among EU MS to agree on a common understanding and define possible ways how to estimate the associated CO₂ emissions to the fossil carbon content in biofuels. The following default values were taken.

Table 75: Values used for the fossil carbon content in biofuels (SEMPOS 2018)

C fossil part – origin from methanol [%]	Carbon content – bio and fossil [% kg/kg]	CO ₂ -EF for fossil FAME [kt CO ₂ /kt FAME]
5.4	76.5	0.1515

The fossil part in the production of ETBE⁶⁰ has been accounted for the whole time series, as we know that 53% of ETBE are produced from fossil sources (Isobuten) and 47% from bioethanol. The fossil part is being reported as fossil gasoline by the companies.

HVO⁶¹ in contrast is produced through the hydro-treatment of the triglyceride-containing feedstocks (vegetable oil or animal fat). All carbon can be considered of biogenic origin (no fossil part).

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?

Uncertainty Assessment

Uncertainty estimates are based on WINIWARTER & RYPDAL (2001) and on HAUSBERGER (2005):

- The uncertainty of activity data (total fuel sold) for road transport is considered to be low (3%), and also the uncertainty of CO₂ emission factors is estimated to be 3%.

⁵⁹ Fatty Acid Methyl Ester

⁶⁰ Ethyl Tert-Butyl Ether

⁶¹ Hydro Vegetable Oil

- N₂O emission factors are determined in vehicle emission tests, mostly carried out on test benches. Therefore emission factors are prone to uncertainties for the following reasons:
 - test driving cycles cannot fully reflect real driving behaviour,
 - uncertainties of test equipment and emission measurement equipment,
 - emission factor varies over time because of chemical characteristics of the fuels,
 - the influence of aging and maintenance of the vehicle stock.

Due to these reasons the uncertainty for the N₂O emission factor is relatively high; it is estimated to be -70 and +170% (lognorm) for gasoline and ±30% (norm) for diesel.

Recalculations

For CRF 1.A.3.b *Road Transport* recalculations of GHG emissions were reported for the whole time series due to the reasons explained below: CO₂ between -2.4 kt (1990: -0.004% of national total and -0.002% of category 1.A.3.b) and -10.3 kt (2021: 0.004% of national total and -0.002% of category 1.A.3.b); CH₄ between -0.002 kt (1990: -0.001% of national total and -0.07% of category 1.A.3.b) and +0.001 kt (2021: +0.0005% of national total and +0.2% of category 1.A.3.b); N₂O between -0.0004 kt (1990: -0.003% of national total and -0.12% of category 1.A.3.b) and +0.0006 kt (2021: +0.005% of national total and +0.07% of category 1.A.3.b).

- *Update of the NEMO fleet model*

1.A.3.b.3 gasoline: 2017–2021:

Road trucks size I (RT I <18t) have been a statistical residual number, with a fleet smaller than one from 2017 onwards. This was due to the algorithm for the probability of failure, but no new registrations of gasoline RT I were reported. Thus they were set to zero in the fleet model from 2017 onwards in the 2024 submission.

1.A.3.b.3 gaseous: 2004–2021:

Energy consumption of CNG has been revised in accordance with the revisions of the national Energy Balance.

1.A.3.b.3 diesel, gasoline & LPG: 1990–2021

RT I driving resistances were adjusted to comply with HBEFA 4.2 (all EFAs have increased slightly except for EURO 6 with a slight reduction).

1.A.3.b.3 diesel: 2021

For 2021, more efficient EURO V and EURO VI diesel trucks have increased total HDV mileage, resulting in a reduced fuel consumption in category HDV (-733.26 TJ).

- *Revision of real fuel consumption for PC and LDV PHEV*

The energy consumption in vehicle concepts with fuel combustion and electric motors is subject to high uncertainties. The fact is that in reality there are use cases with a high proportion of kilometres driven electrically, but also with the almost exclusive use of the combustion engine (ITNA,

2023⁶², p.9). For this reason, a more pessimistic charging behaviour for PHEV vehicles has been assumed, which increased the real gasoline consumption of PHEV cars and LDV, especially in 2021. On an overall level the reduction cannot be seen in category “gasoline cars”, because of an overlapping effect caused by the update of specific mileage per year.

- *Update of specific vehicle mileage per year*

Improvement of data evaluation in the central vehicle assessment database (ZBD - annual “sticker check” in accordance with §57a KFG). An update of the relevant input data made it possible to evaluate half-years for 2021 and 2022 and thus define the specific annual mileage of vehicles more precisely. This has led to an increase for diesel cars, diesel LDV, 2-wheelers (gasoline) for 2021 compared to last year's inventory.

Planned improvements

The implementation of emission factors for emission standard (e.g. EURO 7) are planned with the next update of HBEFA.

3.2.13.3 1.A.3.c Railways

Key Source: No

In this category emissions from diesel railcars and steam engines are considered.

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 2 methodology. The applied methodology is described in the subchapter on mobile sources of CRF 1.A.2.g.vii.

Activity Data & Emission Factors

Activities used for estimating the emissions and the implied emission factors of CRF 1.A.3.c are presented below. In the following table the activity data includes all energy sources (including hard coal). The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards. Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of CRF 1.A.2.g.vii.

Table 76: *Implied emission factors and activity data for 1.A.3.c Railways 1990–2022.*

Year	Activity TJ	Implied Emission Factors		
		CO ₂ t/TJ	CH ₄ kg/TJ	N ₂ O kg/TJ
1990	2 380	74.8	3.8	25.3
1995	1 987	74.8	3.7	25.6
2000	1 815	74.5	3.5	26.5
2005	2 187	73.6	3.2	26.1
2006	2 026	70.3	2.3	22.0

⁶² SCHWINGSHACKL, M. & REXEIS, M. (2023): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2022. ITNA – Institut für Nachhaltige Antriebe und Thermodynamik. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2023.

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
2007	1 714	70.3	2.1	21.0
2008	1 763	70.1	2.0	20.1
2009	1 510	70.4	1.8	18.9
2010	1 637	70.2	1.6	17.6
2011	1 245	69.8	1.6	16.9
2012	1 254	70.3	1.6	16.6
2013	1 368	70.7	1.5	16.0
2014	1 307	70.7	1.5	15.7
2015	1 307	70.9	1.5	15.3
2016	1 149	70.9	1.5	15.0
2017	1 140	70.8	1.4	14.7
2018	1 136	70.9	1.4	14.4
2019	2 380	74.8	3.8	25.3
2020	1 987	74.8	3.7	25.6
2021	1 815	74.5	3.5	26.5
2022	2 187	73.6	3.2	26.1

Recalculations

Energy consumption for category “liquid” (blended diesel) was updated according to revised numbers in the national energy balance for 2016 and 2018-2021. This has also implications on the fuel categories “biomass” and “Other” (FAME fossil part). The corresponding changes in CO₂, CH₄ and N₂O emissions can be detected in all of the three mentioned fuel categories of 1.A.3.c except for CO₂ of biomass, as it is zero per se.

Planned improvements

No category-specific improvements are planned.

3.2.13.4 1.A.3.d Navigation

Key Source: No

This sector includes emissions from gas/diesel oil and gasoline fuelled ships used by vessels and ships of all flags that depart and arrive per trip within Austria. The main sources are the river Danube and some other smaller rivers and lakes.

Methodological Issues

The used methodology conforms to the requirements of the IPCC 2006 GL Tier 2 methodology.

Austria uses the bottom-up model GEORG (HAUSBERGER 2000) to calculate the national fuel consumption of navigation which is made up of freight transport activities on the River Danube and passenger transport on rivers and lakes in Austria. Passenger transport is conducted with passenger ships, private motor boats and sailing boats. The inland navigation fleet (stock) was obtained from registration statistics from provincial governments, the average yearly operating time as well as the average fuel consumption per hour from questionnaires to fleet operators and/or manufacturers' data.

Statistical data (Tkm) for freight activities on the River Danube were obtained from (VIA DONAU 2023). Additionally, fuel consumption for working boats is taken into account in the national fuel consumption of navigation. For detailed methodological issues of the model GEORG see CRF 1.A.2.g.vii.

Since the **submission 2011**, building on data used in the model GEORG (see CRF 1.A.2.g.vii), domestic navigation has been calculated following the bottom-up approach – the assumption being that domestic navigation is navigation between harbours located in Austria using the transport, expressed in

tons x kilometer → (GWh/tkm*tkm; CO₂/tkm*tkm etc.)

The applied methodology for estimating emissions of international navigation is described in subchapter 3.2.2.1 International bunker fuels.

Activity Data & Emission Factors

Activity data is updated yearly for freight activities on the River Danube and is obtained from (VIA DONAU 2023). Emission factors were last updated in a study within the submission 2021 (SCHWINGSHACKL/REXEIS & WELLER 2020) which resulted in

- Updated fuel consumption factors (in g/tkm) of Danube freight shipping. According to studies of real fuel consumption (including empty runs, including secondary consumers) current consumption in the upper Danube region amounts to 8.5 g/tkm.
- Updated activities of passenger shipping (Danube, other rivers and lakes), which reflects the trend towards significantly higher activities than assumed before.

Activities used for estimating the emissions and the implied emission factors of CRF 1.A.3. are presented below. In the following table the activity data includes all energy sources. The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards. Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of 1.A.2.g.vii.

Table 77: Implied emission factors and activity data for 1.A.3.d Domestic Navigation 1990–2022.

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	374	74.9	93.9	22.3
1995	459	74.7	74.4	24.7
2000	564	74.6	55.2	27.1
2005	741	74.0	36.6	26.7
2006	782	70.3	26.4	24.5
2007	838	70.3	23.4	24.3
2008	768	70.2	23.7	23.5
2009	814	70.4	21.2	23.1
2010	909	70.2	18.1	22.7
2011	936	69.8	16.6	22.1
2012	974	70.3	15.2	21.7
2013	1 025	70.6	13.9	21.5

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
2014	1 061	70.5	12.9	21.1
2015	1 183	70.7	11.3	20.9
2016	331	70.3	31.6	16.0
2017	501	70.6	20.9	18.2
2018	972	70.7	11.7	20.3
2019	374	74.9	93.9	22.3
2020	459	74.7	74.4	24.7
2021	564	74.6	55.2	27.1
2022	741	74.0	36.6	26.7

Quality Assurance and Quality Control (QA/QC)

Harmonization 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) Austria explained that emissions of ground activities at domestic harbours are also included, even if they are not separately reported under CRF 1.A.3.e.2 *Other*. All registered road vehicles – including those in ports - are taken into account in the emission calculation of CRF 1.A.3.b. Fuel consumption and emissions of any other port handling equipment are included in the overall calculation. This is ensured because Austria reports emissions from **total fuel sold** from the national energy balance (see chapter on 1.A.3.b. *Road Transport – Top down Methodology – Fuel sold*).

Recalculations

Energy consumption was updated after a linking error has been corrected in the GEORG model for 2019–2021.

Planned improvements

No category-specific improvements are planned.

3.2.13.5 1.A.3.e.i Other Transportation – Pipeline Compressors

Key Source: Yes (CO₂: gaseous)

Category *1.A.3.e Other Transportation* enfold emissions from pipeline transport by gas turbine driven compressors. The share in GHG emissions from sector *1.A* is 0.4% for the year 1990 and 0.3% for the year 2022. The increase of emissions is mainly caused by the increase of natural gas transfer through Austria. Since 2020 emissions have decreased due to the substitution of gas turbines with electric motors.

Methodology

The IPCC Tier 2 methodology is applied for CO₂ and a Tier 1 methodology is applied for CH₄ and N₂O.

Activity data

Activity data (fuel consumption) is taken from (IEA JQ 2023) as presented in Annex 4.

Emission factors

The CO₂ emission factor for natural gas is taken from a national study (BMW 1996). N₂O and CH₄ emission factors are default values from the IPCC 2006 Guidelines.

Table 78: Emission factors of Category 1.A.3.e.

Fuel	CO ₂ [t/TJ]	CH ₄ [kg/TJ]	N ₂ O [kg/TJ]
Natural Gas	55.60	1.00	0.10

Recalculations

No recalculations have been carried out.

3.2.13.6 1.A.3.e.II Other – Airport Ground Activities

Key Source: No

This sector includes emissions from airport ground activities at all Austrian airports. Freight and car traffic to and from the airport is excluded and part of CRF *1.A.3.b*.

Methodological Issues

The used methodology conforms to the requirements of the IPCC 2006 GL Tier 3 methodology. Country-specific technology-based emission factors (IEFs taken from CRF *1.A.3.b*) are available.

Based on a recommendation made by the UNFCCC during the 2020 Review, Austria collected fuel consumption data of mobile sources used for aircraft handling from Vienna's International Airport. Based on this information emissions for aircraft handling on all Austrian airports were estimated and are now reported separately under CRF *1.A.3.e.2*. Emissions from this source were previously part of CRF *1.A.3.b*.

The share between the biggest airport VIE (Vienna) and the other five Austrian airports (GRZ, INN, KLU, LNZ, SZG) was calculated on the basis of the most recent evaluation of FC and CO₂ emissions from all Austrian airports for 2010 (MATHÄ & ELLINGER 2011). With the help of absolute FC numbers

at VIE airport in 2019 (ELLINGER & KRACHER 2020) and the share for the sum of the other Austrian airports in 2010 the total activity data for CRF 1.A.3.e.2 was calculated for 2019. Second, a constant fuel consumption factor per flight movement was calculated and multiplied with yearly IFR flight movements (with departure airport in Austria) to create the FC time series for 1990 - 2020. Third, for the calculation of emissions time series, the activity data of each fuel type have been multiplied with yearly fuel type specific IEFs for road trucks (RT) and passenger cars (PC) taken from CRF 1.A.3.b:

- *HDV-RT Gasoline Size I*
- *HDV-RT Diesel Size II*
- *PC CNG Average*

Activity Data & Emission Factors

Activities include liquid fuels (diesel, gasoline and biofuels) and gaseous fuels (CNG). The quantities of liquid and gaseous fuels used at airports represent only a very small proportion of total national fuel sales (0.01% petrol; 0.03% diesel; 0.3% natural gas).

Due to the minor dimension of CRF 1.A.3.e.2 IEFs for all years and air pollutant are not being displayed separately.

Recalculations

No category specific recalculations have been carried out.

Planned improvements

No category-specific improvements are currently planned.

3.2.14 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.

The share in total GHG emissions from sector 1.A is 28% for the year 1990 and 17% for the year 2022.

3.2.14.1 1.A.4 Other Sectors – Stationary Combustion

Key Source: CO₂ from liquid (1.A.4.a, 1.A.4.b), solid (1.A.4.b), gaseous (1.A.4.a and 1.a.4.b); CH₄ from biomass and solid fuels (1.A.4.b)

Category 1.A.4 *Other Sectors – Stationary Combustion* includes emissions from stationary fuel combustion in the small combustion sector. Emissions from 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*.

3.2.14.1.1 Methodology

For calculation of CO₂ emissions from fossil fuels and CH₄ emissions from solid biomass (fuel wood and wood waste), the IPCC Tier 2 methodology is applied. For calculation of CH₄ emissions from liquid, solid and gaseous fuels, other biomass (biogas, sewage sludge gas and landfill gas, charcoal), peat and other fuels and for calculation of N₂O emissions from all fuel types, the Tier 1 methodology is applied.

Total fuel consumption for each of the sub categories of *1.A.4 Other Sectors – Stationary Combustion* is taken from (IEA JQ 2023) and the national energy balance (STATISTIK AUSTRIA 2023a). This approach provides the most detailed data over time series, while both data sources are different in structure but consistent. From the view of energy statistics compilers this sector is sometimes the residual of gross inland fuel consumption because fuel consumption data of energy industries and manufacturing industry is collected each year in more detail and therefore of higher quality. However, in case of the Austrian energy balance fuel consumption of the small combustion sector is modelled over time series in consideration of heating degree days, micro census data and service industries survey panel.

Information about type of heating is derived from an energy demand model for space heating based on heating market surveys and on federal provinces data validated by micro census surveys and calibrated according to the energy statistics supplier. A clear distinction between 'real' public district heating or micro heating networks which serve several buildings under the same ownership cannot always be made by the interviewed person or interviewers.

The energy demand model for space heating, consists of five consecutive modules:

- **Building and dwelling stock:** by building type, year of construction, type of residence (number of buildings and dwellings, net floor area, useful area, number of residents) (BML 2023a, STATcube 2014a, 2014b, 2014c, 2023a, 2023b, STATISTIK AUSTRIA 1973, 1982, 1992a, 2004, 2013, 2023c, 2023d, 2023e)
- **Heating type by energy carrier:** by categories of module 'building and dwelling stock' and energy carrier including heat pumps, district heating, solar thermal and electric heating (number of buildings and dwellings, net floor area, useful area, number of residents) (STATISTIK AUSTRIA 2019, 2021, 2023f)
- **Heating type by technology:** by categories of module 'building and dwelling stock', type of application (as main or auxiliary heating) and twenty-two technology and fuel dependent subcategories (number of buildings and dwellings, net floor area, useful area, residents) (AMT DER STEIERMÄRKISCHEN LANDESREGIERUNG 2021, AMT DER VORARLBERGER LANDESREGIERUNG 2021, BEKAT 2021, E7 ENERGIE MARKT ANALYSE GMBH 2009 & 2017, LAND SALZBURG 2021, STADT WIEN 2017)
- **Building energy performance:** by categories of module 'building and dwelling stock' based on type of energy-efficient building renovation, year of construction and residents (space heating demand, hot water demand) (AEA 2015, BMWFW 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 (GEOSPHERE AUSTRIA & STATISTIK AUSTRIA 2023) and calibrated according to the energy statistics supplier to maintain consistency with fuel demand reported in (IEA JQ 2023) and (STATISTIK AUSTRIA 2023a)

There are twenty-two technology and fuel dependent main subcategories (heating types) for category *1.A.4 Other Sectors – Stationary Combustion* as presented in the following table.

Table 79: Heating types of category 1.A.4. Other Sectors – Stationary Combustion

No.	Heating type	Fuel
#1	Fuel oil boilers	Light fuel oil, medium fuel oil, heavy fuel oil, diesel, petroleum, other petroleum products
#2	Gas oil stoves	Gas oil
#3	Vapourizing burners	Gas oil
#4	Yellow burners	Gas oil
#5	Blue burners with conventional technology	Gas oil
#6	Blue burners with low temperature or condensing technology	Gas oil
#7	Natural gas convectors	Natural gas
#8	Atmospheric burners	Natural gas, biogas, sewage sludge gas and landfill gas
#9	Forced-draft natural gas burners	Natural gas, biogas, sewage sludge gas and landfill gas
#10	LPG stoves	Liquefied petroleum gases
#11	LPG boilers	Liquefied petroleum gases
#12	Wood stoves and cooking stoves	Fuel wood
#13	Tiled wood stoves and masonry heaters	Fuel wood
#14	Mixed-fuel wood boilers	Fuel wood
#15	Natural-draft wood boilers	Fuel wood
#16	Forced-draft wood boilers	Fuel wood
#17	Wood chips boilers with conventional technology	Wood waste
#18	Wood chips boilers with oxygen sensor emission control	Wood waste
#19	Pellet stoves	Wood waste
#20	Pellet boilers	Wood waste
#21	Coal stoves	Hard coal and Hard coal briquettes, lignite and brown coal, brown coal briquettes, coke, peat
#22	Coal boilers	Hard coal and Hard coal briquettes, lignite and brown coal, brown coal briquettes, coke, peat, industrial waste

In addition, the whole fuel consumption of charcoal is assumed to be combusted in devices similar to #12 *Wood stoves and cooking stoves* and calculated separately. For each technology a fuel dependent emission factor is applied.

3.2.14.1.2 Activity Data

Total fuel consumption for each of the sub categories of 1.A.4 is taken from (IEA JQ 2023) and (STATISTIK AUSTRIA 2023a) as presented in Annex 4 (further details also given in section *Methodology* above).

Fuel Consumption by Fuel Group

Total fuel consumption of 1.A.4.a.1, 1.A.4.b.1 and 1.A.4.c.1 is divided into 6 fuel groups (liquid, solid, gaseous, biomass, peat and other) (see Table 80, Table 81 and Table 82).

Table 80: Fuel consumption from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990, 1995, 2000, 2005 and 2010-2022

CRF	1.A.4.a.1						
Fuel group	Total	Liquid	Solid	Gaseous	Biomass	Peat	Other
Year	[PJ]						
1990	35.39	18.66	0.96	12.60	2.06	NO	1.11
1995	50.64	17.64	0.64	29.29	2.55	NO	0.52
2000	47.43	17.84	1.10	23.67	4.26	NO	0.56
2005	54.73	26.86	0.71	23.16	2.92	NO	1.07
2010	31.09	9.49	0.22	17.19	4.13	NO	0.06
2011	27.33	8.83	0.15	14.99	3.32	NO	0.05
2012	25.61	6.05	0.00	16.90	2.66	NO	NO
2013	25.78	5.87	0.01	17.01	2.82	NO	0.07
2014	22.72	6.01	0.00	14.27	2.36	NO	0.08
2015	24.24	5.95	0.00	15.25	2.96	NO	0.08
2016	22.56	5.60	NO	14.37	2.49	NO	0.09
2017	26.63	7.73	NO	15.10	3.73	NO	0.08
2018	25.97	6.71	NO	15.43	3.74	NO	0.09
2019	26.52	6.25	NO	16.11	4.07	NO	0.10
2020	25.13	6.00	NO	15.15	3.97	NO	0.01
2021	29.23	7.85	NO	16.88	4.50	NO	0.01
2022	23.18	6.65	NO	12.91	3.62	NO	0.01
1990–2022	-34%	-64%	-100%	+2.5%	+75%	NO	-100%
2021–2022	-21%	-15%	NO	-24%	-20%	NO	-9.2%

NO...not occurring

Table 81: Fuel consumption from 1.A.4.b.1 Residential: Stationary Combustion 1990, 1995, 2000, 2005 and 2010–2022

CRF	1.A.4.b.1						
Fuel group	Total	Liquid	Solid	Gaseous	Biomass	Peat	Other
Year	[PJ]						
1990	191.02	72.50	26.62	33.50	58.40	0.0044	NO
1995	200.23	75.59	17.56	44.28	62.80	0.0044	NO
2000	190.62	72.60	9.05	48.90	60.07	0.0044	NO
2005	192.43	63.88	3.97	65.71	58.86	0.0044	NO
2010	199.34	55.88	2.61	65.47	75.38	0.0044	NO

CRF	1.A.4.b.1						
Fuel group	Total	Liquid	Solid	Gaseous	Biomass	Peat	Other
Year	[PJ]						
2011	179.92	48.34	1.69	58.18	71.71	0.0044	NO
2012	180.81	44.01	1.77	59.22	75.81	0.0044	NO
2013	186.20	47.32	1.35	59.83	77.69	0.0044	NO
2014	163.15	41.46	1.11	52.40	68.18	0.0044	NO
2015	173.49	43.18	0.91	56.84	72.55	0.0044	NO
2016	181.09	42.84	0.87	62.82	74.56	NO	NO
2017	180.66	43.35	0.96	61.50	74.85	NO	NO
2018	164.63	38.58	0.82	56.28	68.95	NO	NO
2019	169.63	38.84	0.83	59.49	70.46	NO	NO
2020	171.20	39.80	0.58	60.05	70.78	NO	NO
2021	194.90	41.91	0.48	66.14	86.38	NO	NO
2022	159.93	36.01	0.36	54.52	69.04	NO	NO
1990–2022	-16%	-50%	-99%	+63%	+18%	-100%	NO
2021–2022	-18%	-14%	-25%	-18%	-20%	NO	NO

NO...not occurring

Table 82: Fuel consumption from 1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion 1990, 1995, 2000, 2005 and 2010–2022

CRF	1.A.4.c.1						
Fuel group	Total	Liquid	Solid	Gaseous	Biomass	Peat	Other
Year	[PJ]						
1990	10.26	5.34	0.55	0.37	4.01	NO	NO
1995	7.68	2.30	0.39	0.49	4.49	NO	NO
2000	8.46	2.79	0.18	0.54	4.95	NO	NO
2005	8.11	1.47	0.12	0.77	5.75	NO	NO
2010	7.80	0.53	0.06	0.84	6.37	NO	NO
2011	7.30	0.42	0.04	0.72	6.13	NO	NO
2012	7.56	0.42	0.04	0.46	6.64	NO	NO
2013	8.34	0.53	0.03	0.51	7.28	NO	NO
2014	7.84	0.56	0.02	0.56	6.70	NO	NO
2015	8.02	0.50	0.02	0.62	6.88	NO	NO
2016	8.41	0.60	0.02	0.74	7.05	NO	NO
2017	8.68	0.28	0.03	1.01	7.37	NO	NO
2018	7.86	0.25	0.02	0.90	6.68	NO	NO
2019	7.47	0.16	0.02	1.09	6.20	NO	NO
2020	7.35	0.17	0.02	0.91	6.26	NO	NO

CRF	1.A.4.c.1						
Fuel group	Total	Liquid	Solid	Gaseous	Biomass	Peat	Other
Year	[PJ]						
2021	8.63	0.18	0.01	0.97	7.47	NO	NO
2022	7.06	0.15	0.01	0.83	6.08	NO	NO
1990–2022	-31%	-97%	-98%	+126%	+52%	NO	NO
2021–2022	-18%	-16%	-30%	-15%	-19%	NO	NO

NO...not occurring

Fuel Consumption by Fuel

Fuel consumption of liquid fuels, solid fuels and biomass fuels is further subdivided (from 1.A.4.a.1 see Table 83, Table 84 and Table 85, from 1.A.4.b.1 see Table 86, Table 87 and Table 88, from 1.A.4.c.1 see Table 89, Table 90 and Table 91). All fuel consumption of biogas, sewage sludge gas and landfill gas is assigned to 1.A.4.a.1. Gaseous fuel consumption applies to natural gas only. All fuel consumption of peat (fuel group) is occurring in 1.A.4.b.1 and is peat (fuel) only. Other fuel consumption is industrial waste only.

1.A.4.a.1 Commercial/Institutional: Stationary Combustion

Table 83: Share of liquid fuel consumption from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990, 1995, 2000, 2005 and 2010–2022

CRF	1.A.4.a.1							
Fuel group	Liquid							
Fuel	Total	Light fuel oil	Medium fuel oil	Heavy fuel oil	Diesel	Petroleum and other petroleum products	Gas oil	Liquefied petroleum gases
Year	[% TJ]							
1990	100.0	48.3	24.0	8.7	NO	5.1	5.9	8.0
1995	100.0	44.2	13.1	2.6	0.1	1.5	22.3	16.1
2000	100.0	19.8	8.2	0.8	0.0	1.5	63.4	6.3
2005	100.0	12.5	NO	NO	0.0	NO	75.6	11.8
2010	100.0	2.3	NO	NO	0.0	NO	68.5	29.2
2011	100.0	8.4	NO	NO	0.0	NO	65.8	25.9
2012	100.0	7.2	NO	NO	0.0	NO	89.9	2.9
2013	100.0	8.3	NO	NO	0.0	NO	88.8	2.8
2014	100.0	10.4	NO	NO	0.0	NO	87.4	2.2
2015	100.0	9.3	NO	NO	0.0	NO	88.3	2.4
2016	100.0	20.1	NO	NO	0.0	NO	77.7	2.2
2017	100.0	7.8	NO	NO	0.0	NO	88.1	4.1
2018	100.0	5.0	NO	NO	0.0	NO	90.7	4.3
2019	100.0	0.4	NO	NO	0.0	NO	94.5	5.1
2020	100.0	0.2	NO	NO	0.0	NO	94.7	5.2
2021	100.0	0.7	NO	NO	NO	NO	94.7	4.5
2022	100.0	0.1	NO	NO	NO	NO	95.8	4.2

NO...not occurring

Table 84: Share of solid fuel consumption from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990, 1995, 2000, 2005 and 2010-2022

CRF		1.A.4.a.1			
Fuel group		Solid			
Fuel	Total	Hard coal and hard coal briquettes	Lignite and brown coal	Brown coal briquettes	Coke
Year	[% TJ]				
1990	100.0	33.5	10.4	16.5	39.6
1995	100.0	34.4	8.1	19.2	38.3
2000	100.0	23.3	3.4	59.1	14.2
2005	100.0	38.5	1.4	45.1	14.9
2010	100.0	6.2	2.8	70.9	20.2
2011	100.0	7.8	1.5	65.1	25.5
2012	100.0	NO	NO	NO	100.0
2013	100.0	94.8	NO	NO	5.2
2014	100.0	NO	NO	NO	100.0
2015	100.0	NO	NO	NO	100.0
2016	NO	NO	NO	NO	NO
2017	NO	NO	NO	NO	NO
2018	NO	NO	NO	NO	NO
2019	NO	NO	NO	NO	NO
2020	NO	NO	NO	NO	NO
2021	NO	NO	NO	NO	NO
2022	NO	NO	NO	NO	NO

NO...not occurring

Table 85: Share of biomass fuel consumption from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990, 1995, 2000, 2005 and 2010-2022

CRF		1.A.4.a.1			
Fuel group		Biomass			
Fuel	Total	Fuel wood	Wood waste	Biogas, sewage sludge gas and landfill gas	Charcoal
Year	[% TJ]				
1990	100.0	64.6	30.9	NO	4.5
1995	100.0	45.8	23.6	25.8	4.9
2000	100.0	8.1	77.1	11.9	2.9
2005	100.0	20.2	61.4	13.5	4.9
2010	100.0	14.7	71.0	10.7	3.6
2011	100.0	15.4	67.7	12.7	4.2
2012	100.0	6.8	71.9	15.3	6.0
2013	100.0	6.7	75.2	12.7	5.4
2014	100.0	5.5	69.2	19.2	6.1

CRF		1.A.4.a.1			
Fuel group		Biomass			
Fuel	Total	Fuel wood	Wood waste	Biogas, sewage sludge gas and landfill gas	Charcoal
Year	[% Tj]				
2015	100.0	3.2	74.9	15.8	6.0
2016	100.0	3.8	65.8	22.9	7.5
2017	100.0	5.7	74.6	15.5	4.3
2018	100.0	5.1	77.2	12.8	4.8
2019	100.0	5.2	78.9	11.5	4.4
2020	100.0	5.2	78.2	12.0	4.6
2021	100.0	5.3	79.8	10.8	4.1
2022	100.0	5.1	76.7	14.2	3.9

NO...not occurring

1.A.4.b.1 Residential: Stationary Combustion

Table 86: Share of liquid fuel consumption from 1.A.4.b.1 Residential: Stationary Combustion 1990, 1995, 2000, 2005 and 2010–2022

CRF		1.A.4.b.1						
Fuel group		Liquid						
Fuel	Total	Light fuel oil	Medium fuel oil	Heavy fuel oil	Diesel	Petroleum and other petroleum products	Gas oil	Liquefied petroleum gases
Year	[% Tj]							
1990	100.0	26.6	NO	NO	NO	0.9	71.4	1.0
1995	100.0	10.4	NO	NO	NO	0.0	88.0	1.6
2000	100.0	13.3	NO	NO	NO	NO	83.5	3.2
2005	100.0	7.3	NO	NO	NO	NO	89.6	3.1
2010	100.0	2.2	NO	NO	NO	NO	95.0	2.7
2011	100.0	1.1	NO	NO	NO	NO	96.7	2.3
2012	100.0	0.6	NO	NO	NO	NO	96.8	2.6
2013	100.0	0.4	NO	NO	NO	NO	96.9	2.7
2014	100.0	NO	NO	NO	NO	NO	97.4	2.6
2015	100.0	NO	NO	NO	NO	NO	97.5	2.5
2016	100.0	NO	NO	NO	NO	NO	97.4	2.6
2017	100.0	NO	NO	NO	NO	NO	97.0	3.0
2018	100.0	NO	NO	NO	NO	NO	96.8	3.2
2019	100.0	NO	NO	NO	NO	NO	96.8	3.2
2020	100.0	NO	NO	NO	NO	NO	96.8	3.2
2021	100.0	NO	NO	NO	NO	NO	96.8	3.2
2022	100.0	NO	NO	NO	NO	NO	97.0	3.0

NO...not occurring

Table 87: Share of solid fuel consumption from 1.A.4.b.1 Residential: Stationary Combustion 1990, 1995, 2000, 2005 and 2010–2022

CRF		1.A.4.b.1			
Fuel group		Solid			
Fuel	Total	Hard coal and hard coal briquettes	Lignite and brown coal	Brown coal briquettes	Coke
Year	[% Tj]				
1990	100.0	18.5	8.5	15.5	57.5
1995	100.0	21.8	6.2	16.0	56.0
2000	100.0	22.4	6.6	14.9	56.1
2005	100.0	28.2	3.8	15.7	52.3
2010	100.0	25.3	3.7	16.0	55.0
2011	100.0	25.8	2.5	16.0	55.7
2012	100.0	26.5	2.2	17.3	54.0
2013	100.0	28.2	3.5	21.6	46.7
2014	100.0	28.6	2.8	21.6	47.0
2015	100.0	29.4	4.1	21.5	45.0
2016	100.0	28.8	3.1	20.5	47.7
2017	100.0	37.2	3.9	26.1	32.8
2018	100.0	39.8	3.7	29.3	27.2
2019	100.0	37.7	3.9	23.1	35.3
2020	100.0	19.5	5.2	32.9	42.5
2021	100.0	16.2	2.6	48.9	32.3
2022	100.0	19.5	3.2	43.9	33.4

Table 88: Share of biomass fuel consumption from 1.A.4.b.1 Residential: Stationary Combustion 1990, 1995, 2000, 2005 and 2010–2022

CRF		1.A.4.b.1			
Fuel group		Biomass			
Fuel	Total	Fuel wood	Wood waste	Biogas, sewage sludge gas and landfill gas	Charcoal
Year	[% Tj]				
1990	100.0	98.5	1.3	NO	0.2
1995	100.0	97.5	2.2	IE ⁽¹⁾ , NO ⁽²⁾	0.2
2000	100.0	92.2	7.5	IE ⁽¹⁾ , NO ⁽²⁾	0.3
2005	100.0	90.1	9.5	IE ⁽¹⁾ , NO ⁽²⁾	0.4
2010	100.0	85.5	14.2	IE ⁽¹⁾ , NO ⁽²⁾	0.3
2011	100.0	83.5	16.3	IE ⁽¹⁾ , NO ⁽²⁾	0.3
2012	100.0	82.6	17.1	IE ⁽¹⁾ , NO ⁽²⁾	0.3

CRF		1.A.4.b.1			
Fuel group		Biomass			
Fuel	Total	Fuel wood	Wood waste	Biogas, sewage sludge gas and landfill gas	Charcoal
Year	[% Tj]				
2013	100.0	81.8	18.0	IE ¹⁾ , NO ²⁾	0.3
2014	100.0	80.7	19.0	IE ¹⁾ , NO ²⁾	0.3
2015	100.0	78.4	21.2	IE ¹⁾ , NO ²⁾	0.4
2016	100.0	78.2	21.5	IE ¹⁾ , NO ²⁾	0.4
2017	100.0	77.9	21.8	IE ¹⁾ , NO ²⁾	0.3
2018	100.0	77.1	22.5	IE ¹⁾ , NO ²⁾	0.4
2019	100.0	76.4	23.2	IE ¹⁾ , NO ²⁾	0.4
2020	100.0	76.2	23.4	IE ¹⁾ , NO ²⁾	0.4
2021	100.0	73.7	26.0	IE ¹⁾ , NO ²⁾	0.3
2022	100.0	73.6	26.1	IE ¹⁾ , NO ²⁾	0.3

IE...included elsewhere

NO...not occurring

¹⁾ Biogas included elsewhere in category 1.A.4.a.1

²⁾ Sewage sludge gas and landfill gas not occurring in category 1.A.4.b.1

1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion

Table 89: Share of liquid fuel consumption from 1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion 1990, 1995, 2000, 2005 and 2010-2022

CRF		1.A.4.c.1						
Fuel group		Liquid						
Fuel	Total	Light fuel oil	Medium fuel oil	Heavy fuel oil	Diesel	Petroleum and other petroleum products	Gas oil	Liquefied petroleum gases
Year	[% Tj]							
1990	100.0	97.8	NO	NO	NO	NO	0.8	1.4
1995	100.0	92.3	NO	NO	NO	NO	2.3	5.4
2000	100.0	89.9	NO	NO	NO	NO	1.6	8.6
2005	100.0	82.2	NO	NO	NO	NO	4.0	13.8
2010	100.0	61.1	NO	NO	NO	NO	9.7	29.2
2011	100.0	62.9	NO	NO	NO	NO	10.6	26.5
2012	100.0	61.9	NO	NO	NO	NO	10.7	27.4
2013	100.0	66.8	NO	NO	NO	NO	8.3	24.9
2014	100.0	72.9	NO	NO	NO	NO	6.9	20.2

CRF		1.A.4.c.1						
Fuel group		Liquid						
Fuel	Total	Light fuel oil	Medium fuel oil	Heavy fuel oil	Diesel	Petroleum and other petroleum products	Gas oil	Liquefied petroleum gases
Year	[% Tj]							
2015	100.0	69.6	NO	NO	NO	NO	8.0	22.4
2016	100.0	74.7	NO	NO	NO	NO	6.6	18.8
2017	100.0	35.8	NO	NO	NO	NO	15.1	49.1
2018	100.0	NO	NO	NO	NO	NO	48.6	51.4
2019	100.0	NO	NO	NO	NO	NO	20.6	79.4
2020	100.0	NO	NO	NO	NO	NO	21.0	79.0
2021	100.0	NO	NO	NO	NO	NO	21.7	78.3
2022	100.0	NO	NO	NO	NO	NO	24.9	75.1

NO...not occurring

Table 90: Share of solid fuel consumption from 1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion 1990, 1995, 2000, 2005 and 2010–2022

CRF		1.A.4.c.1			
Fuel group		Solid			
Fuel	Total	Hard coal and hard coal briquettes	Lignite and brown coal	Brown coal briquettes	Coke
Year	[% Tj]				
1990	100.0	5.1	NO	30.0	64.8
1995	100.0	14.2	NO	28.3	57.5
2000	100.0	NO	NO	33.7	66.3
2005	100.0	6.7	NO	54.9	38.4
2010	100.0	8.2	NO	32.8	59.0
2011	100.0	8.8	NO	32.3	58.9
2012	100.0	8.6	NO	34.7	56.8
2013	100.0	8.7	NO	42.8	48.5
2014	100.0	8.1	NO	42.9	49.0
2015	100.0	9.8	NO	43.1	47.2
2016	100.0	8.9	NO	41.0	50.0
2017	100.0	9.3	NO	64.4	26.3
2018	100.0	9.8	NO	69.3	21.0
2019	100.0	13.1	NO	48.2	38.7
2020	100.0	4.9	NO	58.9	36.2

CRF		1.A.4.c.1			
Fuel group		Solid			
Fuel	Total	Hard coal and hard coal briquettes	Lignite and brown coal	Brown coal briquettes	Coke
Year	[% TJ]				
2021	100.0	2.0	NO	72.8	25.2
2022	100.0	2.3	NO	69.9	27.8

NO...not occurring

Table 91: Share of biomass fuel consumption from 1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion 1990, 1995, 2000, 2005 and 2010-2022

CRF		1.A.4.c.1			
Fuel group		Biomass			
Fuel	Total	Fuel wood	Wood waste	Biogas, sewage sludge gas and landfill gas	Charcoal
Year	[% TJ]				
1990	100.0	90.5	9.5	NO	NO
1995	100.0	86.0	14.0	IE ¹⁾ , NO ²⁾	NO
2000	100.0	70.5	29.5	IE ¹⁾ , NO ²⁾	NO
2005	100.0	70.6	29.4	IE ¹⁾ , NO ²⁾	NO
2010	100.0	63.8	36.2	IE ¹⁾ , NO ²⁾	NO
2011	100.0	61.5	38.5	IE ¹⁾ , NO ²⁾	NO
2012	100.0	59.4	40.6	IE ¹⁾ , NO ²⁾	NO
2013	100.0	55.0	45.0	IE ¹⁾ , NO ²⁾	NO
2014	100.0	51.7	48.3	IE ¹⁾ , NO ²⁾	NO
2015	100.0	52.2	47.8	IE ¹⁾ , NO ²⁾	NO
2016	100.0	52.1	47.9	IE ¹⁾ , NO ²⁾	NO
2017	100.0	49.9	50.1	IE ¹⁾ , NO ²⁾	NO
2018	100.0	50.1	49.9	IE ¹⁾ , NO ²⁾	NO
2019	100.0	54.8	45.2	IE ¹⁾ , NO ²⁾	NO
2020	100.0	54.3	45.7	IE ¹⁾ , NO ²⁾	NO
2021	100.0	53.8	46.2	IE ¹⁾ , NO ²⁾	NO
2022	100.0	52.7	47.3	IE ¹⁾ , NO ²⁾	NO

IE...included elsewhere

NO...not occurring

¹⁾ Biogas included elsewhere in category 1.A.4.a.1

²⁾ Sewage sludge gas and landfill gas not occurring in category 1.A.4.c.1

Fuel Consumption by Heating Type

The fuel consumption reported in (IEA JQ 2023) and (STATISTIK AUSTRIA 2023a) is assigned to twenty-two heating types (see section *Methodology* above).

If occurring, all fuel consumption of light fuel oil, medium fuel oil, heavy fuel oil, diesel, and petroleum and other petroleum products is assigned to heating type *#1 Fuel oil boilers*. Fuel consumption of gas oil is assigned to 5 different heating types (*#2 Gas oil stoves, #3 Vapourizing burners, #4 Yellow burners, #5 Blue burners with conventional technology, #6 Blue burners with low temperature or condensing technology*). Fuel consumption of liquefied petroleum gas is assigned to 2 different heating types (*#10 LPG stoves, #11 LPG boilers*) (from 1.A.4.a.1 see Table 92, from 1.A.4.b.1 see Table 95).

If occurring, all fuel consumption of hard coal and hard coal briquettes, lignite and brown coal, brown coal briquettes and coke is assigned to two different types of heating (*#21 Coal stoves, #22 Coal boilers*) with the same share (from 1.A.4.a.1 see Table 93, from 1.A.4.b.1 see Table 96).

Fuel consumption of natural gas is assigned to three different heating types (*#7 Natural gas convectors, #8 Atmospheric burners, #9 Forced-draft natural gas burners*) (from 1.A.4.a.1 see Table 93, from 1.A.4.b.1 see Table 96).

If occurring, fuel consumption of biogas, sewage sludge gas and landfill gas is assigned to two different heating types (*#8 Atmospheric burners, #9 Forced-draft natural gas burners*) (from 1.A.4.a.1 see Table 93, from 1.A.4.b.1 see Table 96).

Fuel consumption of fuel wood (log wood) is assigned to five different heating types (*#12 Wood stoves and cooking stoves, #13 Tiled wood stoves and masonry heaters, #14 Mixed-fuel wood boilers, #15 Natural-draft wood boilers, #16 Forced-draft wood boilers*). Fuel consumption of wood waste (wood chips, pellets and other biomass) is assigned to 4 different heating types (*#17 Wood chips boilers with conventional technology, #18 Wood chips boilers with oxygen sensor emission control, #19 Pellet stoves, #20 Pellet boilers*) (from 1.A.4.a.1 see Table 94, from 1.A.4.b.1 see Table 97). In addition, the whole fuel consumption of charcoal is assumed to be combusted in devices similar to central heating and calculated separately.

If occurring, all fuel consumption of industrial waste is assigned to heating type *#22 Coal boilers*.

1.A.4.a.1 Commercial/Institutional: Stationary Combustion

The fuel consumption from category 1.A.4.a.1 reported in (IEA JQ 2023) and (STATISTIK AUSTRIA 2023a) is assigned to twenty-two heating types derived from an energy demand model for space heating based on heating market surveys and federal provinces data and calibrated according to the energy statistics supplier (see section *Methodology* above).

Table 92: Percentual liquid fuel consumption by type of heating from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990, 1995, 2000, 2005 and 2010-2022

CRF		1.A.4.a.1						
Fuel group		Liquid						
Fuel	Other liquid fuels	Gas oil					Liquefied petroleum gases	
Heating type No.	#1	#2	#3	#4	#5	#6	#10	#11
Year	[% TJ]	[%TJ]					[%TJ]	
1990	100.0	10.1	2.3	78.6	1.7	7.4	86.7	13.3
1995	100.0	9.6	1.7	68.8	4.8	15.1	84.6	15.4
2000	100.0	8.8	1.2	57.0	9.1	23.9	81.8	18.2
2005	100.0	8.2	1.0	52.6	9.6	28.5	76.1	23.9
2010	100.0	7.8	0.7	49.4	6.8	35.3	73.1	26.9
2011	100.0	7.7	0.6	48.2	6.0	37.4	72.2	27.8
2012	100.0	7.6	0.5	47.0	5.1	39.7	71.7	28.3
2013	100.0	7.5	0.4	45.7	4.1	42.3	71.1	28.9
2014	100.0	7.4	0.3	44.1	2.9	45.4	70.0	30.0
2015	100.0	7.3	0.1	42.3	1.4	49.0	69.6	30.4
2016	100.0	6.6	0.1	41.7	1.3	50.3	68.1	31.9
2017	100.0	5.9	0.1	41.0	1.1	51.9	66.4	33.6
2018	100.0	5.2	0.1	40.3	1.0	53.5	64.3	35.7
2019	100.0	4.3	0.1	39.5	0.8	55.3	62.1	37.9
2020	100.0	3.4	0.1	38.9	0.6	57.0	59.6	40.4
2021	100.0	2.3	0.1	38.2	0.4	59.0	57.0	43.0
2022	100.0	1.8	0.1	37.2	0.4	60.5	54.1	45.9

Table 93: Percentual solid, gaseous and biomass fuel consumption by type of heating from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990, 1995, 2000, 2005 and 2010-2022

CRF			1.A.4.a.1				
Fuel group		Solid	Gaseous			Biomass	
Fuel		All solid fuels	Natural gas			Biogas, sewage sludge gas and landfill gas	
Heating type No.	#21	#22	#7	#8	#9	#8	#9
Year	[% T]]		[%T]]			[%T]]	
1990	81.3	18.7	27.0	59.4	13.6	NO	NO
1995	81.4	18.6	19.8	58.1	22.1	72.5	27.5
2000	86.2	13.8	14.6	53.9	31.5	63.1	36.9
2005	89.8	10.2	14.8	49.5	35.7	58.1	41.9
2010	77.3	22.7	15.3	47.7	36.9	56.4	43.6

CRF		1.A.4.a.1					
Fuel group	Solid		Gaseous			Biomass	
Fuel	All solid fuels		Natural gas			Biogas, sewage sludge gas and landfill gas	
Heating type No.	#21	#22	#7	#8	#9	#8	#9
Year	[% TJ]		[%TJ]			[%TJ]	
2011	76.7	23.3	15.8	47.4	36.8	56.3	43.7
2012	69.2	30.8	15.8	47.4	36.8	56.3	43.7
2013	95.3	4.7	15.8	47.5	36.7	56.4	43.6
2014	99.4	0.6	16.6	47.2	36.3	56.5	43.5
2015	99.5	0.5	16.4	47.5	36.1	56.9	43.1
2016	NO	NO	15.7	47.6	36.6	56.5	43.5
2017	NO	NO	15.1	47.6	37.4	56.0	44.0
2018	NO	NO	14.6	47.2	38.2	55.3	44.7
2019	NO	NO	13.8	47.0	39.2	54.5	45.5
2020	NO	NO	13.1	46.7	40.2	53.8	46.2
2021	NO	NO	12.0	46.6	41.4	53.0	47.0
2022	NO	NO	12.2	45.7	42.2	52.0	48.0

NO...not occurring

Table 94: Percentual biomass fuel consumption by type of heating from 1.A.4.a.1 Commercial/Institutional: Stationary Combustion 1990, 1995, 2000, 2005 and 2010–2022 (continued)

CRF		1.A.4.a.1							
Fuel group		Biomass							
Fuel	Fuel wood					Wood waste			
Heating type No.	#12	#13	#14	#15	#16	#17	#18	#19	#20
Year	[%TJ]					[%TJ]			
1990	1.6	64.8	32.7	NO	0.9	89.8	10.0	NO	0.2
1995	1.6	60.4	34.8	NO	3.2	40.1	13.7	0.9	45.4
2000	2.0	55.2	36.3	NO	6.6	19.2	12.1	2.9	65.9
2005	2.0	70.0	21.6	0.2	6.2	10.9	14.4	5.0	69.7
2010	2.4	83.5	10.9	0.1	3.1	13.4	43.3	3.1	40.3
2011	2.8	85.9	8.7	0.1	2.5	10.6	40.3	3.4	45.6
2012	2.8	88.7	6.5	0.1	1.9	11.3	50.0	2.7	35.9
2013	2.9	91.4	4.4	0.0	1.3	9.1	45.8	3.2	42.0
2014	3.7	93.5	2.2	0.0	0.6	6.5	36.8	3.9	52.8
2015	3.5	96.5	NO	NO	NO	8.5	53.6	2.6	35.2
2016	3.4	96.6	NO	NO	NO	5.5	37.4	4.0	53.2
2017	3.4	96.6	NO	NO	NO	4.5	33.6	4.3	57.6
2018	3.7	96.3	NO	NO	NO	5.3	42.2	3.6	49.0

CRF		1.A.4.a.1							
Fuel group		Biomass							
Fuel		Fuel wood				Wood waste			
Heating type No.	#12	#13	#14	#15	#16	#17	#18	#19	#20
Year	[%TJ]				[%TJ]				
2019	3.7	96.3	NO	NO	NO	4.9	42.5	3.5	49.1
2020	3.6	96.4	NO	NO	NO	4.5	43.0	3.4	49.0
2021	3.2	96.8	NO	NO	NO	4.1	43.4	3.3	49.2
2022	3.6	96.4	NO	NO	NO	3.9	43.9	3.0	49.3

NO...not occurring

1.A.4.b.1 Residential: Stationary Combustion

Energy consumption from category 1.A.4.b.1 by type of fuel and by type of heating is derived from an energy demand model for space heating based on heating market surveys and federal provinces data validated with a statistical evaluation of micro census data 1990, 1992, 1999/2000, 2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022 (STATISTIK AUSTRIA 1990, 1992b, 2002, 2019, 2021, 2023e). The calculated shares are used to subdivide total final energy consumption to the several technologies. For the years in between the shares are interpolated. Because the newest census data is always reconsidered to improve previous years' census data evaluation this implies a periodic recalculation in time series. The energy demand model is calibrated according to the energy statistics supplier (see section *Methodology* above).

Table 95: Percentual liquid fuel consumption by type of heating from 1.A.4.b.1 Residential: Stationary Combustion 1990, 1995, 2000, 2005 and 2010-2022

CRF		1.A.4.b.1						
Fuel group		Liquid						
Fuel		Other liquid fuels	Gas oil				Liquefied petroleum gases	
Heating type No.	#1	#2	#3	#4	#5	#6	#10	#11
Year	[%TJ]	[%TJ]				[%TJ]		
1990	100.0	15.0	12.3	64.2	1.4	7.1	24.5	75.5
1995	100.0	12.7	10.6	57.2	3.7	15.9	16.0	84.0
2000	100.0	10.4	8.1	51.3	7.4	22.8	11.6	88.4
2005	100.0	4.4	7.3	51.9	8.4	28.1	9.8	90.2
2010	100.0	2.8	5.8	48.8	6.1	36.4	14.0	86.0
2011	100.0	2.7	5.4	47.5	5.5	38.9	16.6	83.4
2012	100.0	2.8	4.9	46.3	4.7	41.3	15.7	84.3
2013	100.0	2.8	4.3	44.7	3.9	44.2	15.3	84.7
2014	NO	2.9	3.7	43.0	2.9	47.6	19.0	81.0
2015	NO	2.8	2.9	40.9	1.7	51.7	19.0	81.0
2016	NO	2.6	2.6	40.6	1.5	52.7	16.9	83.1
2017	NO	2.4	2.2	40.2	1.3	53.8	15.9	84.1

CRF		1.A.4.b.1						
Fuel group		Liquid						
Fuel	Other liquid fuels	Gas oil					Liquefied petroleum gases	
Heating type No.	#1	#2	#3	#4	#5	#6	#10	#11
Year	[%TJ]	[%TJ]					[%TJ]	
2018	NO	2.4	1.8	39.8	1.1	54.8	19.2	80.8
2019	NO	2.3	1.4	39.4	0.9	55.9	20.8	79.2
2020	NO	2.3	1.0	39.1	0.7	56.8	20.5	79.5
2021	NO	2.0	0.6	38.9	0.5	58.0	19.1	80.9
2022	NO	2.1	0.6	37.8	0.5	59.0	21.3	78.7

NO...not occurring

Table 96: Percentual solid, gaseous and biomass fuel consumption by type of heating from 1.A.4.b.1 Residential: Stationary Combustion 1990, 1995, 2000, 2005 and 2010–2022

CRF		1.A.4.b.1					
Fuel group		Solid		Gaseous			Biomass
Fuel		All solid fuels		Natural gas			Biogas, sewage sludge gas and landfill gas
Heating type No.		#21	#22	#7	#8	#9	#8 #9
Year		[%TJ]		[%TJ]			[%TJ]
1990		30.0	70.0	39.1	53.7	7.2	NO NO
1995		26.6	73.4	31.9	55.4	12.8	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2000		23.2	76.8	24.7	55.3	20.0	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2005		18.2	81.8	16.6	56.1	27.3	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2010		17.7	82.3	14.9	51.7	33.4	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2011		24.1	75.9	15.5	50.1	34.4	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2012		24.1	75.9	13.5	50.0	36.5	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2013		24.2	75.8	11.7	49.6	38.7	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2014		22.2	77.8	12.5	47.7	39.7	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2015		19.8	80.2	12.0	47.3	40.7	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2016		22.0	78.0	11.4	46.6	42.0	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2017		24.0	76.0	11.1	45.6	43.3	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2018		25.9	74.1	12.0	43.7	44.3	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2019		27.9	72.1	12.4	42.1	45.5	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2020		33.0	67.0	11.1	41.4	47.5	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2021		38.6	61.4	9.2	40.9	49.9	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾
2022		41.4	58.6	9.4	39.8	50.8	IE ⁽¹⁾ , NO ⁽²⁾ IE ⁽¹⁾ , NO ⁽²⁾

IE...included elsewhere

NO...not occurring

¹⁾Biogas included elsewhere in category 1.A.4.a.1

²⁾Sewage sludge gas and landfill gas not occurring in category 1.A.4.b.1

Table 97: Percentual biomass fuel consumption by type of heating from 1.A.4.b.1 Residential: Stationary Combustion 1990, 1995, 2000, 2005 and 2010–2022 (continued)

CRF		1.A.4.b.1							
Fuel group		Biomass							
Fuel		Fuel wood				Wood waste			
Heating type No.	#12	#13	#14	#15	#16	#17	#18	#19	#20
Year	[%TJ]				[%TJ]				
1990	22.6	8.7	66.6	NO	2.1	89.9	10.1	NO	NO
1995	19.5	8.2	64.9	NO	7.5	39.2	13.6	NO	47.2
2000	16.3	8.1	61.4	NO	14.3	23.7	18.0	NO	58.3
2005	9.5	7.1	60.3	0.9	22.2	23.3	38.2	1.7	36.8
2010	9.1	8.5	53.0	3.6	25.8	8.3	29.1	3.0	59.5
2011	8.8	8.4	52.1	4.0	26.8	6.5	25.8	3.6	64.2
2012	9.3	8.9	50.3	4.3	27.2	4.9	22.3	3.6	69.2
2013	9.7	9.4	48.8	4.5	27.5	6.6	33.4	2.8	57.2
2014	10.1	9.6	47.6	4.8	27.9	5.9	33.0	2.8	58.2
2015	10.5	9.9	46.3	5.0	28.3	3.7	22.7	3.5	70.1
2016	10.6	9.9	45.2	5.3	29.0	3.5	22.9	3.7	69.9
2017	10.7	9.8	44.0	5.7	29.8	4.1	29.2	3.6	63.1
2018	11.4	10.1	42.3	6.0	30.3	2.4	18.3	4.5	74.8
2019	12.0	10.4	40.4	6.3	30.8	1.6	12.6	5.3	80.6
2020	11.2	9.2	39.9	7.0	32.7	1.3	11.1	5.4	82.2
2021	10.2	7.9	39.0	7.8	35.1	1.9	18.0	4.8	75.3
2022	9.3	6.8	39.2	8.5	36.2	1.8	18.5	4.3	75.4

NO...not occurring

1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary Combustion

The fuel consumption reported in (IEA JQ 2023) and (STATISTIK AUSTRIA 2023a) 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 *Fuel Consumption by Heating Type* above).

Fuel Consumption by Subcategory of Heating Type

The following table shows biomass share of wood stoves and cooking stoves stock from 2001 which are considered with lower CH₄ emissions than equipment installed before 2001. The selected factors are derived from the energy demand model for space heating (see section *Methodology* above).

Table 98: Share of new and conventional wood stoves and cooking stoves stock 2005 and 2010–2022

Heating type No.		#12	
Subcategory	Wood stoves and cooking stoves (new)		Wood stoves and cooking stoves (conventional)
CRF	1.A.4.a.1	1.A.4.b.1	1.A.4.a.1 1.A.4.b.1
Year	[% Tj]		[%Tj]
2005	11.2	7.9	88.8 92.1
2010	20.5	12.7	79.5 87.3
2011	22.4	14.3	77.6 85.7
2012	24.1	16.6	75.9 83.4
2013	25.9	19.0	74.1 81.0
2014	28.0	21.6	72.0 78.4
2015	30.0	24.7	70.0 75.3
2016	31.1	26.4	68.9 73.6
2017	32.6	28.4	67.4 71.6
2018	34.0	28.9	66.0 71.1
2019	35.6	29.5	64.4 70.5
2020	37.3	30.3	62.7 69.7
2021	39.1	31.5	60.9 68.5
2022	40.5	31.8	59.5 68.2

The following table shows biomass share of mixed-fuel wood boilers stock with (comparatively) advanced technology which are considered with (slightly) lower CH₄ emissions than conventional equipment. The selected factors are derived from the energy demand model for space heating (see section *Methodology* above).

Table 99: Share of advanced and conventional mixed-fuel wood boilers stock 1990, 1995, 2000, 2005 and 2010–2022

Heating type No.		#14	
Subcategory	Mixed-fuel wood boilers (advanced)		Mixed-fuel wood boilers (conventional)
CRF	1.A.4.a.1	1.A.4.b.1	1.A.4.a.1 1.A.4.b.1
Year	[% Tj]		[% Tj]
1990	2.1	2.9	97.9 97.1
1995	8.8	13.6	91.2 86.4
2000	11.9	18.7	88.1 81.3
2005	14.4	19.9	85.6 80.1
2010	13.8	19.9	86.2 80.1
2011	13.7	19.8	86.3 80.2
2012	13.6	19.8	86.4 80.2
2013	13.6	19.8	86.4 80.2
2014	13.5	19.7	86.5 80.3

Heating type No.		#14		
Subcategory	Mixed-fuel wood boilers (advanced)		Mixed-fuel wood boilers (conventional)	
CRF	1.A.4.a.1	1.A.4.b.1	1.A.4.a.1	1.A.4.b.1
Year	[% TJ]		[% TJ]	
2015	13.4	19.7	86.6	80.3
2016	13.4	19.3	86.6	80.7
2017	13.3	18.8	86.7	81.2
2018	13.2	18.3	86.8	81.7
2019	13.1	17.8	86.9	82.2
2020	13.1	17.1	86.9	82.9
2021	13.0	16.4	87.0	83.6
2022	12.9	15.9	87.1	84.1

3.2.14.1.3 Emission Factors

CO₂ emission factors are taken from studies (BMW 1990, 1996, 1999), elementary analysis of natural gas (UMWELTBUNDESAMT 2002, until 2018), newly recommended CO₂ emission factor for natural gas (BMNT 2019a, starting from 2019), and the IPCC Guidelines 1996 whereas N₂O emission factors from the IPCC Guidelines 2006 are used. CO₂ and N₂O emission factors are identical for the different heating types burning the same fuels. The studies also provide CH₄ respectively VOC and C_{org} emission factors for different fuels and heating types.

The C_{org} (Organic Carbon) emission factors provided in (BMW 1999) are converted into VOC emission factors with the formula $VOC = 1.3 * C_{org}$. The factor of 1.3 is an expert judgement by Umweltbundesamt as no factor was available from literature. It is based on analytical data of the composition of VOC emissions from the combustion of fuel wood for residential heating.

In some cases only VOC emission factors are provided in the studies, CH₄ emission factors are determined assuming that a certain percentage of VOC emissions is released as NMVOC as listed in Table 100. The split follows closely (STANZEL et al. 1995).

Table 100: Share of CH₄ and NMVOC in VOC for small combustion devices

Pollutant		CH ₄	NMVOC	VOC
Fuel group	Fuel	[% VOC]		
Liquid	Light fuel oil, Medium fuel oil, Heavy fuel oil	25.0	75.0	100.0
	Petroleum, Gas oil	20.0	80.0	100.0
	Liquefied petroleum gases	80.0	20.0	100.0
Solid	All solid fuels	25.0	75.0	100.0
Gaseous	Natural gas	80.0	20.0	100.0
Biomass	All biomass fuels	25.0	75.0	100.0

From 2001 on new wood stove and cooking stove subtypes are considered which have lower VOC emissions and thus lower CH₄ emissions than conventional wood stoves and cooking stoves. In addition, mixed-fuel wood boilers stock with (comparatively) advanced technology are considered with (slightly) lower CH₄ emissions than conventional equipment.

The selected emission factors for 2022 are presented in the following table.

Table 101: Emission factors of category 1.A.4 heating types for the year 2022

CRF		1.A.4	1.A.4.a.1	1.A.4.b.1	1.A.4.c.1	1.A.4
Pollutant		CO ₂	CH ₄			N ₂ O
Fuel	Heating type No.	[t/TJ]	[kg/TJ]			[kg/TJ]
Light fuel oil	#1	77.00	10.00	10.00	10.00	0.60
Medium fuel oil	#1	78.00	10.00	10.00	10.00	0.60
Heavy fuel oil	#1	78.00	10.00	10.00	10.00	0.60
Diesel	#1	75.00	10.00	10.00	10.00	0.60
Petroleum	#1	78.00	10.00	10.00	10.00	0.60
Other petroleum products	#1	64.00	10.00	10.00	10.00	0.60
Gas oil	#2, #3, #4, #5, #6	75.00	3.00	3.00	3.00	0.60
Natural gas	#7, #8, #9	55.60	5.00	5.00	5.00	0.10
Biogas, sewage sludge gas and landfill gas	#8, #9	54.60 ¹⁾	5.00	5.00	5.00	0.10
Liquefied petroleum gases	#10, #11	64.00	5.00	5.00	5.00	0.10
Fuel wood	#12	112.00 ¹⁾	177.69 ²⁾	186.84 ²⁾	300.00	4.00
	#13	112.00 ¹⁾	115.61	115.61	300.00	4.00
	#14	112.00 ¹⁾	145.46 ³⁾	146.30 ³⁾	300.00	4.00
	#15	112.00 ¹⁾	121.42	121.42	300.00	4.00
	#16	112.00 ¹⁾	112.74	112.74	300.00	4.00
Wood waste	#17	112.00 ¹⁾	150.00	150.00	300.00	4.00
	#18	112.00 ¹⁾	27.06	27.06	300.00	4.00
	#19	112.00 ¹⁾	19.84	19.84	300.00	4.00
	#20	112.00 ¹⁾	11.27	11.27	300.00	4.00
Hard coal and hard coal briquettes	#21, #22	93.00	10.00	300.00	300.00	1.50
Lignite and brown coal	#21, #22	108.00	10.00	300.00	300.00	1.50
Brown coal briquettes	#21, #22	97.00	10.00	300.00	300.00	1.50
Coke	#21, #22	92.00	10.00	300.00	300.00	1.50
Peat	#21, #22	106.00	10.00	10.00	10.00	1.40
Industrial waste (<i>fossil</i>)	#22	62.16 ⁴⁾	12.00	12.00	12.00	4.00
Industrial waste (<i>biogenic</i>)	#22	50.00 ¹⁾	12.00	12.00	12.00	4.00
Charcoal	–	112.00 ¹⁾	200.00	200.00	200.00	1.00

¹⁾Reported as CO₂ emissions from biomass

²⁾Implied emission factor based on CH₄ emission factors of new and conventional wood stoves and cooking stoves stock (see Table 102) weighted with fuel consumption by subcategory of heating type (see Table 98)

³⁾Implied emission factor based on CH₄ emission factors of advanced and conventional mixed-fuel boilers stock (see Table 103) weighted with fuel consumption by subcategory of heating type (see Table 99)

⁴⁾Implied emission factor based on fossil fraction of industrial waste

Because no measurements are available, CH₄ emission factors for new wood stoves and cooking stoves (Table 102) are derived from conventional devices emission factors with the ratio of conventional and new devices NMVOC emission factors (BMWA 1999, LANG et al. 2003):

$$EF(CH_4)_{\text{new}} = EF(CH_4)_{\text{conventional}} * EF(NMVOC)_{\text{new}} / EF(NMVOC)_{\text{conventional}}$$

Table 102: CH₄ emission factors of category 1.A.4 for conventional and new wood stoves and cooking stoves

Pollutant			CH ₄	
CRF			1.A.4.a.1	1.A.4.b.1
Fuel	Heating type No.	Subcategory	[kg/TJ]	
Fuel wood	#12	Wood stoves and cooking stoves (new)	115.61	115.61
		Wood stoves and cooking stoves (conventional)	220.00	220.00

Because no measurements are available, CH₄ emission factors for advanced mixed-fuel boilers (Table 103) are derived from conventional devices emission factors with the ratio of conventional and advanced devices NMVOC emission factors (BMWA 1999, LANG et al. 2003):

$$EF(CH_4)_{\text{advanced}} = EF(CH_4)_{\text{conventional}} * EF(NMVOC)_{\text{advanced}} / EF(NMVOC)_{\text{conventional}}$$

Table 103: CH₄ emission factors of category 1.A.4 for conventional and advanced mixed-fuel boilers

Pollutant			CH ₄	
CRF			1.A.4.a.1	1.A.4.b.1
Fuel	Heating type No.	Subcategory	[kg/TJ]	
Fuel wood	#14	Mixed-fuel wood boilers (advanced)	121.42	121.42
		Mixed-fuel wood boilers (conventional)	150.00	150.00

3.2.14.1.4 Recalculations

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

In particular, the following shares with an effect on certain implied emission factors have been revised:

- Share of new and conventional wood stoves and cooking stoves stock 2001–2021 (CH₄) (see Table 98)
- Share of advanced and conventional mixed-fuel wood boilers stock 1990–2021 (CH₄) (see Table 99)

Changes in total fuel consumption are based on the revisions of the energy balance. Please refer to chapter 3.2.17 below.

3.2.14.1.5 Planned Improvements

In order to improve the inventory on accurate heating type information it is planned to award a service-contract for an updated market survey of heating type stock, age distribution, final energy demand and type of heating use by CRF category. In order to determine the user-related impact on emissions from biomass (and coal), it is envisaged to collect data on national conditions within an household survey. It is planned to implement the both survey results into the inventory of submission 2025.

No further category-specific improvements are planned.

3.2.14.2 1.A.4 Other sectors – mobile sources

1.A.4.a.2 Commercial/institutional

Key Source: No

Currently there is neither a statistical basis nor any new study on NRMM (Non-Road Mobile Machinery) which would enable Austria to report emissions from mobile sources of *1.A.4.a.ii Commercial/institutional* separately. Commercial and institutional NRMM are reported as IE and included in CRF 1.A.2.g.7 *Industry* and CRF 1.A.4.c.2 *Agriculture and Forestry*.

1.A.4.b.ii Residential – Off-road vehicles and other machinery

Key Source: No

In addition to NRMM used in household and gardening this category contains ski slope machineries and snow vehicles.

Methodological Issues

The used methodology conforms to the requirements of the IPCC 2006 GL Tier 3 methodology and is described in the subchapter on mobile sources of CRF 1.A.2.g.vii.

Activity Data & Emission Factors

Activities used for estimating the emissions and the implied emission factors of CRF 1.A.4.b.ii are presented below. In the following table the activity data includes all energy sources. The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards. Details concerning emission factors for mobile off-road sources are described in the subchapter on mobile sources of 1.A.2.g.vii.

Table 104: Emission factors and activity data for mobile sources of 1.A.4.b.ii Residential 1990–2022

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	2 286	75.5	185.4	10.6
1995	2 286	75.5	174.2	11.1
2000	2 173	75.5	146.4	11.9

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
2005	2 071	75.2	121.4	11.3
2010	1 870	71.7	67.1	8.9
2011	1 842	71.6	58.8	8.2
2012	1 807	71.4	52.5	7.6
2013	1 773	71.7	49.4	7.0
2014	1 739	71.3	47.6	6.5
2015	1 689	71.1	46.0	6.0
2016	1 631	71.7	44.6	5.7
2017	1 583	71.9	43.0	5.4
2018	1 547	71.4	41.2	5.2
2019	1 510	71.5	39.9	5.0
2020	1 481	71.3	39.0	4.9
2021	1 459	71.4	38.1	4.9
2022	1 442	71.5	37.8	4.9

Recalculations

The CH₄ proportions of HC have been updated to exact proportions of 7%, 3.4% and 2.4% per device group according to the EMEP/EEA Guidebook 2023 [1-a-4-non-road Table 3-6, page 37ff]. The overall CH₄ proportions of HC have been revised slightly upwards for the whole time series (e.g. +0.003 kt in 2021).

Planned improvements

No category-specific improvements are planned.

1.A.4.c.ii Agriculture and Forestry – Off-road vehicles and other machinery

Key Source: No

In this category emissions from NRMM used in agriculture and forestry (mainly tractors) are considered.

Methodological Issues

The used methodology conforms to the requirements of the IPCC 2006 GL Tier 3 methodology. The general methodology applied is described in the subchapter on mobile sources of CRF 1.A.2.g.vii.

Activity Data & Emission Factors

Activities used for estimating the emissions and the implied emission factors of CRF 1.A.4.c are presented below. In the following table the activity data includes all energy sources. The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards. Activities of mobile machinery in CRF 1.A.4.c.ii 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 105: Emission factors and activity data for mobile sources of 1.A.4.c.ii Agriculture and Forestry 1990–2022.

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	10 366	74.2	17.4	24.5
1995	10 106	74.2	15.6	25.4
2000	10 610	74.2	13.5	27.3
2005	11 434	73.6	12.2	25.2
2010	10 901	70.4	8.2	19.8
2011	11 818	70.3	7.1	18.7
2012	10 909	70.2	6.7	17.6
2013	10 560	70.4	6.1	16.6
2014	11 667	70.2	5.2	15.7
2015	10 793	69.8	5.2	14.9
2016	11 611	70.3	4.6	14.1
2017	10 775	70.7	4.8	13.3
2018	10 872	70.6	4.9	12.6
2019	11 455	70.7	4.6	12.1
2020	11 592	70.7	4.1	11.6
2021	11 307	70.6	4.4	11.1
2022	11 221	70.6	4.5	10.8

Recalculations

The CH₄ proportions of HC have been updated to exact proportions of 7%, 3.4% and 2.4% per device group according to the EMEP/EEA Guidebook 2023 [1-a-4-non-road Table 3-6, page 37ff]. The overall CH₄ proportions of HC have been revised slightly upwards for the whole time series (e.g. +0.003 kt in 2021).

Planned improvements

No category-specific improvements are currently planned.

3.2.15 1.A.5 Other

In this category emissions of NRMM used for military transport (off-road and aviation) are reported.

1.A.5.b Mobile combustion – Military

Key Source: No

Military Off-Road (ground operations)

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 3 methodology for road transport. The applied methodology is described in the subchapter on mobile sources of CRF 1.A.2.g.vii.

Activity Data

Emission estimates for military activities were taken from (HAUSBERGER 2000). Information on the fleet composition was taken from official data presented in the internet as for reasons of confidentiality no other data was available. In 2023, our efforts to improve inventory data quality in this area were successful.

For the 2024 submission the Austrian Ministry made some key data available like diesel consumption and vehicle fleet for the year 2021. For the model GEORG this vehicles fleet was grouped into two groups: <130 kW and >130 kW with an average nominal power of 95 kW (<130kW) and 422 kW (>130kW). Activities of 142 h/year (<130kW) and 29 h/year (>130kW) were assumed. Further assumptions were that a) the vehicle fleet remains constant due to long service life (confirmed by expert assessment) and b) the split of new registrations is 40% for <130 kW and 60% for >130 kW nominal power vehicles over the entire time series.

With these assumptions the model result was calibrated with the operating hours in 2021 to meet the diesel consumption of 2021. For time series consistency surrogate data (the statistical time series of the number of military personell) was used to scale the operating hours over the time series and calculate the new amounts of diesel consumption per year.

Emission Factors

For tanks and other special ground military vehicles the emission factors for diesel engines > 130 kW were 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 1.A.2.g.7.

Military Aviation

Methodological Issues

The used methodology corresponds to the requirements of the IPCC 2006 GL Tier 1 (simple) methodology for aviation with country specific emission factors. Methodology is based on hours of operation and average fuel consumption per hour for the years 1990-1998 with a linear trend extrapolation for the years from 1998 onwards. The calculation of emissions from military aviation does not distinguish between LTO and cruise.

Activity Data

For the years 1990–1998 fuel consumption for military flights was reported once by the Austrian Ministry of Defence and used in the course of the general flight study to calculate emissions from military aviation (KALIVODA/KUDRNA 2002).

In response to a recommendation of the UNFCCC Review 2020 on Austria's methodology for estimating emissions from military aviation 2000–2018, data on kerosene consumption was re-evaluated.

However, after several official attempts to allocate data from the Austrian Ministry of Defence, no data was provided. Therefore, the historical number of aircrafts (fighter jets, airplanes, helicopters) was compared with current data found on the Internet on the number of operating military aircraft assuming constant flight hours.⁶³

⁶³ [https://de.wikipedia.org/wiki/Luftstreitkr%C3%A4fte_\(Bundesheer\)](https://de.wikipedia.org/wiki/Luftstreitkr%C3%A4fte_(Bundesheer)); 5.12.2021

Starting with the year 2009, fuel consumption was interpolated according to the trend until the year 2020. The latest inventory year is being updated yearly via this source (last update autumn 2023 for the 2024 submission). According to the trend shown in the table below fuel consumption is now declining from 2009 onwards.

Table 106: Military aircraft stock 2008, 2020 and 2022

	Helicopters	Fighter jets and airplanes	Total number of military aircraft
2008	78	96	174
2020	64 (prev. 82)	43	107 (prev. 125)
2022	60	43	103
Trend 2008-2022	-23%	-55%	-41%

As no aircraft data prior to 2008 could be found (PÖTSCHER 2008), the subsequent revision of activity data refers to the years 2009–2019 only; for the years 1999–2008 the previously applied method (linear extrapolation) has been retained, while for the years 1990–1998 the results of the flight study have been used directly as in previous submissions.

Emission Factors

Country specific IEFs (t/t fuel) taken from a national flight study (KALIVODA/KUDRNA 2002) and based on fuel consumption and emissions in the year 2000 have been used to estimate GHG emissions from military flights.

Table 107: Emission factors used for military flights.

	Amount in 2000 [t]	IEF [t/t]
Fuel	13 613	
CO ₂	42 880	3.1500
N ₂ O	2.69	0.0002
CH ₄	1.41	0.0001

Overall activities and emissions

Activities used for estimating the emissions of the total CRF 1.A.5.b are presented below (activity data includes all energy sources). The increasing substitution of fossil fuels with biofuels can be observed from 2005 onwards.

Table 108: Emission factors and activity data for 1.A.5.b Military 1990–2022.

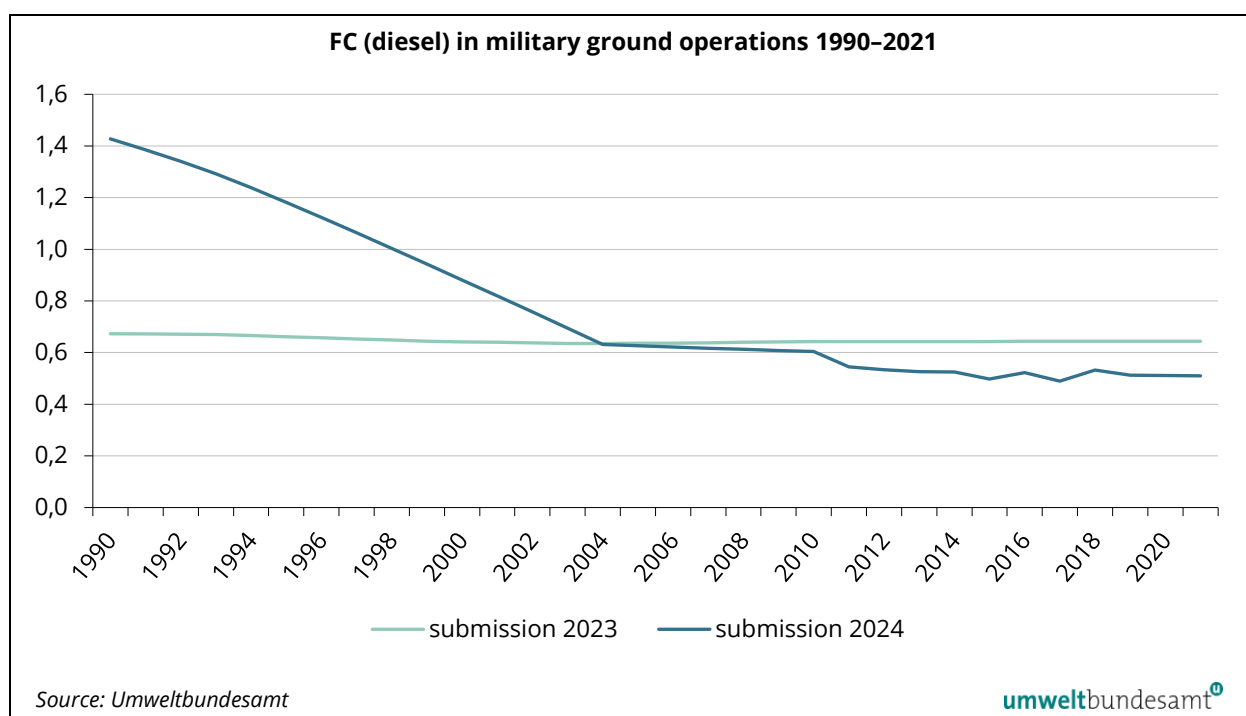
Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
1990	513	72.9	2.5	7.1
1995	469	72.9	2.5	7.0
2000	571	72.8	2.4	6.1
2005	598	72.7	2.4	5.5
2010	582	72.6	2.4	5.3
2011	561	72.6	2.4	5.2
2012	541	72.6	2.4	5.2
2013	522	72.6	2.4	5.2

Year	Activity	Implied Emission Factors		
		CO ₂	CH ₄	N ₂ O
	TJ	t/TJ	kg/TJ	kg/TJ
2014	503	72.6	2.4	5.2
2015	483	72.5	2.4	5.1
2016	464	72.6	2.3	5.1
2017	444	72.6	2.3	5.1
2018	426	72.6	2.3	5.1
2019	407	72.5	2.3	5.1
2020	388	72.5	2.3	5.1
2021	381	72.5	2.3	5.0
2022	373	72.6	2.3	5.0

Recalculations

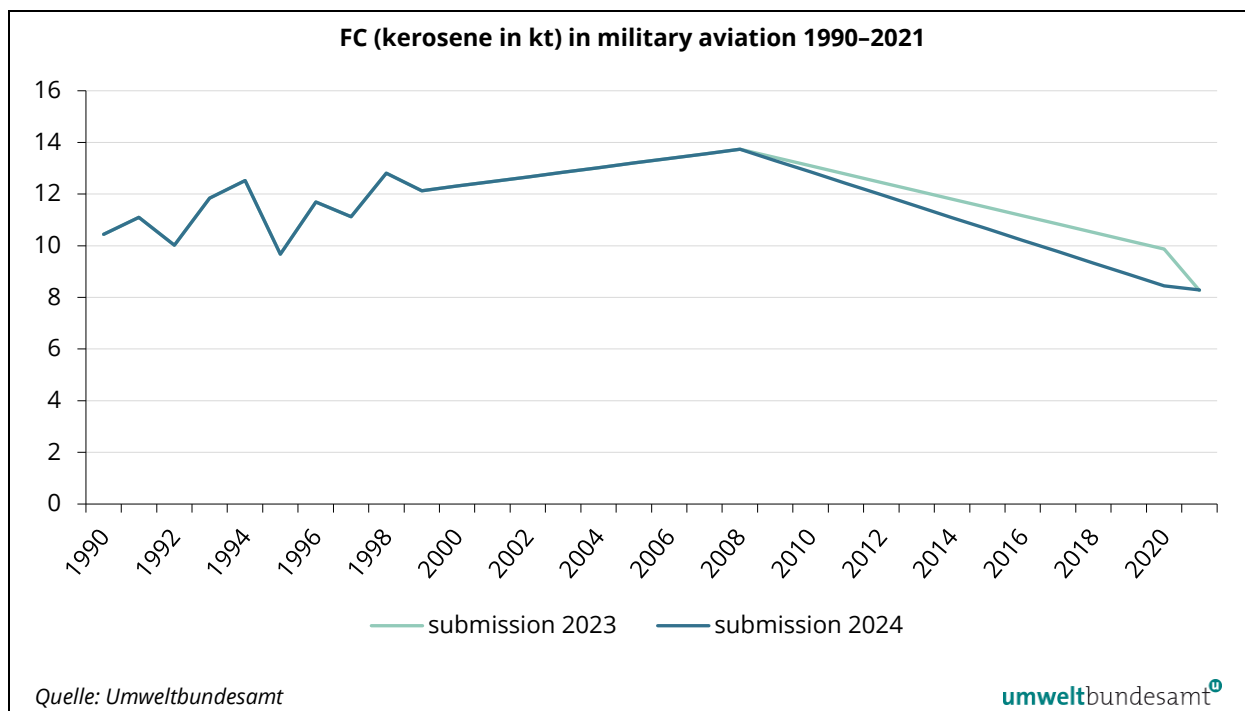
For military ground operations the whole time series has been changed due to new fuel consumption data for 2021 provided by the Austrian Ministry of Defense. In the submission 2024 diesel fuel consumption is 1.43 kt for 1990 (previous value 0.67 kt): +0.8 kt; for 2021 it is 0.51 kt (previous value 0.64 kt): -0.1 kt. The following graph shows the revision over the whole time series.

Figure 13: Comparison of diesel consumption for military ground operations with previous submission



For military aviation a misinterpretation in the data source was corrected regarding the fleet number of helicopters for 2020 (64 instead of 82). This changed the total number of military aircraft in 2020. As data for the years 2009 to 2019 and for 2021 are determined by interpolation these are affected by recalculation as well (2009: -0.12 kt kerosene; 2021: +0.02 kt kerosene). The following graph shows the revision over the whole time series.

Figure 14: Comparison of kerosene consumption for military aviation with previous submission



The overall changes in CO₂ emissions amounts to +2.4 kt in 1990 (0.003% of national total and 6.8% of 1.A.5.b) and -2.1 kt in 2021 (0.003% of national total and 7.1% of 1.A.5.b). CH₄ and N₂O have also changed. CH₄: 1990: +0.0001 kt (0.00003% of national total and 10.3% of 1.A.5.b); 2021: -0.00005 kt (-0.00002% of national total and -5.05% of 1.A.5.b). N₂O: 1990: +0.00008 kt (0.01% of national total and 29.5% of 1.A.5.b); 2021: -0.00005 kt (-0.0004% of national total and -2.5% of 1.A.5.b).

Planned Improvements

In contrast to military ground operations, it was not possible to obtain actual data for military aviation. Austria will launch a new attempt to receive updated activity data for military aviation from the Austrian Ministry of Defence for next inventory submission.

3.2.16 Uncertainty Assessment

As the overall fuel balance for Austria is expected to be considerably more accurate than source specific information (Statistik Austria, pers. communication), also assessment of uncertainties was performed on the level of the overall energy balance. It was not possible, however, to strictly use this straightforward approach because dealing with all fuel related activities at the same time would make it difficult to provide separation of major source categories; as domestic combustion, industry and power plant would fall in the same category with traffic.

For these reasons, an arbitrary split was drawn between energy use in large sources (covering IPCC sectors 1.A.1, refineries as they are included in 1.B.2, and energy in iron and steel production covered in 2.C.1), transport sources (IPCC sector 1.A.3, but including transport related machinery in 1.A.2, manufacturing industry, and 1.A.4, other sectors like agriculture, forestry and households)

and small sources (covering all other combustion sources, specifically the rest of manufacturing industry, 1.A.2, as well as other sectors, 1.A.4. Also 1.A.5, “other” is included which basically covers military energy consumption including transport). Activity uncertainty was assessed separately by fuel for fossil solids (fuel code 102–110), biomass and waste fuels (fuel code 111–118), liquid fuels (fuel codes 203–224 except for black liquor, code 215 which is treated separately) and gaseous fuels (fuel codes above 300). Uncertainty factors have been maintained from previous studies (WINIWARTER & ORTHOFER 2000; CHARLES et al. 1998) and are listed in Table 109. For transport, the respective factors are new and have been taken from an assessment of the overall transport GHG emissions (HAUSBERGER 2005).

Table 109: Uncertainty parameters for fuel combustion activities.

	Fossil solid	Biomass & waste	liquid	Black liquor	Gas
large sources	0.5	5.0*	0.5	–	1.0*
small sources	1.0	10	1.0	10.0	5.0
transport		5.0*	3.0		

* improved expert guess

Uncertainty factors presented account for the generally high quality level of Austrian fuel statistics, which is based on physical measurements (weighing, flow-metering), but data reported in statistics are derived from the respective heat content of fuels. Transformation requires analysis or measurement of the heat content in the fuel. Biomass, waste and black liquor, which are not contained in detail by trade statistics, exhibit a much larger uncertainty.

Emission factors in fuel combustion are also considered to be well-known. CO₂ emissions can be derived from stoichiometry. Carbon content of fuels (within gaseous/liquid/solid fuels, respectively) is largely proportional to its heat content. Thus we estimate uncertainty of the emission factor – separately for solid, liquid and gaseous fuels – at 0.2% to 0.5%. Within these respective fuel classes we consider uncertainty correlated.

Even more interesting is the case of methane. A considerable number of seemingly independent emission factors for different emission situation are available. At closer inspection, however, it appears that data presented by STANZEL et al. (1995) and used in OLI actually derive from HC measurements. The fraction of CH₄ in total HC combustion exhaust has been estimated by ORTHOFER (1991) at 75% in gaseous fuels, 20% in solid fuels and 25% in liquid fuels. As this percentage is what drives overall uncertainty for methane emission factors, we again have to treat gaseous, liquid and solid fuels as dependent (correlated) parameters. As an indicator of overall uncertainty we may refer to CHARLES et al. (1998) who reported 50% for methane from combustion sources. For the transport Sector we use 30% for methane.

For nitrous oxide, emission measurements have been performed by VITOVEC (1991) and resulting uncertainty has been estimated at 20%. This figure has previously been used for Austria, but is not sustainable any more considering the fact that emission factors originally used for an Austrian inventory by ORTHOFER et al. (1995) are now more than 20 years old and refer to a considerably different combustion regime. We now apply 50% (taken from Monni & Syri 2003; see also Ramirez et al. 2006), a figure which we understand to also include uncertainty due to limited knowledge on the fraction of fluidized bed combustion in the installation park. Emission factors reported for nitrous oxide by STANZEL et al. (1991) and used in OLI originally derive from the GEMIS modelling system,

again just one source. Thus they again need to be considered correlated within each fuel class (solid, liquid and gaseous).

3.2.17 Recalculations

This chapter presents the recalculation difference of emissions from fuel combustion activities and its sub categories with respect to the previous submission.

The whole time series of recalculations is included in Annex 8 to the NIR.

3.2.17.1 Revision of energy balance

The federal statistics office “Statistik Austria” revised the energy balance (mainly for the year 2021) with the following **main implications** for energy consumption as used in the inventory and the corresponding CO₂ emissions:

- Natural gas 2021: Gross inland consumption has not been revised. Transformation input has been revised by +0.6 PJ (+33 kt CO₂ for 1.A.1.a). Own use of the energy sector has been revised by +0.4 PJ (+21 kt CO₂ for 1.A.1.c). -1.8 PJ (-97 kt CO₂) of final energy consumption has been subtracted from 1.A.4 and +0.8 PJ (+43 kt CO₂) has been shifted to 1.A.2.
- Gasoil 2021: Gross inland consumption has been revised by -2.2 PJ (-166 kt CO₂), of which -1.1 PJ final energy consumption for 1.A.2 (-84 kt CO₂) and -1.1 PJ for 1.A.4 (-82 kt CO₂).
- LPG 2021: Minor shifts (0.1 PJ) from 1.A.4 and *Transport* to ‘non energy use’.
- Residual fuel oil: 0.7 PJ (59 kt CO₂) has been shifted from 1.A.4 to 1.A.2.
- Coal 2021: Final energy consumption has been revised by -0.1 PJ which results in -16 kt CO₂ for 1.A.4 and + 6 kt CO₂ for 1.A.2.
- Solid biomass 2021: Final energy consumption has been revised by +6.9 PJ, which has been mostly allocated to the residential sector (1.A.4b).
- Industrial waste: Final energy consumption of chemicals industry (1.A.2.c) 2021 has been revised by -0.8 PJ which results to -63 kt CO₂.

3.2.17.2 CO₂ recalculations 1.A

Table 110 shows the recalculations of CO₂ emissions for the subcategories of sector *1.A Fuel Combustion*. Recalculations of CO₂ emissions for 2021 are mainly due to the revision of energy statistics. Recalculations of 1.A.2 CO₂ emissions 2020 are mainly due to improved allocation of ETS industrial waste data.

Table 110: *Recalculation difference of CO₂ emissions in [kt] for Category 1.A Fuel Combustion with respect to previous submission.*

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
1990	-	-	-	-2.4	-	2.4
1995	-	-	-	-1.6	-	1.6
2000	-0.2	-0.2	-	-0.8	-	0.8
2005	0.0	0.0	-	0.0	-	-0.0
2010	-2.7	-	-	0.1	-2.0	-0.9

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
2011	-1.1	-	-	0.3	-	-1.4
2012	-1.5	-	-	0.3	-	-1.8
2013	-1.9	-	-	0.3	-	-2.2
2014	-2.2	-	-	0.4	-	-2.6
2015	-2.6	-	-	0.4	-	-3.0
2016	-3.1	-	-	0.3	-	-3.3
2017	-3.4	-	-	0.4	-	-3.8
2018	-3.8	-	-	0.3	-	-4.1
2019	-4.1	-	-0.2	0.3	0.2	-4.5
2020	62.3	-	66.9	0.3	-0.0	-4.9
2021	-248.8	53.8	-30.0	-10.3	-260.2	-2.1

3.2.17.3 CH₄ recalculations 1.A

Table 111 shows the recalculations of CH₄ emissions for the subcategories of sector *1.A Fuel Combustion*. Minor recalculations were reported for *1.A.4* due to an updated energy demand model for space heating.

Table 111: Recalculation difference of CH₄ emissions in [kt] for Category 1.A Fuel Combustion with respect to previous submission.

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
1990	0.028	-	0.000	-0.000	0.028	0.000
1995	-0.020	-	0.000	0.001	-0.021	0.000
2000	-0.038	-0.000	0.001	0.001	-0.040	0.000
2005	-0.006	0.000	0.000	0.001	-0.007	0.000
2010	0.011	-	0.000	0.001	0.010	-0.000
2011	0.022	-	0.000	0.001	0.020	-0.000
2012	0.027	-	0.000	0.001	0.026	-0.000
2013	0.031	-	0.000	0.001	0.030	-0.000
2014	0.030	-	0.000	0.001	0.029	-0.000
2015	0.032	-	0.000	0.001	0.031	-0.000
2016	0.034	-	0.000	0.000	0.034	-0.000
2017	0.037	-	0.000	0.001	0.036	-0.000
2018	0.048	-	0.000	0.001	0.047	-0.000
2019	0.064	-	0.000	0.000	0.063	-0.000
2020	0.041	-	0.001	0.000	0.040	-0.000
2021	0.603	0.001	-0.010	0.002	0.610	-0.000

3.2.17.4 N₂O recalculations 1.A

Table 112 shows the recalculations of N₂O emissions for the subcategories of sector *1.A Fuel Combustion*. Recalculations of N₂O emissions 2021 are mostly following the revisions o the energy balance.

Table 112: Recalculation difference of N₂O emissions in [kt] for Category 1.A Fuel Combustion with respect to previous submission.

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
1990	0.0004	-	-	-0.0004	-	0.0008
1995	0.0001	-	-	-0.0004	-	0.0006
2000	-0.0001	-0.0000	-	-0.0003	-	0.0002
2005	-0.0000	0.0000	-	-0.0000	-	0.0000
2010	-0.0001	-	-	-0.0002	-0.0000	0.0001
2011	-0.0002	-	-	-0.0003	-	0.0001
2012	-0.0003	-	-	-0.0003	-	0.0000
2013	-0.0004	-	-	-0.0004	-	0.0000
2014	-0.0005	-	-	-0.0005	-	-0.0000
2015	-0.0005	-	-	-0.0004	-	-0.0001
2016	-0.0050	-	-	-0.0050	-	-0.0001
2017	-0.0003	-	-	-0.0001	-	-0.0001
2018	-0.0001	-	-	-0.0000	-	-0.0001
2019	-0.0000	-	-0.0000	0.0001	0.0000	-0.0002
2020	0.0005	-	0.0001	0.0007	-0.0000	-0.0002
2021	0.0243	0.0001	-0.0023	0.0006	0.0260	-0.0000

3.2.17.5 GHG recalculations [kt CO₂e] 1.A

Table 113 shows the recalculations in [kt CO₂ equivalent] for the subcategories of sector 1.A Fuel Combustion. Values smaller than ± 0.005 kt CO₂ equivalent are not displayed.

Table 113: Recalculation difference of GHG emissions in [kt CO₂e] for Category 1.A Fuel Combustion with respect to previous submission.

Year	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5
1990	0.90	-	0.01	-2.50	0.79	2.60
1995	-0.53	-	0.01	-1.74	-0.59	1.79
2000	-1.29	-0.20	0.02	-0.80	-1.12	0.82
2005	-0.15	0.01	0.01	0.05	-0.20	-0.02
2010	-2.42	-	0.01	0.09	-1.69	-0.82
2011	-0.57	-	0.01	0.24	0.57	-1.39
2012	-0.81	-	0.01	0.26	0.72	-1.80
2013	-1.09	-	0.01	0.27	0.85	-2.21
2014	-1.51	-	0.01	0.25	0.82	-2.59
2015	-1.83	-	0.01	0.34	0.87	-3.05
2016	-3.46	-	0.01	-1.05	0.94	-3.36
2017	-2.41	-	-	0.43	1.01	-3.85
2018	-2.45	-	-	0.32	1.33	-4.10
2019	-2.38	-	-0.21	0.39	1.97	-4.54
2020	63.60	-	66.91	0.49	1.12	-4.93
2021	-225.48	53.87	-30.86	-10.15	-236.21	-2.14

3.2.18 Planned Improvements

No improvements are planned.

3.3 Fugitive Emissions (Category 1.B)

Fugitive emissions are intentional or unintentional releases of GHG, which arise during the extraction, processing and delivery of fossil fuels (coal, oil and natural gas) to the point of final use. The fugitive emissions are reported in CRF Category 1.B, whereas emissions from fuel combustion during these processes are reported under CRF Category 1.A.

3.3.1 Emission Trends

In 2022, 0.4% of national total emissions arose from IPCC category 1.B *Fugitive Emissions*. Figure 15 presents GHG emissions arising from this category and the trend from 1990 to 2022.

Figure 15: Greenhouse gas emissions from Category 1.B Fugitive Emissions

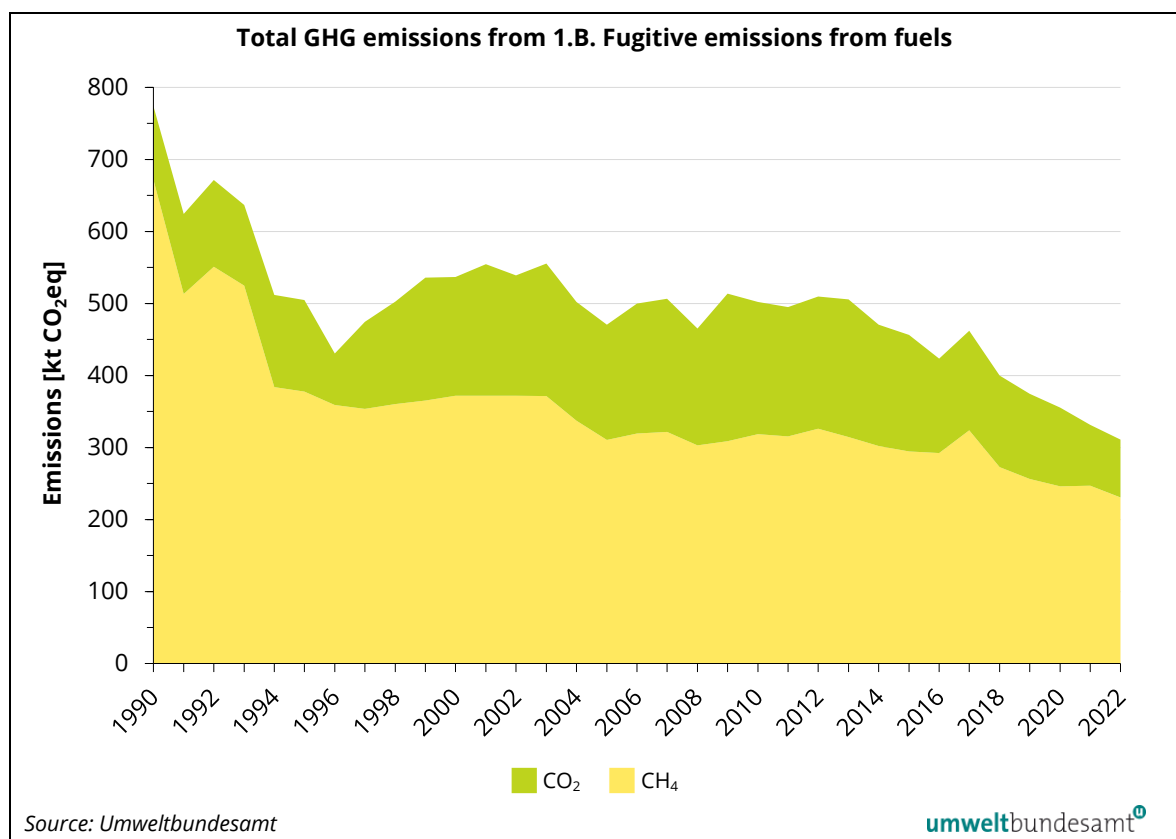


Table 114: Greenhouse gas emissions from Category 1.B Fugitive Emissions

	GHG emissions [kt CO ₂ e]		
	Total	CO ₂	CH ₄
1990	774	102	672
1995	505	127	377
2000	537	165	372
2005	471	160	311
2010	502	184	319
2011	495	180	315
2012	510	184	326
2013	505	191	314
2014	471	169	302
2015	456	162	294
2016	423	131	292
2017	462	138	324
2018	400	127	273
2019	374	118	256
2020	355	109	246
2021	331	84	247
2022	311	80	231
1990–2022	-60%	-21%	-66%

3.3.2 Completeness

Table 115 gives an overview of the IPCC 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. As can be seen in the table, emissions from solid fuel transformation (production of coke oven coke) are included in the energy sector (sub category *Iron and Steel*), because the only solid fuel transformation for production of coke oven coke in Austria is occurring in one coking plant as part of an integrated iron and steel site.

Furthermore, emissions from oil and gas exploration, oil and gas production and gas processing are reported together under gas production (as oil and gas are extracted together at most sites) except CO₂ emissions from sour gas processing, which is reported separately under *1.B.2.b.3 Processing*.

Regarding petroleum refining, all CO₂ emissions, thus including flaring, are reported in the Energy Sector, as these are emissions due to combustion. Fugitive CO₂ losses are considered negligible. In category *1.B* only CH₄ and NMVOC emissions, included venting, are considered.

Table 115: Overview of subcategories of Category 1.B Fugitive Emissions: transformation into SNAP Codes and status of estimation.

IPCC Category	SNAP	Status	
		CO ₂	CH ₄
1.B.1.a Coal Mining and Handling			
i Underground Mines			
1 Mining	050102 Underground mining	NA	✓
2 Post-mining seam gas emissions	050103_X55 Underground mines – Post mining activities	NA	✓
3 Abandoned underground mines	050102_X53 Underground mines – Abandoned mines	NA	NA ¹⁾
4 Flaring of drained methane or conversion of methane to CO ₂		NA	NA
ii Surface Mines			
1 Mining	050101 Open cast mining	NA	✓
2 Post-mining seam gas emissions	050103_X54 Surface mines – Postmining activities	NA	✓
1.B.1.b Solid fuel transformation		IE ²⁾	IE ²⁾
1.B.2.a Oil			
1 Exploration	0502 Extraction, 1 st treatment and loading of liquid fossil fuels	IE ³⁾	IE ³⁾
2 Production and Upgrading		IE ³⁾	IE ³⁾
3 Transport	050601_X50 Oil pipelines	✓	✓
4 Refining	0401 Processes in Petroleum Industries	NA ⁴⁾	✓
5 Distribution of Oil Products	050502 Transport and depots 050503 Service stations	NA	NA ⁵⁾
1.B.2.b Natural Gas			
1 Exploration	0503 Extraction, 1 st treatment and loading of gaseous fossil fuels	NA ³⁾	IE ³⁾
2 Production		✓ ³⁾	✓ ³⁾
3 Processing		✓	NA
4 Transmission and Storage	050601 Pipelines/Storage	✓	✓
5 Distribution	050603 Distribution networks	✓	✓
6 Other		NO	NO
1.B.2.c Venting/Flaring		IE ⁶⁾	IE ⁷⁾
1.B.2.d Other		NA ⁸⁾	NA ⁸⁾

¹⁾ according to an expert judgement all abandoned underground mines in Austria are flooded

²⁾ the production of coke oven coke is included in 1.A.2.a Iron and Steel

³⁾ included in 1.B.2.b.2 are: 1.B.2.a.1 Oil Exploration, 1.B.2.a.2 Oil Production and Upgrading, 1.B.2.b.1 Natural Gas Exploration (CH₄ emissions only, CO₂ emissions are NA), and 1.B.2.b.3 Natural Gas Processing, except CH₄ (NA) and CO₂ emissions from processing of sour gas

⁴⁾ CO₂ emissions due to combustion are included in 1.A.1.b Petroleum Refining, fugitive CO₂ emissions are assumed to be negligible

⁵⁾ also includes storage in storage tanks and refinery dispatch station – only NMVOC emissions are estimated as CH₄ emissions are assumed to be negligible.

⁶⁾ included in 1.A.1.b Petroleum Refining

⁷⁾ included in 1.B.2.a.iv Refining/Storage

⁸⁾ fugitive emissions from geo thermal energy are assumed to be negligible

3.3.3 Methodological Issues

Category *1.B.1.a* Fugitive Emissions from Fuels – Coal Mining covers methane emissions from one brown coal surface mine and underground mines, and is calculated applying a Tier 1 methodology. Fugitive Emissions from oil and gas (*1.B.2.a* and *1.B.2.b*) are calculated using an IPCC Tier 1 methodology except *1.B.2.b.4* (Transmission and Storage) and *1.B.2.b.5* (Distribution) which are calculated applying a Tier 2 methodology, or are reported by the *Association of the Austrian Petroleum Industry*. About 70% of CH₄ emissions for category *1.B.2.b* were estimated using a tier 2 method (2022).

3.3.3.1 1.B.1 Solid fuels

1.B.1.a Fugitive Emissions from Fuels – Coal Mining

Key category: yes (CH₄; LA 1990)

1.B.1.a.i Underground mines

Emissions: CH₄

This category addresses methane emissions from mining and post-mining seam gas activities of brown coal underground mines. CH₄ emissions from mining as well as seam gas from post-mining activities decreased by 97% from 1990 to 1995 due to lower mining activities until it was stopped in 1995.

Mining

Emissions from underground mines (*1.B.1.a.i.1 Mining*) are calculated by multiplying the amount of coal produced (= activity data) with the IPCC 2006 Guidelines average default emission factor of 18 m³ CH₄/t and using the conversion factor of 0.67x10⁻⁶ kt/m³. Activity data are taken from the national energy balance.

Post mining seam gas emissions

Post-mining methane emissions from underground mining (*1.B.1.a.i.2*) are calculated – according to the IPCC 2006 Guidelines – by multiplication of the underground coal production with the average default emission factor of 2.5 m³ CH₄/t and the conversion factor of 0.67x10⁻⁶ kt/m³.

Table 116: Activity data (brown coal produced) and CH₄ emissions from mining and post mining activities for Fugitive Emissions from underground mines since 1990

Year	Coal Mined [t]	CH ₄ emissions from mining [kt]	CH ₄ emissions from post-mining seam gas emissions [kt]
1990	870 403	10.50	1.46
1991	422 350	5.09	0.71
1992	478 095	5.77	0.80
1993	396 549	4.78	0.66
1994	82 625	1.00	0.14
1995	26 713	0.32	0.04
1996 onwards	NO	NO	NO

1.B.1.a.ii Surface mines

Emissions: CH₄

This category addresses methane emissions from one brown coal surface mine. CH₄ emissions from this category decreased by almost 30% from 1990 to 1999 due to lower mining activities. Before coal mining was stopped in 2007 emissions decreased sharply between 2003 and 2004 (80%), see Table 117.

Mining

Emissions from brown coal surface mines (*1.B.1.a.ii.1 Mining*) are calculated by multiplying the amount of brown coal produced (= activity data) by the IPCC 2006 Guidelines average default emission factor of 1.2 m³ CH₄/t coal and using the conversion factor of 0.67x10⁻⁶ kt/m³. Activity data are taken from the national energy balance and statistical year books (WKÖ 2005, WKÖ 2006).

Post mining seam gas emissions

Post-mining methane emissions from surface mining (*1.B.1.a.ii.2*) are calculated – according to the IPCC 2006 Guidelines – by the multiplication of the surface coal production with the average default emission factor of 0.1 m³/t and the conversion factor of 0.67x10⁻⁶ kt/m³.

Activity data are taken from the national energy balance and statistical year books (e.g. WKÖ 2005, WKÖ 2006).

Table 117: Activity data (brown coal produced) and CH₄ emissions from mining and post mining activities for Fugitive Emissions from surface mines since 1990

Year	Coal Mined [t]	CH ₄ emissions from mining [kt]	CH ₄ emissions from post-mining seam gas emissions [kt]
1990	1 577 307	1.27	0.11
1995	1 270 718	1.02	0.09
2000	1 248 869	1.00	0.08
2001	1 205 618	0.97	0.08
2002	1 411 819	1.14	0.09
2003	1 152 383	0.93	0.08
2004	235 397	0.19	0.02
2005	6 168	0.00	0.00
2006	6 677	0.01	0.00
2007 onwards	NO	NO	NO

3.3.3.2 1.B.2 Oil and natural gas

3.3.3.2.1 1.B.2.a Fugitive Emissions from Fuels – Oil

Emissions: CH₄, CO₂

Key Source: No

In this category, fugitive emissions from oil refining (CH₄) and CO₂ and CH₄ emissions from crude oil transport are considered. CO₂ emissions from the refinery resulting from combustion processes (including flaring) are included in *1.A.1.b Petroleum Refining*.

CH₄ emissions contribute 99.9% to GHG emissions from 1.B.2.a. In 2022 fugitive CH₄ and CO₂ emissions from oil contributed 0.01% to total greenhouse gas emissions in Austria.

Transport

Both CH₄ and CO₂ emissions from transport are calculated by using the IPCC Tier 1 methodology, applying the emission factors from Table 4.2.4 of the IPCC 2006 Guidelines.

To calculate CH₄ emissions from this source, the default emission factor of the IPCC 2006 Guidelines of 5.4×10^{-6} kt CH₄ per 1 000 m³ oil transported by pipeline is used. For the calculation of CO₂ emissions, the IPCC 2006 default emission factor of 4.9×10^{-7} kt CO₂ per 1 000 m³ oil transported in pipelines is applied.

The amount of transported crude oil in pipelines (= activity data) is reported annually by the *Association of the Austrian Petroleum Industry* (FVMI 2023).

Refining

Methane emissions from refining are calculated using the IPCC Tier 1 methodology.

For the calculation an emission factor of 31.66 g CH₄/t crude oil input is used. It is in the range of default emission factors in the IPCC Guidelines between 2.6×10^{-6} and 41.0×10^{-6} kt per 10³ m³ oil refined. The conversion from kt per 10³ m³ to g per t was calculated with a density for crude oil of 840 kg/m³. This emission factor is assumed to be conservative since crude oil is being transported by pipeline and, therefore, it is stored for a short period only, which reduces the potential to release fugitive CH₄ emissions compared to the processes represented by the IPCC default emission factors. Further, high standards for the recovery of fugitive CH₄ emissions in accordance with the Austrian Best Available Technology regulations are implemented.

Emissions are then calculated by multiplying the amount of crude oil input (= activity data, taken from the national energy balance) by this converted emission factor of 31.66 g CH₄ /t crude oil.

Table 118: Activity data (Crude Oil Refined) and emissions for Fugitive Emissions from Fuels – Oil Transport and Refining 1990–2022

Year	Crude Oil Refined [kt]	Transport CH ₄ [kt]	Refining CH ₄ [kt]
1990	7 952	0.051	0.252
1995	8 619	0.055	0.273
2000	8 240	0.055	0.261
2005	8 743	0.057	0.277
2010	7 719	0.053	0.244
2011	8 170	0.057	0.259
2012	8 349	0.058	0.264
2013	8 584	0.059	0.272
2014	8 435	0.059	0.267
2015	8 853	0.060	0.280
2016	8 184	0.057	0.259
2017	8 064	0.057	0.255
2018	8 970	0.062	0.284
2019	9 124	0.064	0.289
2020	8 168	0.055	0.259

Year	Crude Oil Refined [kt]	Transport CH ₄ [kt]	Refining CH ₄ [kt]
2021	8 243	0.053	0.261
2022	5 617	0.037	0.178
1990–2022	-29%	-27%	-29%

3.3.3.2.2 1.B.2.b Fugitive Emissions from Fuels – Natural Gas

Emissions: CH₄, CO₂

Key Source: yes (CH₄)

In this category CO₂ emissions from sour gas processing, CH₄ emissions from gas storage and CO₂ and CH₄ emissions from oil and gas exploration, production and processing and gas transmission (i.e. transport in pipelines >6 bar MOP⁶⁴) and distribution (i.e. distribution to end consumer in pipelines <6 bar MOP) are covered.

In 2022 fugitive CH₄ and CO₂ emissions from *1.B.2.b natural gas* contributed 0.4% to total greenhouse gas emissions in Austria.

CH₄ emissions from *1.B.2.b* contributes 74% to total GHG emissions from this category (2022), with *1.B.2.b.4* (transmission & storage) as the main sub-category (52% share in *1.B.2.b*). CH₄ emissions from *1.B.2.b* decreased by 23% between 1990 and 2022 due to decreasing oil and gas produced (*1.B.2.b.2*) and decreased emissions from distribution (*1.B.2.b.5*). Although the natural gas distribution network has almost tripled in length since 1990, CH₄ emissions from this source have decreased by 28% during this period due to replacement of old pipelines made of cast iron with high emission factors by pipelines made of plastics with low emission factors (see Table 122). Due to the implementation of technical measures there is only an increase of 70% in CH₄ emissions from storage between 1990 and 2022, although the storage capacity and volume increased by 345% within the same period of time.

CO₂ emissions from *1.B.2.b* contributes 26% to total GHG emissions from this category (2022), and mainly arise from combined oil and gas production and sour gas processing; the general trend is decreasing due to declining oil and gas production. The exceptional low CO₂ emissions in 1996 in natural gas processing (land based desulfuration, see Table 123) was due to a break in processing during the implementation of pollution control measures. The drop of 36% of raw gas throughput in 2016 was due to the failure of one sour gas tube in one plant. Natural gas transmission and distribution are only minor sources of CO₂ emissions.

According to information from the *Austrian Oil and Gas Association*, flaring at the only refinery in Austria does not take place on a regular basis but is usually limited to unplanned shutdowns or emergency cases as a safety system. Therefore, CO₂ emissions from this source are very low. As described in chapter 3.2.10.2 *1.A.1.b Petroleum Refining* fugitive CH₄ emissions from category *1.B.2.a Fugitive Emissions from Fuels – Oil – Refining/storage* are reported in category *1.A.1.b* which includes emissions from fuel combustion, flaring and thermal cracking. The installation is included in the EU ETS. According to the Commission Regulation (EU) No 601/2012, Annex IV, emissions from flaring are included in the reported ETS emission data. The emission factors and caloric value of flared gas are based on analysis and the activity data are measured.

⁶⁴ Maximum Operating Pressure

It has to be noted that there is only one refinery in Austria and separate reporting of emissions from flaring could enable drawing conclusions about the operating conditions in this refinery and this would cause a confidentiality issue. ETS data gained for inventory purpose is in general considered confidential, and emissions are only reported in aggregated form as provided by the operators. Thus 'IE'⁶⁵ is used for the reporting of emissions from flaring together with all other components from this source.

There are several legal bases that consider the protection of personal and company-related data:

- The protection of confidentiality is e.g. one of the fundamental principles of national statistical agencies (NSA), committing them⁶⁶ “to safeguarding information that plainly reveals the operations, belongings, attitudes or any other characteristics of individual respondents”.
- The Federal Statistics Act⁶⁷ prohibits the evaluation and publication of data in a manner that allows conclusions on characteristics of persons or individual operators.
- Confidential transfer of emissions data e.g. is regulated in the Commission Implementing Regulation (EU) 2018/2066⁶⁸, ensuring that “data is only accessible to the party for which it was intended and that no data can be read, written or updated by unauthorised parties”.
- Also the Commission Delegated Regulation (EU) 2019/1122⁶⁹ regulates in Art. 80 the confidential treatment of “all information held in the EUTL and the Union Registry”.

As we use plant specific data of individual operators provided by the Austrian statistical agency (“Statistik Austria”) and the Union Registry, we also comply with the related specifications regarding confidentiality and the corresponding principles.

Production

Emissions of *1.B.2.a.1 Oil Exploration*, *1.B.2.b.1 Natural Gas Exploration* (CH₄ emissions only, CO₂ emissions are NA), *1.B.2.a.2 Oil Production*, *1.B.2.b.2 Natural Gas Production* and *1.B.2.b.3 Natural Gas Processing* (except CO₂ emissions from processing of sour gas), are all included in category *1.B.2.b.2 Natural Gas Production*.

The amount of natural gas produced and the related CO₂ emissions from combined oil and gas production are reported annually by the *Association of the Austrian Petroleum Industry* (FVMI 2023), see Table 119.

⁶⁵ The UNFCCC Reporting GL (Ar. 37) state that “Where ‘IE’ is used in an inventory, the Annex I Party should indicate, in the CRF completeness table, where in the inventory the emissions or removals for the displaced source/sink category have been included, and the Annex I Party should explain such a deviation from the inclusion under the expected category, especially if it is due to confidentiality”

⁶⁶ <http://unstats.un.org/unsd/methods/statorg/>

⁶⁷ BGBl. I Nr. 163/1999:

<https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10006095>

⁶⁸ COMMISSION IMPLEMENTING REGULATION (EU) 2018/2066 of 19 December 2018 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council“
[umweltbundesamt.at/Projekte/20000/20690_QS-Inventur/Intern/2_Basisnorm_Gesetze u. Leitfäden/Gesetze, RL, GL, GB, etc. \(fachlich\)/Regulation_EU_2018-2066_engl.pdf](https://umweltbundesamt.at/Projekte/20000/20690_QS-Inventur/Intern/2_Basisnorm_Gesetze_u_Leitfaeden/Gesetze_RL_GL_GB_etc_fachlich/Regulation_EU_2018-2066_engl.pdf)

⁶⁹ COMMISSION DELEGATED REGULATION (EU) 2019/1122 of 12 March 2019 supplementing Directive 2003/87/EC of the European Parliament and of the Council as regards the functioning of the Union Registry“
[umweltbundesamt.at/Projekte/20000/20690_QS-Inventur/Intern/2_Basisnorm_Gesetze u. Leitfäden/Gesetze, RL, GL, GB, etc. \(fachlich\)/Regulation \(EU\) 2019-1122_UnionRegistry_EU-ETS_engl.pdf](https://umweltbundesamt.at/Projekte/20000/20690_QS-Inventur/Intern/2_Basisnorm_Gesetze_u_Leitfaeden/Gesetze_RL_GL_GB_etc_fachlich/Regulation_EU_2019-1122_UnionRegistry_EU-ETS_engl.pdf)

CH₄ emissions from oil and gas production are calculated applying a IPCC Tier 1 method with an aggregate production-based emission factor of 0.0026 t CH₄/t oil and gas produced (OGP Tier 1 EF from: THE OIL INDUSTRY INTERNATIONAL EXPLORATION & PRODUCTION FORUM 1994) and national production data annually received by the *Association of the Austrian Petroleum Industry*.

Activity data on natural gas produced is reported by the *Association of the Austrian Petroleum Industry* as a total of natural gas and oil gas. Since those two components have a different density an intermediate step to convert data from m³ to tonnes was introduced based on assumptions on the composition of raw gas, derived from the annual reports of the Austrian Petroleum Industry (FVMI 2000–2023).

Table 119: Activity data (natural gas produced) and emissions for Fugitive Emissions from Fuels – Production 1990–2022

Year	Production				
	Natural Gas produced [Mio m ³]	Oil produced [1 000 t]	CH ₄ [kt]	CO ₂ [kt]	IEF CO ₂ [kg/1 000 m ³]
1990	1 288	1 149	5.77	43	33
1995	1 482	1 035	5.89	38	26
2000	1 805	971	6.41	72	40
2005	1 637	855	5.80	77	47
2010	1 816	876	6.24	91	50
2011	1 684	854	5.86	91	54
2012	1 807	837	6.07	91	51
2013	1 467	846	5.38	103	70
2014	1 247	883	5.02	89	72
2015	1 166	848	4.73	89	77
2016	1 253	753	4.65	84	67
2017	1 742	705	5.54	71	41
2018	969	664	3.82	64	66
2019	891	627	3.56	58	65
2020	743	595	3.16	50	67
2021	655	560	2.90	40	61
2022	483	521	2.43	38	79
1990–2022	-63%	-55%	-58%	-12%	

Natural Gas Processing

Activity data and CO₂ emissions from the processing of natural gas (reported under 1.B.2.b.2) as well as sour gas processing (1.B.2.b.3) are reported by the *Association of the Austrian Petroleum Industry*, the latter calculated from sour gas composition.

Transmission & Storage and Distribution

Detailed information on fugitive CH₄ emissions from natural gas transmission and storage as well as distribution in Austria is included in a national study conducted for the year 1999 (WARTHA 2005). In this study emissions were collected for each transport system, for each storage site and for each distribution system. The study accounted for the different emission sources with the respective emission factors. The study was updated in 2011 (WARTHA 2011) to reflect technical

measures that were implemented to reduce fugitive emissions from the natural gas supply network. For this update, providing data for 2009, a detailed survey and a literature review were performed.

Fugitive CH₄ emissions from **gas transmission** (1.B.2.b.4), i.e. from the transport of natural gas in pipelines under high pressure, covering long-distance pipelines as well as other high pressure pipelines >6 bar MOP, mainly result from compressors, connections, pneumatic aggregates, venting and accidental releases. Fugitive emissions due to diffusion through pipeline material are small because in Austria the material used is nearly 100% insulated steel. Detailed information on the main emission sources could be obtained for 1999 and 2009 thus the same approach as for storage emissions was chosen applying a Tier 2 approach for emission calculation. The country-specific emission factor was developed using the results of the detailed bottom-up approach (WARTHA 2005, WARTHA 2011) and relating them to the total length of the pipeline system. The developed EFs equal to 495 kg (based on WARTHA 2005) and 386 kg (based on WARTHA 2011) CH₄ per km pipeline and year for 1999 and 2009 respectively. The lower emission factor in 2009 is due to technical improvements such as recompression and smart plug and the exchange of gas-pneumatic to electric valves. It was assumed that the technical improvements to reduce fugitive emissions from gas transmission were made continuously, thus interpolation was done to derive emission factors for 2000-2008.

The annual pipeline length is annually provided by the Austrian Natural Gas and District Heat Association (FVGW 2023).

Fugitive CH₄ emissions from **gas storage** (1.B.2.b.4) mainly result from storage sensors, compressors, separators and venting. As the information on these emissions is limited to the years 1999 and 2009 (WARTHA 2005, WARTHA 2011) and no detailed information could be collected for the other years a country-specific emission factor was developed based on the bottom-up emission calculation described in the national study. The amount of gas injection and withdrawal was given as reference in the national study (WARTHA 2005) and was considered to be appropriate as emissions are directly related to the amount of gas handled. The 1999 and 2009 emissions from storage as compiled in the national studies were divided by the mean value of the annual amount of gas injection and withdrawal for the year 1999 and 2009 respectively. The resulting EFs equal to 541 kg CH₄ per Nm³ natural gas for 1999 and 207 kg CH₄ per Nm³ natural gas for 2009.

The lower emission factor in 2009 is due to technical improvements such as the exchange of valves and the reduction of gas that is released to the atmosphere during tests. It was assumed that technical improvements to reduce fugitive emissions from gas storage have been made continuously since the year that was assessed in the original study (WARTHA 2005), thus interpolation between the emission factor from (WARTHA 2005) and (WARTHA 2011) was done to derive annual emission factors for 2000-2008.

The emission factors were then applied to the respective mean value of the annual amount of gas injection and withdrawal for all years thus the method applied equals to a Tier 2 methodology.

Activity data is taken from the Austrian Energy Regulator E-Control (E-CONTROL 2023a).

Table 120: Activity data and emissions for 1.B.2.b.4 Fugitive Emissions from Fuels – Natural Gas Transmission and Storage 1990–2022

Year	Natural Gas Transmission (Pipelines Fugitive & Venting)			Natural Gas Storage	
	Pipelines	CH ₄ Emissions	CO ₂ Emissions	Natural Gas Stored	CH ₄ Emissions
	[km]	[kt]	[kt]	[Mm ³]	[kt]
1990	3 628	1.79	0.09	1 500	0.81
1995	5 972	2.95	0.15	1 820	0.99
2000	5 966	2.89	0.15	1 665	0.85
2005	6 290	2.70	0.15	1 828	0.62
2010	6 798	2.62	0.17	3 070	0.64
2011	6 983	2.69	0.17	3 850	0.80
2012	7 109	2.74	0.17	4 449	0.92
2013	7 177	2.77	0.18	5 747	1.19
2014	7 227	2.79	0.18	5 334	1.10
2015	7 242	2.79	0.18	5 317	1.10
2016	7 231	2.79	0.18	5 519	1.14
2017	7 250	2.80	0.18	6 745	1.40
2018	7 248	2.80	0.18	6 168	1.28
2019	7 231	2.79	0.18	4 669	0.97
2020	7 230	2.79	0.18	5 100	1.06
2021	7 203	2.78	0.18	6 668	1.38
2022	7 196	2.78	0.18	6 714	1.39
1990–2022	+98%	+55%	+98%	+348%	+71%

The natural **gas distribution** (1.B.2.b.5) system consists of pipelines working under medium and low pressure (<6 bar MOP) supplying the end-consumer. Fugitive emissions from natural gas distribution mainly result from diffusion through the pipelines and emission factors largely depend on the pipeline material (see Table 121). Small emission sources are also connections to dwellings, pressure regulating valves and accidental releases.

CH₄ emissions were calculated applying a Tier 2 approach. Specific distribution pipeline lengths separated by material are provided annually by the Austrian Natural Gas and District Heat Association (FVGW 2023), which are then multiplied with material specific emissions factors taken from a national study (WARTHA 2005). As the updated study (WARTHA 2011) does not provide detailed emission data per pipeline material the same emission factors (based on WARTHA 2005) are applied for the whole time series.

For calculation of CO₂ emissions from distribution of natural gas (1.B.2.b.5) the same ratio of CH₄ to CO₂ was applied as also in category transmission of natural gas (1.B.2.b.4).

Table 122 gives an overview of the development of the structure of the gas distribution network in Austria since 1990. Specific annual information on the smaller emission sources except connections to dwellings were not available thus these emissions were kept constant at the rate of 69 t CH₄. Nevertheless the uncertainty introduced by this approach is small because these small emission sources contribute less than 5% to the total emissions from natural gas distribution in Austria.

Table 121: Emission factors applied for the gas distribution network.

Gas distribution network	Emission factors
Material	[kg CH ₄ /km and year]
Insulated steel	25
Plastics (HDPE PVC)	13
Ductile cast iron	701
Grey cast iron	892

Table 122: Structure of the gas distribution network.

Year	Length of gas distribution network				
	Insulated steel	Plastics (HDPE PVC)	Ductile cast iron	Grey cast iron	Total
	[km]	[km]	[km]	[km]	[km]
1990	2 881	6 368	2 213	210	11 672
1995	3 384	12 270	1 925	183	17 762
2000	3 746	18 501	1 720	118	24 086
2005	3 566	21 778	1 522	89	26 955
2010	3 532	23 645	1 516	18	28 711
2011	3 523	23 935	1 531	13	29 002
2012	3 499	24 196	1 515	9	29 220
2013	3 488	24 494	1 489	5	29 476
2014	3 488	24 850	1 467	3	29 808
2015	3 454	25 131	1 462	2	30 048
2016	3 452	25 307	1 436	2	30 197
2017	3 537	25 541	1 411	2	30 490
2018	3 394	25 289	1 389	1	30 073
2019	3 377	25 521	1 364	1	30 263
2020	3 359	25 855	1 339	0	30 553
2021	3 349	25 917	1 311	0	30 577
2022	3 325	26 050	1 283	0	30 658
1990-2022	+15%	+309%	-42%	-100%	+163%

Table 123: Activity data and emissions for 1.B.2.b.5 Natural Gas Distribution and 1.B.2.b.3 Sour Gas Processing 1990–2022

Year	Natural Gas Distribution			Sour Gas Processing	
	Gas network	CH ₄ Emissions	CO ₂ Emissions	Crude gas throughput	CO ₂ Emissions
	[km] ⁷⁰	[kt]	[kt]	[1 000 m ³]	[kt]
1990	11 672	1.99	0.07	248 090	59
1995	17 778	1.85	0.07	405 638	89
2000	24 099	1.73	0.07	358 357	93
2005	26 958	1.63	0.08	338 349	83
2010	28 733	1.58	0.08	397 132	92
2011	29 023	1.60	0.08	375 168	88
2012	29 260	1.58	0.08	375 420	92

⁷⁰ Including “other material” not further defined in the statistics.

Year	Natural Gas Distribution			Sour Gas Processing	
	Gas network	CH ₄ Emissions	CO ₂ Emissions	Crude gas throughput	CO ₂ Emissions
	[km] ⁷⁰	[kt]	[kt]	[1 000 m ³]	[kt]
2013	29 496	1.56	0.07	335 874	88
2014	29 826	1.55	0.07	307 475	79
2015	30 067	1.55	0.07	279 102	72
2016	30 215	1.53	0.07	179 474	47
2017	30 507	1.52	0.06	252 837	67
2018	30 089	1.50	0.07	237 622	63
2019	30 279	1.48	0.07	227 559	60
2020	30 569	1.47	0.07	219 605	59
2021	30 591	1.45	0.06	159 693	44
2022	30 670	1.43	0.06	151 733	42
1990–2022	+163%	-28%	-11%	-39%	-29%

3.3.4 Category-specific QA/QC

3.3.4.1 1.B.1 – Coal Mining

An external expert was consulted and confirmed the correctness of the methodology to estimate historical emissions from *1.B.1 Coal mining*.

3.3.4.2 1.B.2. – Oil and natural gas

Before the studies Life Cycle Inventory Austria 2000 – Review (WARTHA 2005) and Life Cycle Inventory „Erdgasbereitstellung Austria – Update 2010 (WARTHA 2011) were used for the Austrian National Inventory, QA checks were made to ensure that the data quality was appropriate. These QA checks included consultations with the Association of Gas- and District Heating Supply Companies. Only after QA checks and consultations were finished and the quality of the data was approved, the data was used for the calculation of the national GHG emissions following the internal QA/QC requirements.

To validate the developed country-specific emission factors, they were compared with gas losses described in the 2006 IPCC Guidelines (Table 4.2.8).

For storage the developed emission factor for 1999 (541 kg CH₄ per Mm³) lies well above the Tier 1 emission factor for Gas Storage (25 kg CH₄ per Mm³ marketable gas) given in the 2006 IPCC GL (Table 4.2.4). Emissions in 2012 equal to 0.02% of the working gas capacity, which is classified as low (0.05%) as in the IPCC 2006 Guidelines.

For transmission the developed EFs (1999: 495 kg CH₄ per km pipeline and year, 2009: 386 kg CH₄ per km pipeline and year) are lower than the range given in the IPCC. Nevertheless, the gas losses in 2012 of 497 m³/km/a are classified between low (200 m³/km/a) and medium (2 000 m³/km/a) in the 2006 IPCC Guidelines.

For distribution the IEFs range between 0.05 and 0.17 t/km/a, this is lower than the range given by IPCC 2006 GL. The mean gas losses of 107 m³/km/a are classified between low (100 m³/km/a) and medium (1 000 m³/km/a) in the IPCC 2006 GL. Material specific emission factors of pipelines are not provided in the IPCC 2006 GL for comparison.

Based on the above-described validation it was concluded that the developed country-specific EFs are reasonable.

3.3.5 Uncertainty Assessment

For 1.B.2.b Natural Gas – CH₄ an uncertainty estimate was made that was calculated from the combination of estimated uncertainties of the sub-sources.

Transmission: Pipeline length (medium and high pressure) is provided by the Austrian Natural Gas and District Heat Association that collects these numbers directly from the operators. The associated uncertainty is assumed to be low (5%). The uncertainty of the country-specific EF is estimated to be very accurate for the year that was under investigation, but the uncertainty for other years is assumed to be higher (10%).

Storage: The amount of natural gas injected and withdrawn from the storage sites is well known (uncertainty 5%). For the uncertainty of the country-specific EF the same assumption as for transmission was applied (uncertainty 10%).

Distribution: The length of distribution pipelines is directly obtained from the operators. Kilometres by material are provided, thus the uncertainty is considered to be low (4%). Emission factors are material specific and from international literature, thus the associated uncertainty is assumed to be low (7%).

This leads to the combined uncertainty (using the Tier 1 approach, with weights for the contribution to total source emissions) of 5% for AD, 10% for EF, resulting in a total uncertainty of emissions of 11%.

3.3.6 Recalculations

No recalculations are reported in this years' submission.

3.3.7 Planned improvements

To increase transparency of reporting, it is planned to disaggregate emission data currently reported under category 1.B.2.b.2 into sub-categories 1.B.2.a.2 and 1.B.2.b.2 from the submission 2025 onwards.

In order to improve the inventory on natural gas transmission and storage (1.B.2.b.4) as well as distribution (1.B.2.b.5) a service contract was awarded to an Austrian research institute (Forschung Burgenland GmbH) to collect emissions and other relevant data via a comprehensive survey among the Austrian gas supply network. It is planned to implement the study results in the 2025 inventory submission.

3.4 CO₂ transport and storage (Category 1.C)

CO₂ transport and CO₂ storage is not occurring in Austria.

4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF SECTOR 2)

4.1 Sector Overview

This chapter includes information on and descriptions of methodologies used for estimating greenhouse gas emissions as well as references for activity data and emission factors reported under IPCC Sector 2 *Industrial Processes and Product Use (IPPU)* for the period from 1990 to 2022.

Emissions from this category comprise emissions from the following sub categories: *Mineral Industry, Chemical Industry, Metal Industry, Non-energy products from fuels and solvent use, Electronic Industry, Product uses as substitutes for ODS and Other product manufacture and use.*

Only process related emissions are considered in this sector; emissions due to fuel combustion in manufacturing industries are reported in IPCC Category 1.A.2 *Fuel Combustion – Manufacturing Industries and Construction* (see Chapter 3). Not all sub sectors for which emissions due to combustion are reported in 1.A.2 additionally emit process specific emissions that would be reported in IPCC Category 2. For the categories *pulp and paper* as well as *food and drink industry* for example the additional (process related) emissions are of biogenic origin, which is why – in line with the guidelines – they are not accounted for.

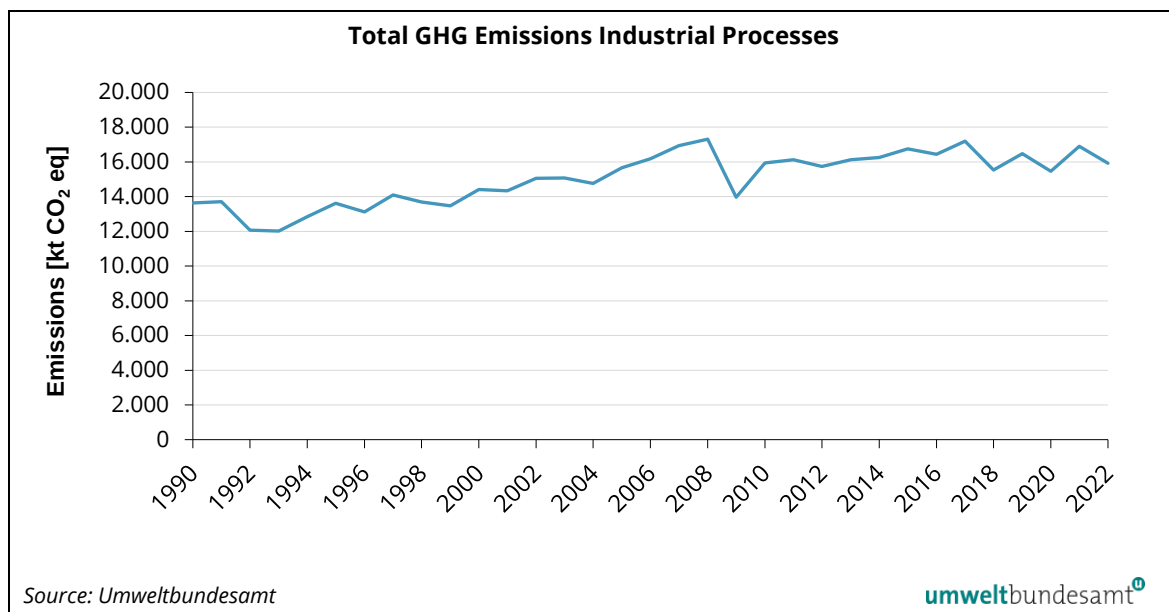
An overview on categories relevant in Austria as well as the status of emission reporting is presented in Table 129

4.1.1 Emission Trends

In 2022, greenhouse gas emissions from Sector 2 *Industrial Processes and Product Use* amounted to 15 929 kt CO₂ equivalent, compared to 13 633 kt CO₂ equivalent in 1990. These emissions constituted 22% of Austria's total greenhouse gas emissions (excluding LULUCF) in 2022 and 17% of total emissions in 1990.

Greenhouse gas emissions from this sector show a long term increasing trend until 2008, and remain quite stable with minor fluctuations after the economic crisis in 2009, with the metal industry being the dominant sub-sector. The minimum in 1992/1993 resulted from the termination of primary aluminium production in Austria. In the following years, emissions increased due to extended activities in the iron and steel industry. The trend 2008-2010 is characterised by the effects of the economic crisis, followed by its recovery. The dip in 2018 is due to revision works at a blast furnace, the one in 2020 due to the Covid pandemic and its effects on production (reduced demand due to production stops in all major customer segments). The most recent dip in 2022 (decrease of 6% compared to 2021) results from reduced production due to increased energy costs caused by the geopolitical situation.

Figure 16: GHG emissions from Sector 2 Industrial Processes and Product Use 1990–2022



The following table presents greenhouse gas emissions from the IPPU sector as well as their share in total greenhouse gas emissions in 1990 and in 2022.

Table 124: GHG emissions from Sector 2 Industrial Processes and Product Use by gas.

GHG	Emissions [kt CO ₂ e]		Trend	Percent of total	
	1990	2022		1990	2022
Total	13 633	15 929	17%	100%	100%
CO ₂	11 140	13 998	26%	81.7%	87.9%
CH ₄	47	60	29%	0.3%	0.4%
N ₂ O	897	55	-94%	6.6%	0.3%
HFCs	2	1 411	68 994%	0.0%	8.9%
PFCs	1 063	26	-98%	7.8%	0.2%
SF ₆	485	365	-25%	3.6%	2.3%
NF ₃	0	14	NA	0.0%	0.09%

Carbon dioxide constitutes the most important greenhouse gas of the IPPU sector, contributing 87.9% of emissions to this sector in 2022, followed by HFCs with 8.9%, SF₆ with 2.3%, CH₄ with 0.4%, N₂O with 0.3%, and PFCs with 0.2% and finally NF₃ with 0.09%.

Table 125: Emissions from IPCC Sector 2 Industrial Processes and Product Use by gas from 1990 to 2022 and overall trend.

	Emissions [kt CO ₂ e]							
	Total	CO ₂	CH ₄	N ₂ O	HFC	PFC	SF ₆	NF ₃
1990	13 633	11 140	47	897	2	1 063	485	NO/NA
1995	13 625	11 189	47	850	324	75	1 134	6
2000	14 417	12 078	48	930	678	80	592	10
2005	15 653	13 509	49	301	1 109	150	509	26
2010	15 938	13 926	58	101	1 434	71	346	4

	Emissions [kt CO ₂ e]							
	Total	CO ₂	CH ₄	N ₂ O	HFC	PFC	SF ₆	NF ₃
2015	16 750	14 386	59	78	1 850	45	319	13
2020	15 461	13 179	59	80	1 650	27	455	11
2021	16 892	14 922	58	74	1 431	23	371	12
2022	15 929	13 998	60	55	1 411	26	365	14
1990–2022	+17%	+26%	+29%	-94%	+68 994%	-98%	-25%	

Concerning sub-categories of the sector, 65% of GHG emissions (expressed in CO₂ equivalent) originate from *Metal Industry* (mainly *Iron and Steel Production*) and 18% from *Mineral Industry*. 8.8% originate from *Product Uses as Substitutes for ODS*, and 4.3% from *Chemical Industry* (mainly *Ammonia Production*).

CO₂ emissions

As can be seen in Figure 17, CO₂ emissions from the *Industrial Processes and Product Use* sector showed a strong increase in the period from 1999 to 2008, mainly due to increasing emissions from metal production. The effect of the economic crisis is strongly visible in 2009. In 2022, CO₂ emissions from industrial processes amounted to 13 998 kt, making up 88% of total emissions from *Industrial Processes and Product Use*. Emissions increased by 26% compared to 1990 levels.

CH₄ emissions

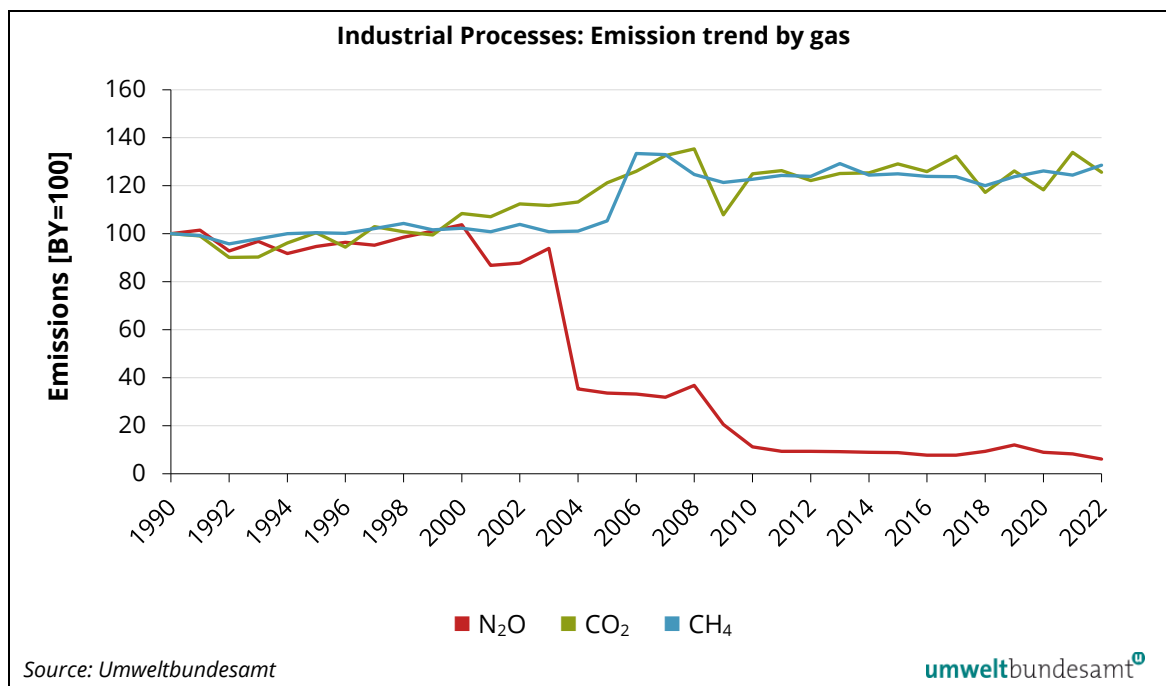
Only 0.4% of IPPU emissions are CH₄ emissions. They arise from *Chemical Industry* (*Production of Ethylene, Urea, Fertilizers and Ammonia*) and *Metal Industry* (*Steel Production*). As can be seen in Figure 17, CH₄ emissions from industrial processes remained quite stable until 2005. The increase in 2006 can be attributed to an increase in ethylene production capacity. In the following years, emissions remained at similar levels and in 2022 were 29% above 1990 levels.

N₂O emissions

N₂O emissions mainly arise from *Nitric Acid Production* (*Chemical Industry*) which in Austria takes place at one site with two (and for some years three) plants. Emissions also arise from the use of N₂O as an anaesthetic and as cream propellant. As can be seen in Figure 17, N₂O emissions remained quite stable until 2000. The decreases since then are due to the introduction of emission control measures in the main emitting process nitric acid production:

- 2001: installation of a new catalyst
- 2004: installation of a N₂O decomposition facility
- 2009 (May): installation of a second catalyst in the nitric acid plant
- 2010: full operation of the second catalyst
- 2011: further optimisation of the production process as well as slightly reduced production

In 2022, N₂O emissions from *Industrial Processes* were 94% below the level of 1990, and now only contribute 0.4% of the sectoral emissions.

Figure 17: CO₂, CH₄ and N₂O emissions from Industrial Processes 1990–2022 (base year = 100)

HFC emissions

As can be seen in Figure 18, HFC emissions increased remarkably during the period from 2 kt CO₂ equivalents in 1990 to 1 411 kt CO₂ equivalents in 2022 due to the use of these gases as substitutes for ozone depleting substances. HFC emissions mainly arise from the subcategory *Refrigeration and Air Conditioning*. Other important (sub-) categories include *Foam Blowing Agents* and *Electronics Industry*.

Because of the significant second step of the phase-down according to the EU F-gas regulation HFC emissions peak 2018 and have been decreasing since then.

PFC emissions

As can also be seen in Figure 18, PFC emissions decreased remarkably during the period from 1990 to 1993 – from 1 063 kt CO₂ equivalents to 26 kt CO₂ equivalents – due to the termination of primary aluminium production in 1992 which was the major source for PFC emissions. From 1993 onwards, PFC emissions solely arise from semiconductor manufacture, where a strong increase in production capacity was partly counterbalanced by emission reduction measures.

In 2022, PFC emissions amounted to 26 kt CO₂ equivalents, which is 98% below the level of 1990.

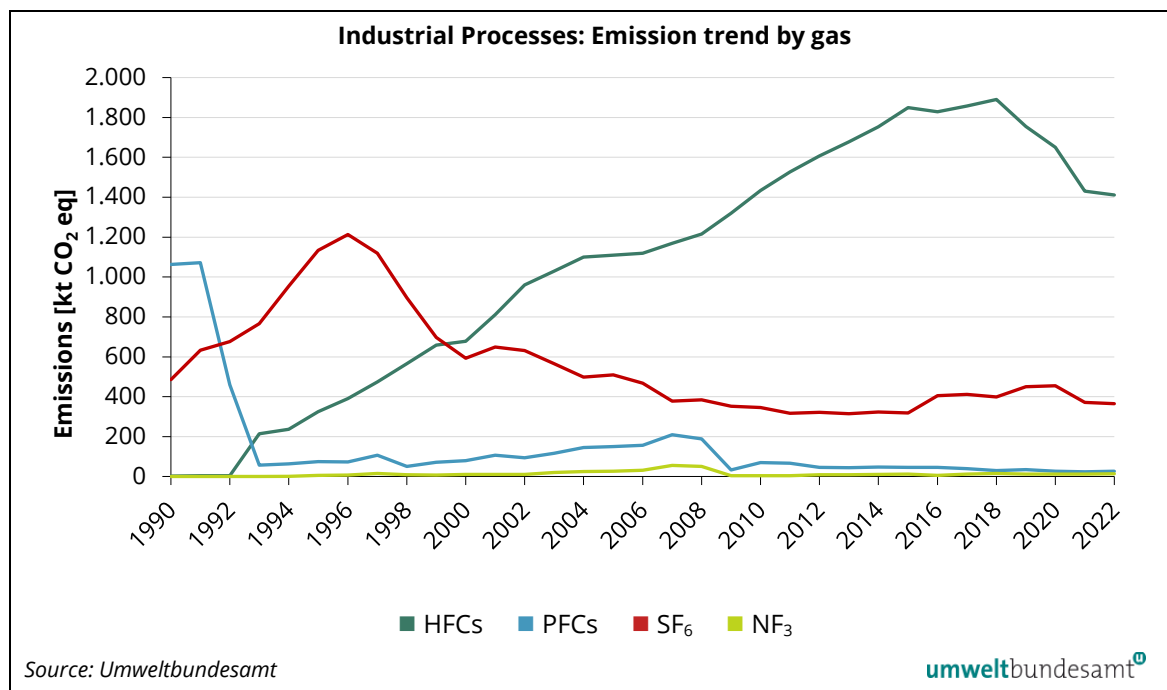
SF₆ emissions

As depicted in Figure 18, SF₆ emissions increased at the beginning of the reporting period and reached a maximum in 1996 as a result of increasing emissions from metal production and semiconductor manufacture, which decreased in the subsequent years. Current emissions mainly result from disposal of noise insulating windows. In 2022, SF₆ emissions amounted to 365 kt CO₂ equivalents corresponding to a reduction of 25% compared to the 1990 level.

NF₃ emissions

NF₃ emissions solely arise from semiconductor manufacture. NF₃ was first introduced to the Austrian market in 1994. In 2022, NF₃ emissions amounted to 14 kt CO₂ equivalents.

Figure 18: HFC, PFC, SF₆ and NF₃ emissions from Industrial Processes 1990–2022



Emission trends by sources

The main sources of greenhouse gas emissions in the industrial processes sector are *Metal Industry* and *Mineral Industry*, causing 65% and 18% respectively, of the emissions from this sector in 2022 (see Table 126).

Emissions from processes in *Iron and Steel Production* are the most important single source of the industry sector. It is also one of the ten most important sources regarding Austria's total greenhouse gas emissions (see below and Chapter 4.4.1).

Table 126: Greenhouse gas emissions from IPCC Sector 2 Industrial Processes and Product Use by Category, their share and trend for 1990 and 2022.

	Emissions [kt CO ₂ e]		Share [%]		Trend 1990–2022
	1990	2022	1990	2022	
2 Industrial Processes	13 633	15 929	100%	100.0%	17%
A Mineral Industry	3 131	2 918	23%	18.3%	-6.8%
B Chemical Industry	1 464	677	11%	4.3%	-54%
C Metal Industry	8 304	10 315	61%	64.8%	24%
D Non-Energy Products from Fuels and Solvent Use	349	172	2.6%	1.1%	-51%
E Electronics Industry	133	55	1.0%	0.3%	-58%
F Product Uses as Substitutes for ODS	-	1 409	-	8.8%	NA
G Other Product Manufacture and Use	252	382	1.9%	2.4%	51%

Figure 19 and Table 127 present greenhouse gas emissions from IPCC Sector 2 *Industrial Processes and Product Use* by category for the years 1990 to 2022.

Figure 19: Greenhouse gas emissions from IPCC Sector 2 *Industrial Processes and Product Use* per category 1990–2022

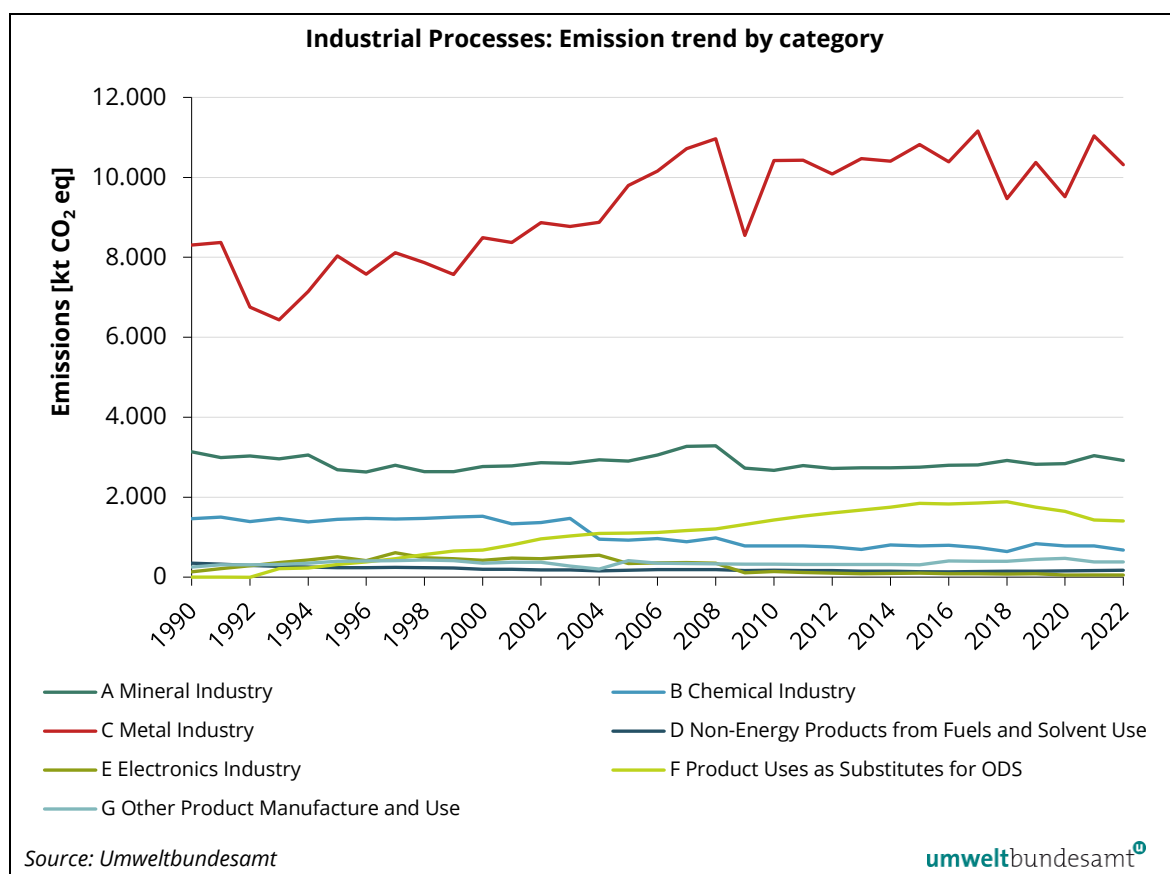


Table 127: Greenhouse gas emissions from IPCC Sector 2 *Industrial Processes* (total and per category), 1990–2022.

Year	GHG emissions [kt CO ₂ e]							2 total
	2.A	2.B	2.C	2.D	2.E	2.F	2.G	
1990	3 131	1 464	8 304	349	133	NO	252	13 633
1995	2 690	1 448	8 033	234	512	315	394	13 625
2000	2 766	1 523	8 489	198	420	674	346	14 417
2005	2 901	922	9 800	174	342	1 105	409	15 653
2010	2 671	778	10 420	169	144	1 432	325	15 938
2011	2 794	782	10 429	168	113	1 525	319	16 130
2012	2 718	756	10 082	160	97	1 605	314	15 732
2013	2 732	693	10 468	151	86	1 676	315	16 122
2014	2 731	808	10 407	146	93	1 751	313	16 248
2015	2 752	779	10 823	135	102	1 848	311	16 750
2016	2 796	799	10 387	136	88	1 827	405	16 437
2017	2 807	741	11 159	144	87	1 854	399	17 191
2018	2 918	640	9 469	147	78	1 886	397	15 535

Year	GHG emissions [kt CO ₂ e]							
	2.A	2.B	2.C	2.D	2.E	2.F	2.G	2 total
2019	2 825	836	10 375	149	85	1 752	448	16 470
2020	2 838	779	9 518	155	54	1 648	470	15 461
2021	3 041	784	11 039	162	53	1 428	383	16 892
2022	2 918	677	10 315	172	55	1 409	382	15 929

2.A Mineral Industry

Greenhouse gas emissions from this category remained quite stable over the period, with an overall decrease of 6.8% from 1990 to 2022, and effects of the economic crisis 2009 clearly visible. The dominating sub category in total emissions and trend is *Cement Production*, other important subcategories are *Lime Production* with increasing and *Other Process Uses of Carbonates: Non-metallurgical Magnesium* with decreasing emissions over the considered period. Only CO₂ emissions arise from this category.

2.B Chemical Industry

For the source category *Chemical Industry*, greenhouse gas emissions remained quite stable over the period from 1990 to 2003, with nitric acid production as the main emission source (53% in 1990). Due to the implementation of emission reduction measures, ammonia production is now the main emitter, contributing 72% to total emissions from this category in 2022. Another 22% are contributed by emissions from the sub category “Other”, which mainly comprises of CO₂ emissions from organic chemical industry production. Minor sources in 2022 include nitric acid, carbide and ethylene production.

In 2022, emissions were 54% below the level of 1990.

2.C Metal Industry

Greenhouse gas emissions from *Metal Industry* fluctuated over the reporting period, which is mainly a result of a drop in PFC emissions from primary aluminium production which was terminated in 1992 and a strong increase in CO₂ emissions from *Iron and Steel Production* (+50%) over the whole time series. Dips in the time series relate to the economic crisis in 2009, a makeover at the iron & steel plant in 2018, the pandemic in 2020 and high energy prices due to the geopolitical situation in 2022.

From 1990 to 2022 emissions increased by 24%. The main source of this category is CO₂ emissions from *Iron and Steel Production*.

2.D Non-energy products from fuels and solvent use

Emissions from non-energy products from fuels and solvent use are 51% below 1990 level. This is due to several legal measures (see chapter 4.4.1) that resulted in a decrease of emissions due to a lower solvent content of solvents in products e.g. paints as well as use of alternatives to solvents, implemented abatement measures and decreased use of lubricants.

2.E Electronic Industry

Emissions from this sector are solely attributed to semiconductor manufacturing, and contain HFC, PFC, SF₆ and NF₃ emissions. Emissions in 2022 are 58% lower compared to 1990, which is due to abatement measures taken by the companies.

2.F Product uses as substitutes for ODS

Emissions from products used as substitutes for ozone depleting substances (ODS) contribute 8.8% to the total emissions of the IPPU sector in 2022. HFCs as substitutes for ODS were introduced in the early 1990 and their use in the expanding refrigeration- air conditioning- and heat pumps- (RACHP) sector and with it emissions from use increased strongly since then.

Because of the significant second step of the phase-down according to the EU F-gas regulation HFC emissions peak 2018 and have been decreasing since then.

2.G Other product manufacture and use

Emissions from this sector contain emissions from the use of electrical equipment, as well as other product manufacture and use (use in tyres, shoes, soundproof windows, research etc.). Emissions in this sector are now 51% higher than in 1990, because high amounts of SF₆ are being released during the disposal of sound proof windows that were produced in the 1990ies.

2.H Other

No GHG emissions are reported in this category.

4.1.2 Methodology

In some categories, emission and production data were reported directly by industry or associations of industries and thus represent plant specific data and for some (e.g. *2.B.1 Ammonia Production*) very detailed methodologies trying to reflect the actual production process is applied.

Detailed information on the methodologies can be found in the corresponding subchapters.

Emission data reported under the European Emission Trading System

Verified CO₂ emissions reported under the EU ETS are available for the years 2005–2021, this data is used for emissions reporting of *2.A.1 Cement Production*, *2.A.2 Lime Production*, *2.A.3 Glass Production*, *2.A.4.a Ceramics*, *2.A.4.c Non Metallurgical Magnesia Production*, *2.A.4.d Other Process Uses of Carbonates*, *2.C.1 Iron and Steel production*. With the extension of the ETS in 2014, data for additional categories became available: *2.B.10 Chemical Industry – Other* and *2.C.3 (Secondary) Aluminium Production*. Special attention was given to time-series consistency. Furthermore, background data for emission calculations under the ETS were used for further QA/QC checks.

4.1.3 Uncertainty Assessment

In this year's submissions uncertainty estimates for all key sources based on the IPCC GL, on the uncertainty study by WINIWARTER (2007) and on estimates by Umweltbundesamt are provided (see Table 128, for explanations see the respective subchapters).

Table 128: Uncertainty assessment of 2022 estimates for key sources of Sector 2 Industrial Processes and Product Use.

IPCC Category	Source Categories	Uncertainty [%]		
		Activity data	Emission factor	Combined Uncertainty
2.A.1	Cement Production – CO ₂	1.0	2.0	2.2
2.A.2	Lime Production – CO ₂	5.0	2.0	5.4
2.A.4.c	Non-metallurgical Magnesium – CO ₂	2.0	2.0	2.8
2.B.1	Ammonia Production – CO ₂	2.0	5.0	5.4
2.B.2	Nitric Acid Production – N ₂ O	2.0	2.0	2.8
2.C.1	Iron and Steel Production – CO ₂	0.5	0.5	0.7
2.C.3	Aluminium Production – CO ₂	20.0	5.0	20.6
2.C.3	Aluminium Production – F-Gases	20.0	50.0	54
2.C.4	Magnesium Production – Mg Foundries – SF ₆	5.0	5.0	7.1
2.D	Non-Energy Products from Fuels and Solvent Use – CO ₂	20	30.0	36
2.F.1	Refrigeration and Air Conditioning Equipment – HFC	10	50.0	51.0
2.G.2	SF ₆ from other product use – SF ₆	25.0	50.0	55.9
2.G	Other Product Manufacture and Use – N ₂ O	20	0	20

4.1.4 Quality Assurance and Quality Control (QA/QC)

For the Austrian Inventory an internal quality management system has been established. The QC procedures defined in the QMS correspond to general QC Tier 1 procedures. For further information see Chapter 1.2.3.

Concerning measurement and documentation of emission data within the EU ETS (Emission Trading System; former Emission Trading Scheme), Commission Decision 2004/156/EC established guidelines for monitoring and reporting of greenhouse gas emissions. This decision provided general guidelines on emission reporting and verification as well as sector specific guidelines on the methodologies to account for process specific CO₂ emissions. These include guidance on calculations and measurements at different level of detail similar to the different Tier methods in the IPCC guidelines. The original Commission Decision was replaced by Commission Decision 2007/589/EC and, most recently, Commission Regulation (EU) No 601/2012.

In Austria, the EU ETS is implemented by specific national regulations: the Austrian Emissions Allowance Trading Act⁷¹ and the Ordinance regarding Monitoring and Reporting of Greenhouse Gas Emissions⁷².

Furthermore most of the plants that report emission data – this includes plants that are not obliged to participate in the EU ETS – have quality management systems in place according to the ISO 9000 series or similar systems.

For the 2024 submission, the uncertainty assessment for the IPPU sector was internally reviewed, and some improvements were implemented.

⁷¹ Emissionszertifikatesgesetz 2011, Federal Law Gazette I No. 118/2011, as amended

⁷² Überwachungs-, Berichterstattungs- und Prüfungsverordnung, Federal Law Gazette II No. 339/2007, as amended

4.1.5 Recalculations

This chapter explains the recalculation performed and informs on the resulting recalculation difference of emissions in the IPPU sector with respect to the previous submission.

The whole time series of recalculations is included in Annex 8 to the NIR.

Consideration of additional sources/processes

2.A.2 Lime Production

For three processes in pulp and paper production reported in the ETS related to limestone production or lime use and PCC production respectively, time series were prepared and emissions and removals were considered in category 2.A.2 *Lime Production* (recalculation difference 2021: - 9.41 kt CO₂).

2.F.1.e Mobile Air Conditioning

Following the recommendation of the 2022 UNFCCC review, an estimate for emissions from air conditioning stock for construction site vehicles was included (recalculation difference 2021 +12.44 kt CO₂e).

Allocation of emissions between subcategories

2.B.1 Ammonia Production / 2.D.3.ii Other: Urea used as a catalyst

Updated urea amounts used in road traffic for 2005 onwards led to a redistribution of minor amounts between these two categories (-0.02 kt CO₂ 2021). Additionally, for the years 1990 – 2019, the recalculation of the time series of CH₄ emissions from 2.B.10.ii *Urea Production* described below affected the reported CO₂ emissions from 2.B.1 *Ammonia Production*.

Methodological improvements

2.B.10.ii Urea Production

An inconsistency in the time series was corrected: values reported by the company for methane emissions until 2019 were based on an assumed raw gas methane content, whereas from 2020 onwards measured data were used. The measured data showed that the methane content for the years until 2019 had been assumed too low. For this submission, emissions until 2019 are calculated using the average IEF of the years 2020-2022 for which measured raw gas composition is available (recalculation difference 2019: +2.09 kt CO₂e).

2.D.3.i Solvent Use

Data on facility level that is prepared by the operators according to the VOC directive were collected and incorporated. During intensive QC of the data, which included comparison with the data of 2015 and 2019, some corrections of the data for 2015 and 2019 were made, leading to a recalculation for most sub-categories from 2015 onwards. Also, corrections on the top down data were made: besides correction of minor transcription errors for the years 2016ff, non-solvent use of a new company became available which was considered for 2021, leading to a decrease of total solvent use in Austria. As bottom up data is extrapolated to this value, this resulted in lower activity data and thus lower emissions for 2021. Overall, the recalculation difference 2021 in this subcategory is -2.95 kt CO₂e.

2.F.1.a Commercial Refrigeration and 2.F.1.d Industrial Refrigeration

A previous double-counting error was identified and corrected. During extensive QA/QC it became obvious that amounts of F-gases placed on the Austrian market reported as import were not imported by the company itself, but bought from an importer. The amounts were therefore already included in the reported amounts for F-gas import of the selling company. This led to a reduction of import data for the years 2011 onwards, affecting the two residual sub-categories *2.F.1.a Commercial Refrigeration* and *2.F.1.d Industrial Refrigeration*.

Also, for supermarkets, which are considered separately in the calculation, an allocation error for one specific refrigerant was corrected, which also affected activity data and emissions from these two sub categories.

Overall, the recalculations led to a reduction of emissions of 68.48 kt CO₂e in 2021.

2.F.1.e Mobile Air Conditioning

For trains, refill data has become available for the years 2014ff and was used instead of calculation of emissions assuming a leakage of 5%. As data showed that the leakage factor was higher than the previously assumed value, the average leakage factor of 2014-2022 was applied for the years before 2014 (recalculation difference 2021: +3.97 kt CO₂e).

2.F.2.a Foam Blowing

The emission factor for 2020 and 2021 was corrected, it was a software generated artefact of extrapolating the methodology to the next year (recalculation difference 2021: -3.47 kt CO₂e).

Update of activity or emissions data*2.C.1.b Steel*

CH₄ emissions for 2021 that previously were extrapolated have been updated (recalculation difference 2021: - 0.11 kt CO₂e).

2.F.1.d Transport refrigeration

Data for 2021 were updated (recalculation difference 2021: - 0.11 kt CO₂e).

2.F.3 Fire protection

Previously, emissions from stock in fire protection units was extrapolated for 2021, now the actual value is used (recalculation difference 2021: + 1.04 kt CO₂e).

2.G.2 Other uses of SF₆ – particle accelerators.

Data for (medical) particle accelerators from 2012 onwards were updated (recalculation difference 2021: + 0.14 kt CO₂e).

4.1.6 Completeness

Table 129 gives an overview of the IPCC 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 129: Overview of subcategories of Sector 2 Industrial Processes and Product Use: transformation into SNAP Codes and status of estimation.

IPCC Category		SNAP		Status		
				CO ₂	CH ₄	N ₂ O
2.A	MINERAL PRODUCTS					
2.A.1	Cement Production	040612	Cement (decarbonising)	✓	NA	NA
2.A.2	Lime Production	040614	Lime (decarbonising)	✓	NA	NA
		040618_X4T	Limestone and dolomite use – carbide			
		040618_X4U	Limestone and dolomite use – PCC			
		040618_X4V	Limestone and dolomite use - desulfurization			
2.A.3	Glass Production	040613	Glass (decarbonizing)	✓	NA	NA
2.A.4	Other Process Uses of Carbonates					
	2.A.4.a Ceramics	040617	Bricks and Tiles (decarbonizing)	✓	NA	NA
	2.A.4.b Other uses of soda ash	040619	Soda ash production and use	✓	NA	NA
	2.A.4.c Non Metallurgical Magnesia Production	040617	Magnesia sinter production	✓	NA	NA
2.B	CHEMICAL INDUSTRY					
2.B.1	Ammonia Production	040403	Ammonia	✓	✓	NA
2.B.2	Nitric Acid Production	040402	Nitric acid	NA ¹⁾	NA	✓
2.B.3	Adipic Acid Production	040521	Adipic acid	NO	NA	NO
2.B.4	Caprolactam, Glyoxal and Glyoxylic Acid Production			NO	NA	NO
2.B.5	Carbide Production					
	2.B.5.a Silicon Carbide			NO	NO	NO
	2.B.5.b Calcium Carbide	040412	Calcium carbide production	✓	NA	NA
2.B.6	Titanium Dioxide Production			NO	NA	NA
2.B.7	Soda Ash Production	040619	Soda ash production and use	NO	NA	NA
2.B.8	Petrochemical and Carbon Black Production					
	2.B.8.a Methanol			NO	NO	NO
	2.B.8.b Ethylene	040501	Ethylene production	IE	✓	NA
	2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer			NO	NO	NO
	2.B.8.d Ethylene Oxide			NO	NO	NO
	2.B.8.e Acrylonitrile			NO	NO	NO
	2.B.8.f Carbon Black			NO	NO	NO
2.B.9	Fluorochemical Production			NO (F-gases)		
2.B.10	Other					
	2.B.10.i CO ₂ from Nitric Acid Production	040402	Nitric acid	✓	NA	NA
	2.B.10.ii Other chemical bulk production	040407	NPK fertilisers	✓	✓	NA
		040408	Urea			
		040527_X4S	CO ₂ from Chemical Products			
2.C	METAL INDUSTRY					
2.C.1	Iron and Steel Production					

IPCC Category		SNAP	Status		
			CO ₂	CH ₄	N ₂ O
2.C.1.a Steel	040206	Basic oxygen furnace steel plant	✓	NA ²⁾	NA
2.C.1.b Pig Iron	040202	Blast furnace charging	IE ³⁾	✓	NA
2.C.1.c Direct Reduced Iron			NO	NO	NO
2.C.1.d Sinter	040209	Sinter and pelletizing plant	IE ³⁾	IE ⁴⁾	NA
2.C.1.e Pellet			NO	NO	NA
2.C.1.f Other: Electric Furnace Steel	040207	Electric furnace steel plant	✓	NA	NA
2.C.2 Ferroalloys Production	040302	Ferro alloys	✓	NA	NA
2.C.3 Aluminium Production	040301	Aluminium Production	✓	NA	NA
2.C.3 Aluminium Production – By-product emissions and Al Foundries			✓ ⁵⁾ (PFC, SF ₆)		
2.C.4 Magnesium Production – Mg Foundries			✓ (SF ₆)		
2.C.5 Lead Production	030307	Secondary Lead production	✓	NA	NA
2.C.6 Zinc Production			NO	NO	NO
2.D	Non-Energy Products from Fuels and Solvent Use				
2.D.1 Lubricant Use			✓	NA	NA
2.D.2 Paraffin Wax Use			✓	NA	NA
2.D.3 Other (Solvent Use)					
2.D.3.1 Solvent use	0601-0604	Solvent and other product use	✓	NA	NA
2.D.3.2 Road paving with asphalt	040611	Road paving with asphalt	NA	NA	NA
2.D.3.3 Roof covering with asphalt materials	040610	Roof covering with asphalt materials	NA	NA	NA
2.E	Electronics Industry		✓ (F-gases)		
2.F	Product Uses as Substitutes for ODS				
2.F.1 Refrigeration and Air Conditioning	060502	Refrigeration and air conditioning equipments	✓ (F-gases)		
2.F.2 Foam Blowing Agents	060504	Foam blowing (except 060304)	✓ (F-gases)		
2.F.3 Fire Protection	060505	Fire extinguishers	✓ (F-gases)		
2.F.4 Aerosols	060506	Aerosol cans	✓ (F-gases)		
2.F.5 Solvents		Solvents	✓ (F-gases)		
2.F.6 Other applications			✓ (F-gases)		
2.G	Other Product Manufacture and Use				
2.G.1 Electrical Equipment			✓ (F-gases)		
2.G.2 SF ₆ and PFCs from Other Product Use			✓ (F-gases)		
2.G.3 N ₂ O from Product Uses	0605		NA	NA	✓
2.G.4 Other			✓	NA	NA
2.H	Other				
2.H.1 Pulp and Paper Industry			NA	NA	NA
2.H.2 Food and Beverages Industry			NA ⁶⁾	NA	NA

¹⁾ CO₂ emissions from nitric acid production are included in the new category "2.B.10.i CO₂ from Nitric Acid Production"

²⁾ reported as "NA" as no default EF is provided in the IPCC 2006 GL

³⁾ Emissions are included in category 2.C.1.a.

⁴⁾ Emissions are included in category 2.C.1.b.

⁵⁾ Primary aluminium production was terminated in 1992.

⁶⁾ CO₂ emissions from this source are of biogenic origin.

4.2 Mineral Products (Category 2.A)

4.2.1 Cement Production (2.A.1)

4.2.1.1 Source Category Description

Emissions: CO₂

Key Source: Yes (CO₂)

In this category, only process specific CO₂ emissions are reported; emissions from combustion are reported in the energy sector (category 1.A.2.f).

CO₂ emissions from 2.A.1 *Cement production* are a key category because of their contribution to the level of the greenhouse gas inventory in 1990 and in 2022. In 2022, they contributed 2.5% to total greenhouse gas emissions in Austria (without LULUCF).

Process specific CO₂ is emitted during the production of clinker (calcination process) when carbonates (mainly CaCO₃) are heated in a cement kiln up to temperatures of about 1 300°C. During this process, calcium carbonate is converted into lime (CaO – Calcium Oxide) and CO₂.

Table 130 presents process-related CO₂ emissions from cement production for the period from 1990 to 2022. To increase transparency (in response to a question in the course of the UNFCCC review 2012), data on raw meal used was incorporated into the table.

Table 130: CO₂ emissions from decarbonising in cement production, clinker production, raw meal used and implied emission factor, 1990–2022

Year	Clinker [t]	Raw meal used [t]	Process specific CO ₂ emissions [kt]	IEF [kg CO ₂ /t Clinker]
1990	3 693 539	5 832 777	2 033	551
1995	2 929 973	4 671 693	1 631	557
2000	3 052 974	4 890 919	1 712	561
2005	3 221 167	5 148 317	1 797	558
2010	3 097 043	4 854 280	1 622	524
2011	3 175 642	4 947 150	1 666	525
2012	3 206 055	4 942 334	1 673	522
2013	3 156 286	4 858 175	1 656	525
2014	3 143 495	4 842 710	1 639	521
2015	3 256 561	5 033 733	1 701	522
2016	3 299 974	5 093 970	1 729	524
2017	3 313 459	5 057 751	1 710	516
2018	3 551 969	5 421 197	1 827	514

Year	Clinker [t]	Raw meal used [t]	Process specific CO ₂ emissions [kt]	IEF [kg CO ₂ /t Clinker]
2019	3 422 866	5 264 330	1 771	517
2020	3 522 299	5 404 367	1 821	517
2021	3 662 612	5 623 758	1 889	516
2022	3 560 071	5 433 926	1 832	514
1990–2022	-3.6%	-6.8%	-9.9%	-6.5%

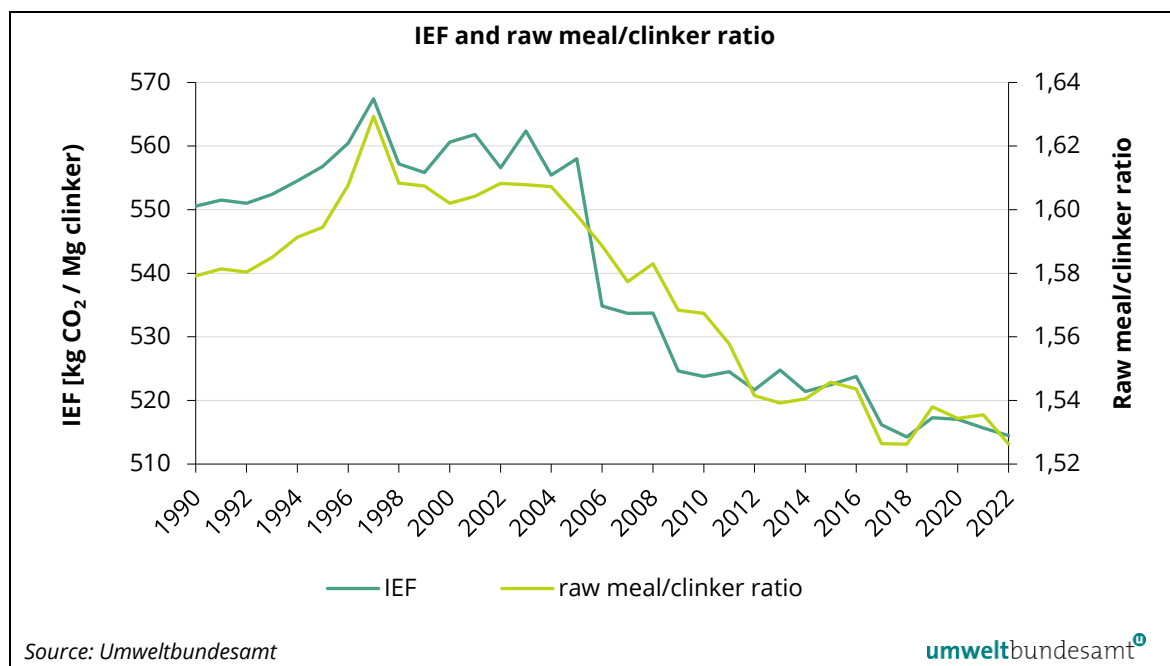
CO₂ emissions mainly follow production figures: they remained quite constant from 1990 to 1994 and dropped afterwards due to an economic downturn in the cement industry and the shutdown of one clinker oven. After 1995, emissions as well as production of clinker increased slowly, following cement demand, with minor fluctuations only. The trend from 2008 onwards is a result of the economic crisis followed by a (slow) recovery in the cement industry.

The overall emission trend from 1990 to 2022 is minus 9.9%. Production decreased by 3.6% during that period.

As process specific emissions are considered only, the IEF solely depends on the raw materials used (carbonate contents of fresh materials but also of secondary raw materials such as clay substitute, brick chips, and recycled gypsum) – smaller fluctuations of the IEF are also a result of opening/closing or shifting of production between plants that operate under different conditions (such as differing use of secondary materials). Currently, nine plants operate in Austria.

As can be seen in Figure 20, the IEF largely follows the trend of the raw meal/clinker ratio as it is a result of the raw materials used.

Figure 20: Time series of the implied emission factor (IEF) for cement production and ratio of raw meal used to clinker produced



In an effort to enhance transparency, information on the composition of raw material and its calcium carbonate and magnesium carbonate was collected. In 2011, the average CaCO_3 content was 76.3% and the average MgCO_3 content was 3.1%. In 2012, the values were 75.0% and 3.7%, respectively; in 2013, 74.9% and 3.8%, respectively. In 2014, the average CaCO_3 content was 74.8% and the average MgCO_3 content was 3.7% in the plants in operation.

It has to be noted that from 2005 onwards, emissions are calculated for each plant in line with the requirements of the EU ETS. Total carbonate contents of the raw meal are determined for each plant individually. However, the specific shares of CaCO_3 and MgCO_3 are not determined under this approach as this is not required for the determination of process emissions. Contents of various carbonates cannot be measured individually, but are calculated based on estimates in the individual plants. The procedures in the individual plants may differ and the percentages given above were calculated without weighing the percentages reported by the plant operators.

4.2.1.2 Methodological Issues

Until 2004, CO_2 emissions from cement production were estimated using a country specific method similar to the IPCC Tier 2 methodology. CO_2 emissions from raw meal calcination (decarbonising) were calculated based on the raw meal composition:

$$M_{(\text{CO}_2 \text{ calc})} = \sum_k (m_{(\text{raw meal})})_k \cdot (x_{(\text{MeCO}_3)})_k \cdot M$$

Where: m mass stream [kg/a] M molecular weight CO_2 /molecular weight Me-carbonate
 x mass portion MeCa, Mg
 k for the k^{th} cement plant

Based on raw meal data and plant specific production data, total emissions from this source were calculated. With this methodology, no cement kiln dust (CKD) correction factor has to be considered.

Activity data (clinker production) as well as emission data were taken from studies on emissions from the Austrian cement production industry (HACKL & MAUSCHITZ 1995, 1997, 2001, 2003 and MAUSCHITZ 2004). The studies cover the years 1988 to 2003. In these studies process-specific CO_2 emissions and CO_2 emissions due to combustion are presented separately. In the course of these studies all cement production plants in Austria were investigated. The determination of the emission data took place by inspection of every single plant, recording and evaluation of plant specific records and also plant specific measurements and analysis carried out by independent scientific institutes.

Activity data and emissions for 2004–2022 conform to verified CO_2 emissions data of the EU ETS. A summary of the data is also published in annual reports (MAUSCHITZ 2004, 2009, 2010–2023). The methodology for these emission calculations is the same as in the years before.

4.2.1.3 Category-specific QA/QC

Raw material analysis was carried out by independent scientific institutes. Clinker production data was compared with publications from the Association of the Austrian Cement Industry to ensure completeness.

During various reviews, the Austrian IEF has been considered high compared to other Parties and the IPCC default value. A possible explanation can be found in (HACKL & MAUSCHITZ 2003), where the authors apply both methods, based on clinker and on raw meal, to calculate CO₂ emissions and find that if CO₂ emissions are calculated from clinker instead of raw meal, this leads to 4% lower emissions.

For 2005–2022, verified CO₂ emissions (total of all plants) were checked against national emissions taken from the studies – no deviations were identified.

4.2.1.4 Uncertainty Assessment

As the applied methodology is based on plant specific data, the uncertainty of activity data is assumed to be low: it was assumed 5% for the base year and 1% for the recent year as now this data is verified under the EU ETS scheme. According to the IPCC 2006 GL the uncertainty of the CO₂ emission factor for Tier 2 is 1–2%. In the Austrian method, the uncertainty basically derives from the raw meal composition as the uncertainty for the stoichiometric emission factor is negligible; thus, the uncertainty of the emission factor is assumed to be 2%. This results in a combined uncertainty of 2.2%.

4.2.1.5 Recalculations

No recalculations have been carried out since the last submission.

4.2.2 Lime Production (2.A.2)

4.2.2.1 Source Category Description

Emissions: CO₂

Key Source: Yes (CO₂)

CO₂ emissions from lime production are a key category because of their contribution to the total inventory's level in 1990 and in 2022, as well as because of their contribution in terms of their trend. In 2022, emissions from this category contributed 0.8% to the total amount of greenhouse gas emissions in Austria.

In this category all processes using limestone or lime in Austria (both directly marketed and process use only) leading to CO₂ emissions or CO₂ removals are reported:

- Lime production in all lime kilns in Austria
- Lime production for calcium carbide production
- Lime production for PCC (precipitated calcium carbonate) production as well as CO₂ recovery from PCC use in sugar and pulp and paper industry
- Limestone use for desuphurisation

CO₂ is emitted during the calcination step of lime production. Calcium carbonate (CaCO₃) in limestone and calcium/magnesium carbonates in dolomite rock (CaCO₃•MgCO₃) are decomposed to form CO₂ and quicklime (CaO) or dolomite quicklime (CaO•MgO) respectively.

Table 131 presents activity data for this category (lime produced) as well as CO₂ emissions from lime production for the period from 1990 to 2022.

Table 131: CO₂ emissions, activity data and implied emission factors for lime production 1990–2022

Year	Lime Produced [t]	CO ₂ [kt]	IEF (not considering CO ₂ recovery) [t CO ₂ /t lime produced]
1990	672 436	456	0.72
1995	678 313	452	0.71
2000	830 632	556	0.71
2005	940 085	618	0.70
2010	912 285	604	0.72
2011	967 750	637	0.72
2012	911 180	598	0.72
2013	928 397	615	0.73
2014	940 300	616	0.72
2015	922 436	609	0.72
2016	928 417	609	0.72
2017	920 128	608	0.72
2018	897 581	573	0.70
2019	918 281	608	0.71
2020	867 384	579	0.72
2021	991 958	653	0.71
2022	957 007	624	0.70
1990–2022	+42%	+37%	-3.3%

CO₂ emissions from this category have been increasing since 1990, with a pronounced dip due to the economic crisis in 2009. In the year 2022, emissions were 37% higher than in 1990 (see Table 131).

4.2.2.2 Methodological Issues

Lime produced at lime kilns

Emissions were estimated using a country specific method based on detailed production data.

Activity data for the whole time series and emission data until 2004 were reported by the *Association of the Stone & Ceramic Industry*. For 2005–2022, verified CO₂ emissions reported under the ETS were used for the inventory: some plants calculate emissions based on raw material data, most calculate emissions from lime produced; thus the activity data reported under the ETS for some plants is production volumes, others report the amount of raw materials used. For the calculation of an overall IEF, the overall value of Austrian lime production as reported by the *Association of the Stone & Ceramic Industry* is used.

Also reported emissions for the years before 2005 are based on detailed data of each of the seven lime production plants in Austria, including production volumes and the respective CaO and MgO contents of lime produced in the respective plant.

The IEF depends on the quality ($\text{CaCO}_3/\text{MgCO}_3$ content) of the limestone used; it ranges between 0.73 and 0.77 tonnes CO_2 per tonne lime produced – which corresponds to the default range for purity of high calcium lime of 93–98%.

Lime production for calcium carbide production

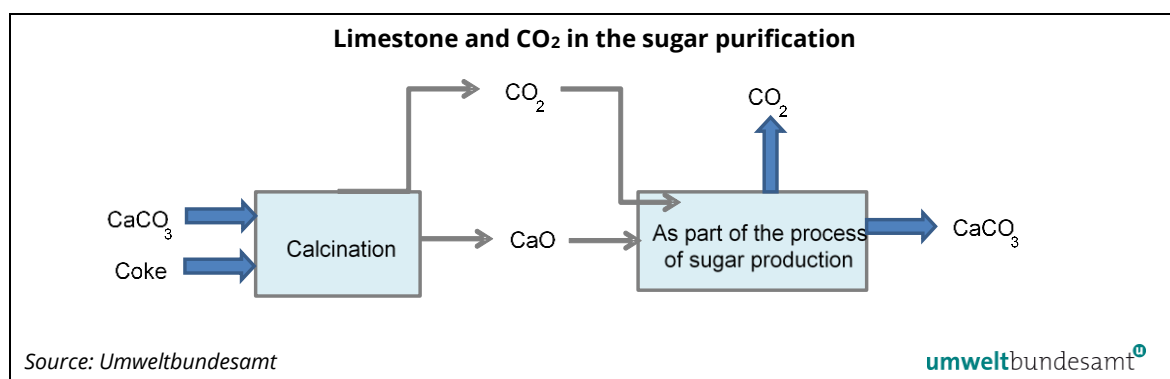
Calcium carbide production as well as the plant specific emission factor for the lime production step (0.7153 t CO_2 /t carbide) is reported by the only producer in Austria.

Lime production for PCC (precipitated calcium carbonate) production as well as CO_2 recovery from PCC use

Lime used for sugar purification

In Austria, two sugar processing plants are in operation, owned by the same company and integrated in the EU ETS. In these plants, limestone is converted into lime, using coke as fuel to maximise the amount of CO_2 available for the internal process. Both lime and CO_2 produced in the decarbonising step are fed into the raw sugar solution (this takes place in the sugar purification unit, see Figure 21). At this point, the lime re-reacts with CO_2 forming a limestone sediment which binds impurities in the raw sugar solution. Surplus CO_2 leaves the system. The sediment, the by-product of the sugar purification step, is known as 'Carbokalk'. It also contains the bound impurities (organic substances and minerals) and is used as a fertilizer (WASNER 2009).

Figure 21: Purification step in the sugar production: lime production (calcination) and reaction of CO_2 and lime back to limestone (sediment).



The majority of CO_2 originating from lime is contained in the sediment. However, following the recommendation by the Expert Review Team, mass balance data were obtained from the producer. Based on this mass balance, it was found that part of the CO_2 originating from limestone does not end up in the sediment but is emitted, and an emission factor of 2.07 kg CO_2 per t CaCO_3 input was calculated.

Lime used for production of PCC

Until 2019 PCC (precipitated calcium carbonate) was produced at one site in Austria. The process is basically the same as in sugar purification explained above (limestone calcination and subsequent precipitation using i.a. the CO_2 emitted in the calcination step), only that the precipitation step takes place under defined conditions to produce calcium carbonate with the desired physical parameters concerning particle size, crystal structure, surface area, purity, opacity etc.

For the years 2005 to 2019 CO₂ emissions data was available from the EU ETS, for the years before the value of 2005 was used. For CO₂ recovered data was only available for the years 2017 and 2018, for 2019 the data was not complete as the production was terminated in this year. Therefore the share of recovered data 2017 and 2018 was used for calculating CO₂ recovered for the other years.

Lime use and PCC production in pulp and paper industry

In the EU-ETS scheme, several pulp and paper production sites report process emissions from limestone use and recovery from PCC production respectively (this data and information is independently verified). As data is only available for recent years, production capacities for the different plants have been used to prepare time series of emissions and removals.

Limestone use for desulphurisation

Activity data for limestone used for desulphurization were taken from a national report on desulphurization technologies in Austria (WINDSPERGER & HINTERMEIER 2002). The time series was constructed with the help of plant specific SO₂ emission declarations from the Austrian steam boiler database.

For calculation of CO₂ emissions, the IPCC default emission factors of 440 kg CO₂/t limestone and 477 kg CO₂/t dolomite were used. From 2005 onwards, ETS background data provided more detailed information on the actual carbon content of the limestone and dolomite used. Therefore, the IEFs from 2005 onwards are slightly different to the IPCC default values.

4.2.2.3 Category-specific QA/QC

The emission values for 2005 onwards are verified under the EU ETS. IEFs are compared with IPCC default values. The *Association of the Stone & Ceramic Industry* reported total CO₂ emissions, which were compared to ETS data.

For limestone use for desulfurisation it was checked whether data cover all industrial activities of this type in Austria.

4.2.2.4 Uncertainty Assessment

As emissions from lime kilns cover about 95% of total emissions from this category, the uncertainty assessment was made for this main sub category only:

The uncertainty of the emission factor derives basically from the raw-material composition and is assumed to be 2%. Uncertainties for activity data are considered to be low as they are based on verified plant specific data of all Austrian plants, we assumed 5%. This leads to a combined uncertainty of 5.39%.

4.2.2.5 Recalculations

For three processes in pulp and paper production reported in the ETS related to limestone production or lime use and PCC production respectively, time series were prepared and emissions and removals were considered in category 2.A.2 *Lime Production* (recalculation difference 2021: - 9.41 kt CO₂).

4.2.3 Glass Production (2.A.3)

4.2.3.1 Source Category Description

Emissions: CO₂

Key Source: no

In this category CO₂ emissions from decarbonising of soda, limestone, dolomite and other carbonates used for glass production is considered. This category contributed 0.05% to total greenhouse gas emissions in Austria (without LULUCF).

4.2.3.2 Methodological Issues

Emissions are calculated based on the input of carbonates and a CO₂ emission factor for the different types of carbonates.

For years 2002 to 2004 input data on carbonates (limestone, dolomite and soda) was reported by the *Association of Glass Industry*. The factor of tonne carbonate used/ tonne glass for 2002 (the only year where both glass production and carbonate input was available) was also applied for 1990-2001. For the calculation of CO₂ emissions the IPCC 2006 default emission factors of 414.92 kg CO₂/t soda ash, 439.71 kg CO₂/t limestone and 477.32 kg CO₂/t dolomite were applied for the years 1990 to 2004.

Since 2005 verified CO₂ emissions and activity data reported under the ETS is used for the inventory.

Table 132 presents activity data and CO₂ emissions from this category for the period from 1990 to 2022.

Table 132: CO₂ emissions and carbonate use in glass production 1990–2022

Year	Glass Prod. [t]	CO ₂ emissions [kt]
1990	398 515	39
1995	435 094	42
2000	375 348	36
2005	417 685	35
2010	498 156	40
2011	474 222	36
2012	472 040	37
2013	487 359	39
2014	496 782	37
2015	497 368	40
2016	480 781	38
2017	501 881	38
2018	487 341	38
2019	525 624	41
2020	503 490	39
2021	509 577	36
2022	545 652	35
1990–2022	+37%	-9.2%

4.2.3.3 Category-specific QA/QC

The country-specific EFs for limestone, dolomite and soda ash have been compared with the IPCC default values. They deviate from the IPCC default values less than 1%.

4.2.3.4 Uncertainty assessment

The uncertainty of activity data for 2022 is assumed to be 1%. The uncertainty of the emission factor is estimated to be about 2%. This leads to a combined uncertainty of 2.2%.

4.2.3.5 Recalculations

No recalculations have been carried out since the last submission.

4.2.4 Other Process Uses of Carbonates (2.A.4)

In this category ceramics (bricks), magnesia sinter production and soda ash use are addressed.

4.2.4.1 Ceramics (2.A.4.a)

Source Category Description

Emissions: CO₂

Key Source: No

This category includes CO₂ emissions from the production of bricks where CO₂ is generated through decomposition of the carbonate content of the raw materials.

Table 133 presents CO₂ emissions from bricks production for the period from 1990 to 2022. CO₂ emissions from bricks production showed a maximum in 1995/1996 due to a peak in brick production. In 2022, emissions from this category contributed 0.14% to total greenhouse gas emissions in Austria and were 14% lower than in 1990.

Methodological Issues

Activity data for the production of bricks was taken from national statistics (STATISTIK AUSTRIA), for 1996 the value of 1995 was used due to lack of data. Since 2006 the volumes sold of the short-term statistics are directly provided by the Statistik Austria on annual basis.

Emission values for the years 1998–2001 were reported by the *Association of the Stone & Ceramic Industry*. The reported CO₂ emission data is based on data of the different brick production sites in Austria, also considering the carbonate contents of raw materials used for bricks production at the respective plants. From the IEF for 1998, emissions of the years prior to 1998 were calculated and the IEF of 2001 was used to calculate emissions of 2002 to 2004.

For 2005–2022, verified CO₂ emissions reported under the ETS were used for the inventory (2006 IPCC GL, Tier 3). This data covers all brick production sites in Austria.

Table 133 presents activity data for production of bricks and CO₂ emissions for this category for the period from 1990 to 2022.

Table 133: Activity data and CO₂ emissions for bricks production 1990–2022

Year	Bricks [m ³]	CO ₂ emissions [kt]	IEF [kg CO ₂ /m ³]
1990	2 230 000	116	52
1995	2 848 716	149	52
2000	1 954 855	116	59
2005	2 170 069	128	59
2010	1 789 882	81	45
2011	2 371 494	99	42
2012	1 749 297	93	53
2013	1 671 812	80	48
2014	1 615 127	94	58
2015	1 698 612	91	54
2016	1 800 235	91	51
2017	1 715 450	95	55
2018	1 693 833	105	62
2019	1 976 520	104	53
2020	1 915 919	106	55
2021	1 730 891	96	55
2022	1 928 528	100	52
1990–2022	-14%	-14%	-0.5%

The increasing IEF between 1998 and 2001 is due to a switch in porous material used in brick production. Previously mainly sawdust was used, whereas nowadays residual fibre material from paper industry is used. Furthermore, CaCO₃ is added for moisture compensation.

Generally, fluctuations in the IEF occur because of different brick types produced. High and low density bricks have different properties, and different raw materials with different carbon contents are used. The higher the density of the particular brick, the more CO₂ is emitted during production. For example, in 2010 and 2011, raw material (loam) with lower carbon content was used (verified by chemical analysis: loss on ignition), resulting in a lower average implied emission factor for these two years.

Uncertainty Assessment

The uncertainty of activity data is assumed to be low (1%). The uncertainty of the emission factor is estimated to be about 2%. This leads to a combined uncertainty of 2.2%

Recalculations

No recalculations have been performed since the last submission.

4.2.4.2 Other Uses of Soda Ash (2.A.4.b)

Source Category Description

Emissions: CO₂

Key Source: No

In this category CO₂ emissions from soda ash use in metallurgy and other industries is considered, CO₂ emissions from soda ash used in glass production are reported in *2.A.7.c Glass production*.

Soda ash was produced in Austria until 2005. However, als it was produced by the Solvay process which is CO₂-neutral (except for coke used for calcination of limestone which is accounted for as fuel in the energy sector subcategory *1.A.2.c*), the category *2.B.7 Soda ash production* is reported as "NO" for all years.

In 2022, CO₂ emissions from soda ash use contributed 0.01% to total GHG emissions in Austria. The following table presents CO₂ emissions from this category.

Table 134: Activity data and CO₂ emissions for soda ash use 1990–2022

Year	Soda ash used [t]	CO ₂ emissions [kt]
1990	12 374	5
1995	13 531	6
2000	18 247	8
2005	30 208	13
2010	23 325	10
2011	27 234	11
2012	29 585	12
2013	24 816	10
2014	26 820	11
2015	23 461	10
2016	25 828	11
2017	24 712	10
2018	24 960	10
2019	21 221	9
2020	22 710	9
2021	24 640	10
2022	24 640	10
1990–2022	+99%	+99%

Methodological Issues

Emissions were estimated using the methodology and the default emission factor of the IPCC Guidelines 2006 Tier 2 (415 kg CO₂/t soda ash).

The only Austrian producer Solvay Österreich GmbH provided data for 1990 and from 2008–2013 for solvent use. Activity data for the years in between was interpolated, for the years 2014ff the value of 2013 was used. From this total amount, the amount used in glass production that is already considered in category 2.A.3 was subtracted. Also Soda used for the production of detergents is subtracted as it is a non-emissive use. From the remaining soda ash use CO₂ emissions are calculated using the IPCC default EF.

Uncertainty Assessment

The uncertainty of activity data is assumed to be 30%. The uncertainty of the emission factor is estimated to be 2%. This leads to a combined uncertainty of 30.1%.

Recalculations

No recalculations have been performed since the previous submission.

Planned Improvements

It is planned to update data for the different soda ash uses for the next submission.

4.2.4.3 Magnesia Sinter Production (2.A.4.c)

Emissions: CO₂

Key Source: Yes (CO₂)

This category includes CO₂ emissions from the production of magnesia sinter. CO₂ emissions from magnesia sinter production are a key category due to their contribution to total emissions in 1990 and in 2022. In 2022, this category contributed 0.4% to the total amount of greenhouse gas emissions in Austria.

During production of magnesia sinter, CO₂ is generated in the calcination step, when magnesite (MgCO₃) is sintered at high temperatures in a kiln to produce MgO. Magnesia sinter is processed to refractory materials such as bricks.

Table 135 presents CO₂ emissions from production of magnesia sinter for the period from 1990 to 2022. CO₂ emissions from magnesia sinter plants vary over the period from 1990 to 2022, with an overall decreasing trend. Fluctuations in CO₂ emissions from this category are explained by:

- Varying implied emission factors that reflect different qualities of sinter produced and proportions of sinter/caustic sinter production.
- Varying production figures. For example, magnesia sinter production showed a distinct dip in 2009 due to the economic crisis.

Methodological Issues

No IPCC methodology is available for this source.

Emission values and activity data were directly reported by the only company in Austria sintering magnesia. For 2005–2022, verified CO₂ emissions, reported under the ETS, were used for verification of the reported emissions. Emissions are calculated according to “calculation method B: alkali oxides” in Annex II of the EU ETS monitoring and reporting guidelines⁷³. The composition of the oxides is measured using X-ray fluorescence analysis.

Table 135 presents activity data and CO₂ emissions from this category for the period from 1990 to 2022.

⁷³ Commission Decision 2004/156/EC of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

Table 135: CO₂ emissions from magnesite sinter production 1990–2022

Year	Magnesite [t]	CO ₂ Emissions [kt]	IEF [kg CO ₂ /t magnesite]
1990	966 066	481	498
1995	753 575	410	544
2000	699 707	339	485
2005	638 749	310	485
2010	627 612	314	500
2011	710 573	345	486
2012	625 259	305	488
2013	669 414	330	494
2014	676 263	334	494
2015	609 517	301	494
2016	643 350	318	495
2017	684 322	345	504
2018	744 227	365	490
2019	615 710	293	475
2020	579 845	282	487
2021	724 655	357	492
2022	557 419	317	569
1990–2022		-34%	

Source specific QA/QC

The calculation is based on a recognised European standard method. Order of magnitude and time-series checks are performed. The operator is contacted in case of inconsistencies. The operator reported total CO₂ emissions, which were compared with EU ETS data and found to accord.

Uncertainty Assessment

The uncertainty of the emission factor equals the uncertainty of raw material composition which is estimated to be about 2%. The uncertainty of activity data is assumed to be low (2%) as there is only one plant in Austria and data is obtained from this plant. This leads to a combined uncertainty of 2.8%.

Recalculations

No recalculations have been carried out since the last submission.

4.3 Chemical Industry (Category 2.B)**4.3.1 Ammonia Production (2.B.1)****4.3.1.1 Source Category Description**

Emissions: CO₂ and CH₄

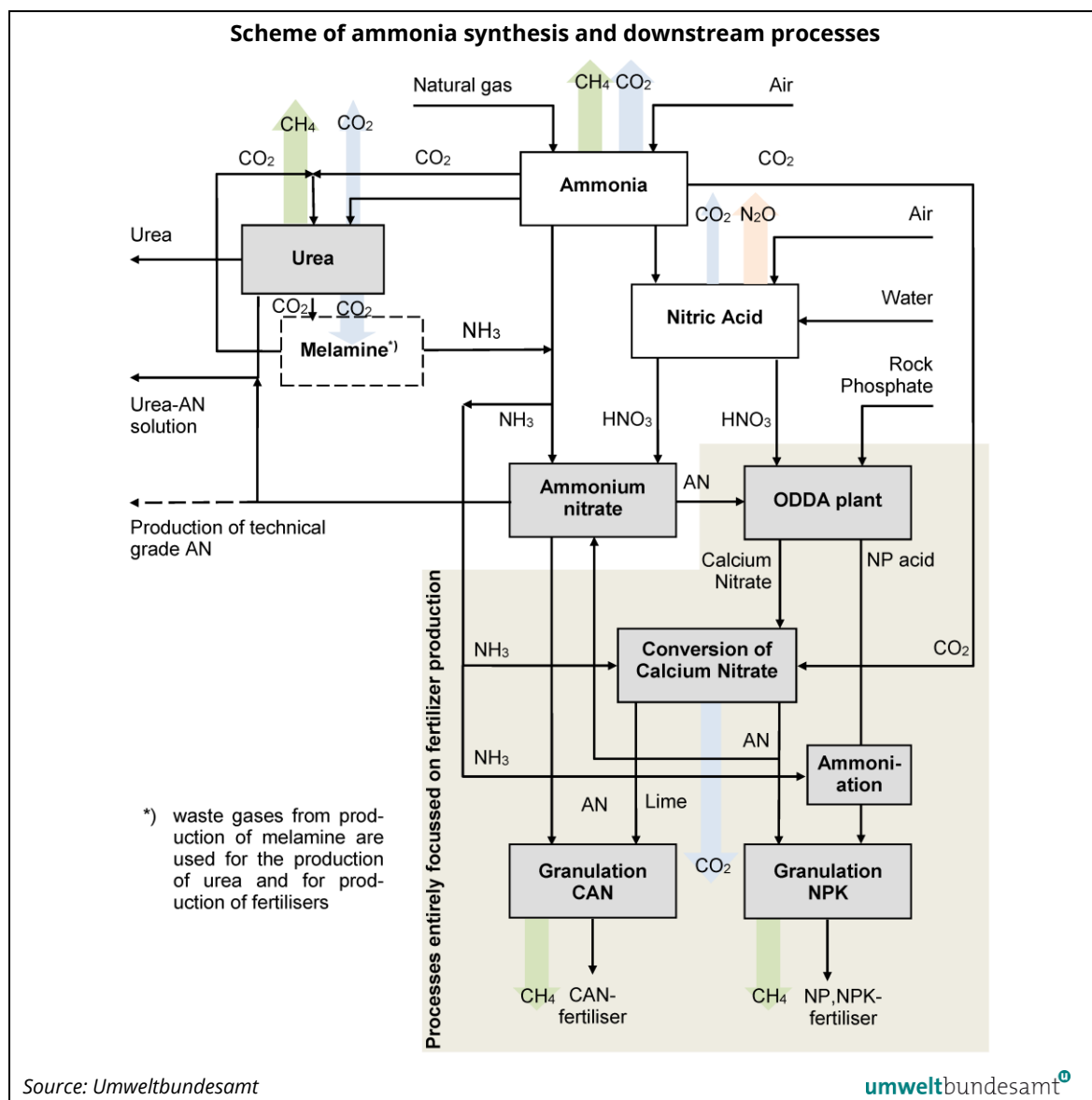
Key source: Yes (CO₂)

Ammonia production is a key category due to its contribution of sectoral CO₂ emissions to total greenhouse gas emissions in Austria in 1990 and in 2022. In 2022, this category contributed 0.6% to Austria's total greenhouse gas emissions.

Ammonia (NH₃) is produced by catalytic steam reforming of natural gas or other light hydrocarbons (e.g. liquefied petroleum gas, naphtha) – in Austria, natural gas is used. In this process, the feed-stock is reformed with steam in a heated primary reformer and subsequently with air in a second reformer in order to produce the synthesis gas. CO₂ is produced by stoichiometric conversion and is mainly emitted during the primary reforming step (UMWELTBUNDESAMT 2001d).

Ammonia is produced at one plant in Austria. The process chart below (Figure 22) shows the scheme of ammonia synthesis and downstream processes at the integrated plant: the main production lines (ammonia, urea, melamine, nitric acid, different types of fertilisers and intermediate products), flows of main raw materials and intermediate products as well as relevant emissions.

Figure 22: Scheme of ammonia synthesis and downstream processes at Austria's integrated ammonia plant.
Note: Grey coloring highlights those processes related to fertilizer production.



Approximately half of the methane introduced in the synthesis is CH_4 that is generated in the so called methanator: small amounts of CO and CO_2 , remaining in the synthesis gas, are harmful for the ammonia synthesis catalyst and have to be removed by conversion to CH_4 in the methanator. The other half consists of recycled methane that has not been converted in the reforming step. Only a small part of the methane is actually emitted as leakage during start-ups of the ammonia production, the main part is used as a fuel in the primary reformer.

Table 137 presents CO_2 and CH_4 emissions from ammonia production as well as ammonia production figures and natural gas input for the period from 1990 to 2022.

Emissions vary during the period, following closely the trend in ammonia production. In 2022, CO_2 emissions are 11% lower than in 1990. The interannual change 2013/2014 is due to lower production because of technical problems at the plant. In 2018 production was lower due to a turnaround at the plant.

4.3.1.2 Methodological Issues

Activity data (ammonia production and natural gas input) for the whole time series and CH_4 emission data from 1994 onwards were reported directly to the Umweltbundesamt by the only ammonia producer in Austria and thus represent plant specific data. The composition of the synthesis gas is measured regularly.

CH_4 emissions are calculated from the measured synthesis gas composition and the number and duration of start-ups. The implied emission factor for CH_4 that was calculated from activity and emission data from 1994 was applied to calculate emissions of the years 1990 to 1993 as no emission data was available for these years.

CH_4 emission factors of ammonia plants largely depend on the number of shutdowns and start-ups during the year. Especially a start up after a turn around with exchange of catalyst in some of the reactors of the plant needs a prolonged start up procedure resulting in an increase of the IEF.

CO_2 emissions are calculated as follows:

1. Carbon input is calculated from natural gas input – following the tier 2 method of the IPCC guidelines – with an emission factor of 55.4 t/TJ. Natural gas is the only carbon input for the ammonia synthesis and its downstream processes. Plant-specific natural gas data are available for the whole time series.
2. Subtraction of carbon that is accounted for elsewhere or stored to avoid double counting of emissions (the total of these is reported as recovery):
 - a. Fugitive CH_4 emissions during start-ups of the **ammonia** production reported in 2.B.1
 - b. CO_2 and CH_4 emissions from **fertilizer** production (downstream process). These emissions are reported under CRF category 2.B.10.ii, further explanation see chapter 4.3.7.
 - c. CO_2 and CH_4 emissions from **urea** production (downstream process). These emissions are reported under CRF category 2.B.10.ii, further explanation see chapter 4.3.7.
 - d. CO_2 emissions from **nitric acid** production (downstream process). These emissions are reported under CRF category 2.B.10.i *CO₂ from Nitric Acid Production*, further explanation see chapter 4.3.5.
 - e. CO_2 emissions from **urea use** reported in Sector *Agriculture* (see chapter 5.7)
 - f. CO_2 emissions from **urea use** reported in 2.D.3 Other “Urea used as a catalyst” (Adblue)

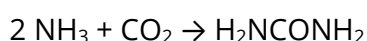
g. Carbon stored in **melamine**⁷⁴:

3. the remainder carbon is accounted for as CO₂ emissions from ammonia production.

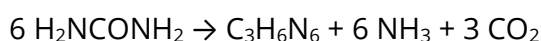
Melamine

Melamine is primarily used to produce melamine resin, which, when combined with formaldehyde, produces a very durable thermoset plastic. Melamine is fire resistant and heat tolerant and has a highly stable structure. It is mainly used for wood based panels, but also everyday objects such as kitchenware. The life time of these products is assumed to be 10 to 30 years, as for other plastics.

The first step is the production of urea from ammonia:



The second step is the production of melamine from urea:



So for every molecule of melamine, six molecules of CO₂ are needed, and only three molecules of CO₂ are emitted (see formulas above), so for every molecule of melamine, three CO₂ molecules are stored in the product, or – relating to urea used for the process - half of the carbon content of the urea (i.e. three C out of six) used as feedstock in step two is securely bound within the molecular structure.

According to the IPCC Guidelines no account should be taken for intermediate binding of CO₂ in downstream manufacturing processing and products. The rationale behind this guidance is that all emissions should be accounted for, and consideration of intermediate binding might result in an underestimation, if these amounts are not accounted for elsewhere, particularly as end of life emissions.

So even though the binding of carbon in melamine cannot be considered as long-time (which rather refers to several decades or centuries), the carbon stored in melamine is subtracted to avoid double counting of emissions, as the carbon in melamine is accounted for at the end of life as fossil carbon content of waste, and accounted for under the waste sector either as disposal (until 2004/2008 under 5.A), or in the energy sector under 1.A *Other Fossil Fuels*.

The Austrian approach of accounting for carbon stored in melamin is reported analogously to the approach used for plastics:

Plastics	Melamine
Production: fossil fuels used for production of plastics is accounted for as non-energy use of fuels, and thus accounted as carbon stored.	Production: fossil carbon used for melamine production is subtracted from carbon emissions, it is accounted for as carbon stored in melamine.
As carbon is bound within the molecular structure, no emissions during use occur.	
End of life emissions are being accounted for as fossil carbon content of waste, and accounted for under the waste sector either as disposal (until 2004/2008 under 5.A), or in the energy sector under 1.A <i>Other Fossil Fuels</i> .	

⁷⁴ see description on melamine below

During the 2006 in-country review, the Austrian approach was explained to the ERT and accepted to be in line with the IPCC guidelines.

Table 136: CO₂ emissions from urea use

Reported in category	CO ₂ emissions from urea use in selective catalytic reduction (SCR) in the transport sector	CO ₂ emissions from application of urea to soils in the agriculture sector
	2.D.3 Other	3.H Urea application
Year	[kt]	[kt]
1990	NO	4.4
1995	NO	7.9
2000	NO	8.4
2005	0.4	11.8
2010	16.3	19.6
2011	16.6	18.4
2012	18.1	21.7
2013	23.4	21.5
2014	24.9	25.4
2015	26.9	26.5
2016	27.6	31.3
2017	30.5	30.0
2018	35.1	23.9
2019	40.3	19.2
2020	40.2	17.0
2021	45.8	15.7
2022	44.6	18.2
1990–2022		+313%

Table 137 shows relevant parameters for the calculation of CO₂ emissions from ammonia production. The trend of the resulting CO₂ IEF (with respect to ammonia) decreases over time, when the fluctuations caused by the included melamine production are taken in account.

Table 137: Activity data, emissions and implied emission factor for ammonia production 1990–2022.

Year	Ammonia produced [t]	Natural gas input [TJ]	CO ₂ Recovery ⁷⁵ [kt]	CO ₂ Emissions [kt]	CH ₄ Emissions [t]	CO ₂ IEF [t/t ammonia]
1990	461 000	10 193	97	467	62	1.22
1995	473 000	10 516	74	509	61	1.23
2000	482 333	10 548	94	491	60	1.21
2005	478 427	10 719	132	462	94	1.24

⁷⁵ CO₂ emissions reported in other categories or bound in melamine.

Year	Ammonia produced [t]	Natural gas input [TJ]	CO ₂ Recovery ⁷⁵ [kt]	CO ₂ Emissions [kt]	CH ₄ Emissions [t]	CO ₂ IEF [t/t ammonia]
2010	495 353	11 248	148	475	70	1.26
2011	502 461	11 347	135	494	77	1.25
2012	479 475	10 881	132	470	76	1.26
2013	435 244	9 840	123	423	225	1.25
2014	537 000	11 973	138	525	86	1.24
2015	519 860	11 562	140	501	91	1.23
2016	551 118	12 093	148	522	69	1.22
2017	507 689	11 071	146	467	91	1.21
2018	405 103	8 922	137	357	89	1.22
2019	552 973	12 091	152	520	67	1.22
2020	515 843	11 454	146	491	70	1.23
2021	527 858	11 614	145	500	48	1.22
2022	457 935	9 941	135	418	48	1.21
1990–2022	-0.7%			-11%	-23%	

4.3.1.3 Category-specific QA/QC

The emission factor for natural gas is consistent with the emission factor used in fuel combustion. Natural gas input from the energy balance was checked for plausibility with ammonia production figures using the conversion factor 0.451 t natural gas per tonne ammonia. This factor is plant specific and derived from natural gas input and ammonia output.

4.3.1.4 Uncertainty assessment

As activity data are obtained from the only ammonia plant in Austria, uncertainty is rated as very low (2%). Also the emission factor and other conversion factors are considered to have low uncertainties. Thus, the quality of emission estimates is rated as “high” (5% uncertainty). This leads to a combined uncertainty of 5.4%.

4.3.1.5 Recalculations

Updated urea amounts used in road traffic for 2005 onwards led to a redistribution of minor amounts between these two categories (–0.02 kt CO₂ 2021). Additionally, for the years 1990 – 2019, the recalculation of the time series of CH₄ emissions from 2.B.10.ii *Urea Production* described below affected the reported CO₂ emissions from 2.B.1 *Ammonia Production*.

4.3.2 Nitric Acid Production (2.B.2)

4.3.2.1 Source Category Description

Emission: N₂O, CO₂

Key Source: Yes (N₂O)

N₂O emissions from nitric acid production are a key source due to their contribution to total greenhouse gas emissions in Austria in 1990 and in terms of their trend. In 2022, this source contributed 0.03% to the total amount of greenhouse gas emissions in Austria, whereas in 1990 the contribution was 0.99%.

In line with the IPCC 2006 Guidelines, N₂O emissions from nitric acid production are reported in category 2.B.2. As in the CRF only N₂O emission can be reported in this category, the CO₂ emissions are reported in 2.B.10.i CO₂ from nitric acid production.

Nitric acid (HNO₃) is manufactured from ammonia (NH₃). In a first step, NH₃ reacts with air to NO and NO₂ and is then transformed with water to HNO₃.

Ammonia used as feedstock (gaseous or liquid) in the nitric acid plant always contains small amounts of methane, which is dissolved in ammonia. In Austria there is only one producer of nitric acid which operates two different dual pressure plants at one site. So called weak nitric acid is produced with a concentration of 59.6% HNO₃ by oxidation of ammonia produced at the same location (UMWELTBUNDESAMT 2001d). There is no production of concentrated nitric acid in Austria. Nitric acid is mainly used for the production of fertilisers.

Table 138 presents N₂O and CO₂ emissions from production of nitric acid for the period from 1990 to 2022.

N₂O emissions follow the trend of nitric acid production for the period 1990 to 2000 with only minor fluctuations. The interannual change 2013/2014 is due to lower production because of technical problems at the plant. In 2018 production was lower due to a turnaround at the plant.

The increasing IEF between 1993 and 1994 is due to the closing down of part of a production facility that contributed to total emissions with lower specific N₂O emissions per produced unit of HNO₃. In 2007 and 2008 the IEF slightly increased again due to changes in the combustion system of one plant.

The decrease of the IEF is due to the introduction of emission reduction measures:

- 2001: installation of a new catalyst (IEF decreased from an average of 5.7 kg N₂O/t nitric acid to approx. 5.0 kg N₂O/t nitric acid)
- 2004: installation of a N₂O decomposition facility⁷⁶ called Uhde process (Envinox® process) for the combined removal of N₂O and NO_x from the tail gas of nitric acid plants. The IEF decreased from an average of 5.0 kg N₂O/t nitric acid, to approx. 1.6 kg N₂O/t nitric acid.
- May 2009: installation of a second catalyst in the nitric acid plant
- 2010: full operation of the second catalyst
- 2011 further optimisation of the production process as well as slightly reduced activities

The increase of the IEF (increase of N₂O emissions despite lower activities) in 2012 can be attributed to a combination of various reasons with the last option being the predominant one:

- Reduced activity of the catalyst over time
- Reduced activity of the catalyst at lower productivity

⁷⁶ This facility is documented as example in BAT Reference Document LVIC-AAF, section 3.4.7 (EUROPEAN COMMISSION 2007)

- Emissions dependent on which of the two plants was in operation as their N₂O emissions differ

In 2022, N₂O emissions were 97% below the emissions of 1990.

CO₂ emissions also varied over the period from 1990–2022, closely following the trend of nitric acid production until 1999. Specific emissions decreased since 2000 due to process optimisation (see implied emission factors in Table 138).

4.3.2.2 Methodological Issues

Following the IPCC Guidelines and monitoring and reporting guidelines⁷⁷ for the European Emission Trading System (ETS), plant specific measurement data was collected.

Activity and N₂O emission data was obtained directly from the plant operator. From 1998 onwards, emissions are measured continuously using a calibrated concentration monitor and volumetric flow meter. The monitoring method remained unchanged over time. Based on the analysed emission data of 1998 and due to the fact that the production technology has not changed between 1990 and 1998, emission factors per tonne of product were calculated for the technologies used (nitric acid has been produced at one site in five types of plants with different technologies over the years – with some of the plants closed or refurbished; currently two are in operation). With these estimates of plant specific emission factors and the production volume of the individual plants, the total emissions of N₂O per year were calculated.

Activity and emission data of CO₂ emissions from the years 1994 onwards have been reported directly to Umweltbundesamt by the plant operator and thus represent plant specific data. CO₂ emissions are measured discontinuously in the exhaust gas flow. The implied emission factor that was calculated from activity and CO₂ emission data from 1994 was applied to calculate CO₂ emissions of the years 1990 to 1993 as no CO₂ emission data was available for these years. Since 2008 the nitric acid plant is part of the EU ETS, and emissions reported are verified emissions. As in category 2.B.2 *Nitric Acid Production* only N₂O emission are to be reported, a specific category was included under “Chemical Industry – Other” to report CO₂ emissions from Nitric Acid production.

Table 138: Activity data, emissions and implied emission factors for N₂O and CO₂ from nitric acid production 1990–2022

Year	Nitric acid produced [t]	N ₂ O emissions [t]	CO ₂ emissions [kt]	N ₂ O IEF [kg/t]	CO ₂ IEF [kg/t]
1990	529 998	2 942	0.41	5.55	0.78
1995	484 016	2 765	0.37	5.71	0.76
2000	533 715	3 070	0.37	5.75	0.69
2005	557 870	884	0.41	1.59	0.74
2010	547 699	205	0.40	0.37	0.73
2011	542 289	154	0.40	0.28	0.74
2012	534 641	170	0.39	0.32	0.74
2013	475 254	161	0.34	0.34	0.72

⁷⁷ Commission Decision 2007/587/EC of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

Year	Nitric acid produced [t]	N ₂ O emissions [t]	CO ₂ emissions [kt]	N ₂ O IEF [kg/t]	CO ₂ IEF [kg/t]
2014	552 041	159	0.40	0.29	0.73
2015	562 426	157	0.40	0.28	0.72
2016	567 507	120	0.41	0.21	0.72
2017	500 958	129	0.36	0.26	0.72
2018	429 840	189	0.32	0.44	0.73
2019	575 262	272	0.42	0.47	0.72
2020	556 936	176	0.40	0.32	0.71
2021	519 516	156	0.39	0.30	0.74
2022	460 341	86	0.34	0.19	0.73
1990–2022	-13%	-97%	-18%		

4.3.2.3 Category-specific QA/QC

Measurements are done by an accredited testing body with internationally recognized standard methods. In the Austrian Ordinance regarding Monitoring and Reporting of Greenhouse Gas Emissions⁷⁸, the requirements for laboratories carrying out the analysis are described in § 15 and in Annex 2, section 5 the methods for determination of the flue gas are described.

Furthermore at Austrian plants, continuous measurements of N₂O and NO_x are state-of-the-art technology and the emission values are forwarded online to the local authority.

Order of magnitude and time-series checks are performed and the operator is contacted in case of inconsistencies.

Further QA/QC checks:

- Comparison with BAT

Modern M/H-type plant complies with BAT

For older L/M-type plants no BAT conclusions have been drawn

- Comparison with international studies: ENTEC UK LIMITED (2006) page 15 and ECOFYS et al. (2009)

4.3.2.4 Uncertainty assessment

An uncertainty of 2% was considered for the EF as N₂O emissions are continuously measured. The uncertainty of activity data is assumed to be low (2%) as it is collected from the only plant in Austria. This results in a combined uncertainty of 2.8%.

4.3.2.5 Recalculations

No recalculations have been carried out since the last submission.

⁷⁸ Überwachungs-, Berichterstattungs- und Prüfungsverordnung, Federal Law Gazette II No. 339/2007, as amended

4.3.3 Calcium Carbide Production (2.B.5.b)

4.3.3.1 Source Category Description

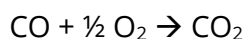
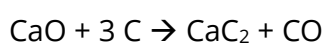
Emission: CO₂

Key Source: No

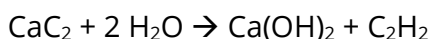
In this category the production of calcium carbide by reducing lime with carbon as well as production of acetylene from calcium carbide is considered – both processes lead to emissions of CO₂. Emissions from the preceding lime production step are reported in category 2.A.2 Lime production.

This category is a minor source of CO₂ emissions in Austria. In 2021, it contributed 0.06% of national total emissions.

For calcium carbide production quick lime is heated mixed with coke in an electric arc furnace:



Some of the produced carbide is used for production of acetylene, which is needed for welding:



4.3.3.2 Methodological Issues

Activity data (carbide production as well as carbide used for acetylene production) were directly reported by the plant operator of the only carbide production plant in Austria.

Emissions from carbide production were estimated using a country specific methodology.

The country specific emission factor was derived from a carbon balance of the process for 2020, accounting for the following carbon input/outputs and parameters:

Carbon input to the process was derived from coke and electrode use and purity of the materials

Carbon outputs:

- Stoichiometrical CaC₂-carbon in product, considering the purity of the produced calcium carbide
- Elementary carbon in product
- Elementary carbon in waste from flue gas treatment

Balancing input with the outputs leaves carbon which is emitted as CO₂; from these emissions an EF related to carbide production is calculated: 0.589 t CO₂/ t of technical carbide.

It has to be noted, that the emission factor is low compared to the IPCC default value, as the IPCC default value considers excess coke is used for the generation of heat needed for the process, whereas in Austria an electric arc furnace is used.

Emissions from acetylene production are calculated using the IPCC default value of 1.1 t CO₂/ t of carbide used.

Table 139: Activity data and CO₂ emissions from calcium carbide and subsequent acetylene production 1990–2022 reported in CRF Category 2.B.5.b

Year	Calcium Carbide [t]	CO ₂ Emissions [kt]
1990	28 951	38
1995	20 236	32
2000	37 130	43
2005	27 677	38
2010	33 041	37
2011	38 155	44
2012	37 606	43
2013	37 159	43
2014	36 022	42
2015	40 639	46
2016	36 752	43
2017	33 361	41
2018	37 078	43
2019	35 545	42
2020	34 979	40
2021	36 322	44
2022	38 860	43
1990–2022	+34%	+14%

4.3.3.3 Uncertainty Assessment

The uncertainty of the emission factor is estimated with about 5% and the uncertainty of activity data with 1% (default uncertainty from the IPCC 2006 Guidelines). This leads to a combined uncertainty of 5.4%.

4.3.3.4 Recalculations

No recalculations have been carried out since the last submission.

4.3.4 Chemical Industry – Ethylene (2.B.8.b)

4.3.4.1 Source Category Description

Emission: CH₄

Key Source: No

Ethylene is produced by steam cracking of petrochemical feedstock (naphta). This production process leads to fugitive methane emissions. This category is a minor source of CH₄ emissions in Austria (1.50 kt CH₄ in 2022). In Austria, there is only one plant, which produces ethylene. This plant is located on the same general site as the refinery. According to information from the plant operator, no other products for which a guidance is provided in the IPCC 2006 Guidelines are produced at this site. Emissions from combustion including flaring are reported under 1.A.2.c. All the GHG emissions of the plant have been verified under the EU-ETS.

4.3.4.2 Methodological Issues

Emissions were estimated using the IPCC default methodology.

Activity data are equal to the capacity of the only ethylene producing plant in Austria and amount to 350 000 t ethylene per year until 2005. In 2006, the capacity of the ethylene plant was expanded to 500 000 t. The IPCC default emission factor of 3 kg CH₄/t ethylene produced was used to calculate the emissions that amount to 1 050 tonnes CH₄ until 2005 and 1 500 tonnes CH₄ from 2006 onwards.

Depending on the further use of steam cracking by-products, this process may be a source of substantive CO₂ emissions. At the Austrian ethylene plant, all by-products are returned to the refinery, because this plant is located on the refinery site. Somehow it can be seen as a sub process of the refinery, but this ethylene plant does not belong to the same company as the refinery.

As the refinery and its related emissions are covered under sector 1, all CO₂ emissions related to by-products of ethylene production are reported in this sector. Hence, "IE" is reported under CO₂ emissions from category 2.B.8.b *Ethylene*.

4.3.4.3 QA/QC

It was checked in 2021 that the production capacity used is still valid.

4.3.4.4 Uncertainty Assessment

The uncertainty for 2.B.8 activity data is assumed to be 20%. The uncertainty of the emission factor is estimated to be about 10%. This leads to a combined uncertainty of 22.4%.

4.3.4.5 Recalculations/Planned Improvements

No recalculations were required for this year's submission. For next year's submission it is planned to reassess the EF used.

4.3.5 Chemical Industry – Other: CO₂ from Nitric Acid Production (2.B.10.i)

Emission: CO₂

Key Source: No

As in category 2.B.2 *Nitric Acid Production* only N₂O emission are to be reported, this category was incerted under "Chemical Industry – Other" to report CO₂ emissions from Nitric Acid production. For further details, please refer to chapter 4.3.2.

4.3.6 Chemical Industry – Other: Production of bulk chemicals (2.B.10.ii)

4.3.6.1 Source Category Description

Emission: CO₂

Key Source: No

The production of formaldehyde, maleic anhydride and phthalic anhydride involves process emissions of CO₂. Total CO₂ emissions from these processes amounted to 138kt in 2022.

4.3.6.2 Methodological Issues

Detailed information on process emissions for the years 2013 onwards are available as these processes were included in the ETS in 2013. For the years prior 2013, the emission factors obtained in 2013 were used and applied to activity data obtained from industry.

4.3.6.3 Uncertainty Assessment

The uncertainty for 2.B.10 activity data is assumed to be 2%. The uncertainty of the emission factor is estimated to be about 2%. This leads to a combined uncertainty of 2.8%

4.3.6.4 Recalculations

No recalculations have been carried out since the last submission.

4.3.7 Chemical Industry – Other: Production of Fertilizers and Urea (2.B.10.ii)

4.3.7.1 Source Category Description

Emission: CH₄, CO₂

Key Source: No

This category includes CH₄ and CO₂ emissions from the production of urea and from the production of fertilizers (NPK as well as calcium ammonium nitrate). There is only one producer of urea in Austria; it is also the main producer of fertilizers in Austria, both processes are downstream processes of ammonia production at that plant (see Figure 22).

This category is a minor GHG emission source in Austria: in 2022, total emissions from this category contributed 0.04% to national total emissions. They remained quite constant over the reporting period, basically following the trend of fertilizer production as CO₂ from fertilizer production is the main emission source of this category. In 2022, overall emissions from this category were 13% lower than in 1990.

4.3.7.2 Methodological Issues

No IPCC methodology is available for these sources.

Data for urea production were directly reported by the Austrian producer of urea and thus represent plant-specific data. Urea is a downstream manufacturing process of ammonia production. The input gases for urea production are NH₃ and CO₂; the latter is a by-product of ammonia production. In urea production, CO₂ is emitted at start-ups of the process and emissions are calculated from the number and duration of start-ups. The ammonia stream entering the process contains a small amount of non-reacted CH₄ that is released when NH₃ reacts to urea. These CH₄ emissions

are calculated from the ammonia input into the urea production process and the methane content of the ammonia stream.

Urea production

CH₄ emissions from the production of urea were reported for the years 2002–2022. For earlier years, no emission data is available; therefore the implied emission factor for the year 2002 was used for all years. CO₂ emissions are reported by the operator since 1995. The IEF from this year was applied to calculate emissions for previous years.

Fertilizer production

Activity data for fertilizer production for 1990 to 1994 were taken from national statistics (STATISTIK AUSTRIA), for 1995 to 2022, production data were reported directly by the main producer of fertilizers in Austria.

Emission data for CO₂ emissions from the production of fertilizers for 1992 to 2022 were directly reported by industry and thus represent plant-specific data. The average implied emission factor of the years 1992–2003 was applied to the years 1990 and 1991. CO₂ emissions from fertilizer production were calculated by the plant operator using a mass-balance approach.

CH₄ emissions from the production of fertilizers were reported for the years 2002–2022; these data became available due to a measurement programme for CH₄ at the plant starting in 2002. For earlier years, no data is available; therefore the implied emission factor for the year 2002 was used for these years.

Table 140 presents activity data, emissions and implied emission factors for CH₄ and CO₂ emissions from *Fertilizer Production* and *Urea Production* for the period from 1990 to 2022.

Table 140: Activity data, emissions and implied emission factors for CO₂ and CH₄ from NPK fertilizer production and urea production, 1990–2022

Year	Urea Production				Fertilizer Production			
	Urea production [t]	CO ₂ [kt]	CH ₄ [t]	IEF CO ₂ [kg CO ₂ /t urea]	Fertilizer production [t]	CO ₂ [kt]	CH ₄ [t]	IEF CO ₂ [kg CO ₂ /t fertilizer]
1990	282 000	0.27	152	0.97	1388 621	30	184	22
1995	393 000	0.40	212	1.02	916 265	20	121	21
2000	390 185	0.22	210	0.57	1022 983	21	135	20
2005	416 407	0.21	224	0.50	1043 916	24	149	23
2010	419 997	0.49	226	1.16	1051 087	26	140	25
2011	426 861	0.26	230	0.60	1058 249	26	138	24
2012	421 659	0.22	227	0.53	1034 833	28	137	27
2013	351 921	0.46	189	1.32	890 501	19	106	21
2014	433 364	0.20	233	0.46	1046 152	22	126	21
2015	434 587	0.20	234	0.46	1044 451	22	125	21
2016	446 020	0.22	240	0.50	1065 611	24	128	22
2017	420 106	0.40	226	0.95	949 667	24	113	25
2018	351 697	0.19	189	0.55	796 968	22	96	28
2019	448 535	0.22	241	0.50	1093 985	26	130	24
2020	438 127	0.16	202	0.37	1022 319	22	197	22
2021	456 800	0.11	236	0.25	990 179	22	159	23

Year	Urea Production				Fertilizer Production			
	Urea production [t]	CO ₂ [kt]	CH ₄ [t]	IEF CO ₂ [kg CO ₂ /t urea]	Fertilizer production [t]	CO ₂ [kt]	CH ₄ [t]	IEF CO ₂ [kg CO ₂ /t fertilizer]
2022	379 313	0.10	242	0.25	844 568	16	175	19
1990–2022	+35%	-65%	+60%		-39%	-47%	-4.8%	

4.3.7.3 Uncertainty Assessment

The uncertainty for 2.B.10 activity data is assumed to be 2%. The uncertainty of the emission factor is estimated to be about 2%. This leads to a combined uncertainty of 2.8%.

4.3.7.4 Recalculations

An inconsistency in the time series was corrected: values reported by the company for methane emissions until 2019 were based on an assumed raw gas methane content, whereas from 2020 onwards measured data were used. The measured data showed that the methane content for the years until 2019 had been assumed too low. For this submission, emissions until 2019 are calculated using the average IEF of the years 2020-2022 for which measured raw gas composition is available (recalculation difference 2019: +2.09 kt CO₂e).

4.4 Metal Production (Category 2.C)

4.4.1 Iron and Steel (2.C.1)

4.4.1.1 Source Category Description

Emissions: CO₂

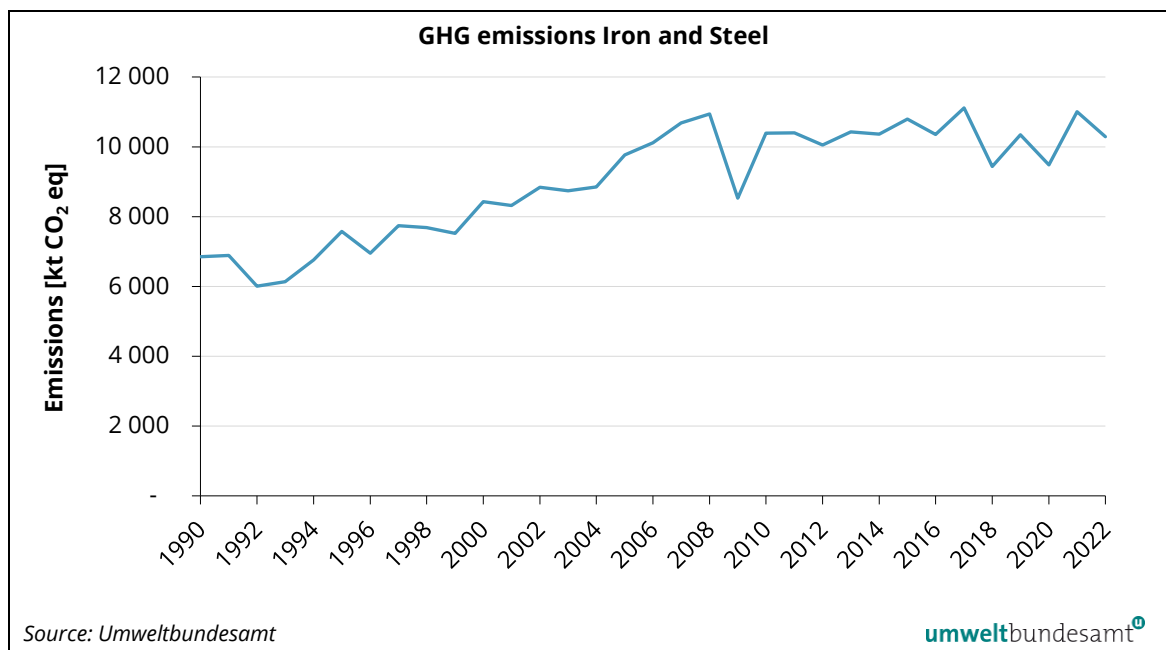
Key Category: Yes (CO₂)

CO₂ emissions from iron and steel production are an important key category of the Austrian greenhouse gas inventory because of their contribution to the total emission level for 1990 and for 2022 and in terms of their trend. In the year 2022, total emissions from production of iron and steel contributed 14.1% to total greenhouse gas emissions in Austria (see Chapter 1.5). In Austria, iron and steel production is concentrated at two integrated sites operated by the same company. It is the only company operating blast furnaces in Austria. Additionally there are companies operating electric arc furnaces, contributing approx. 10% to total steel production in Austria. Figure 23 presents total CO₂ emissions from the production of iron and steel for the period from 1990 to 2022.

The main driver behind CO₂ emissions from Iron and Steel Production is the production of iron and steel. The dip in 2009 was due to the economic downturn in 2009, the one in 2018 due to a shut down for upgrading of a blast furnace. The dips in 2020 and 2022 are due to lower production as a result of the economic effects of the covid pandemic 2020, and due to high energy prices caused by the geopolitical situation in 2022. In 2022, CO₂ emissions were 50% above the level of 1990.

Also minor CH₄ emissions arise from this sector, the contribution to total GHG emissions from iron and steel production in Austria is 0.08%.

Figure 23: GHG emissions from iron and steel production



4.4.1.2 Methodological Issues

CO₂ emissions from integrated iron and steel plants

Process specific CO₂ emissions result from the use of reducing agents in pig iron production (in blast furnaces) and in steel production (lowering of the carbon content of pig iron).

Total CO₂ emissions from the two integrated iron and steel plants in Austria are reported in the ETS scheme since 2005, where they are also independently verified. They are calculated based on analysis of the carbon content and measurements of all relevant inputs such as coke, coal, natural gas, heating oil, plastics used as a substitute fuel, ore, limestone, scrap and additives, as well as outputs in iron and steel products and the carbon contained in coal tar, benzene, slag, dust and sludges. Detailed information on carbon contents, fluxes, and process volumes used for the calculation of emissions from this sector are not displayed here due to the confidentiality of this information.

According to the IPCC 2006 Guidelines, all emissions from iron and steel production should be reported under category 2.C.1, irrespective of their role as reducing agent or fuel. However, as there is on site power generation taking place at the iron and steel production site, and also a coke oven is operated there, a carbon balance is applied to calculate CO₂ emissions that theoretically are attributable to iron and steel production itself and which are reported in 2.C.1.a. The remainder of the verified total is then attributed to the energy sector as it is related to on site power plants and the coke oven operation. The carbon balance is based on the detailed ETS data on carbon inputs and outputs, but considers different system boundaries (only process directly related to iron and steel production and not the overall iron and steel production site). For this approach the ETS data is complemented with data taken from the national energy balance and data directly reported from the plant operator. As the detailed ETS data is only available since 2005, correlation techniques had to be used for the years 1990-2004. It has to be noted, that total CO₂ emissions for all years were calculated by the company on a detailed level (IPCC T3), the correlation techniques only add uncertainty to the split not to total emissions. Emissions of category 2.C.1.b (pig iron) are reported as "IE", they are included in 2.C.1.a (steel) as a further disaggregation is not feasible.

CH₄ emissions from integrated iron and steel plants

CH₄ emissions from sinter and coke production were calculated using plant specific EFs based on measurements. In 2003 and 2008 abatement measures were implemented, resulting in lower EFs.

CO₂ emissions from electric arc furnace steel production

Emissions were estimated using a country specific methodology.

CO₂ emissions for the year 2003 have been reported by each electric steel site in Austria. The IEF calculated for this year (52 kg/t steel) was also used to calculate emissions for earlier years and for 2004. For 2005–2020, verified CO₂ emissions, reported under the ETS, were used for the inventory.

The plant operators calculate emissions on the basis of the Austrian Monitoring, Reporting and Verification Ordinance^[3]. The important part is §8(3) which defines the mass balance approach as the methodology to be used. Annex 2, (5) provides the relevant Tiers for this approach and the formula regarding carbon content.

The CO₂ emissions and production data are based on data of each of the three electric arc furnace plants in Austria. All CO₂ emissions from electric arc furnaces are allocated in 2.C.1 according to IPCC guidelines. There are no fuel related emissions.

The IEF depends on

- the raw material (carbon content of the used scrap)
- the production process (different processes with more or less input of electrical power and different additions of surcharges)

The increase of the IEF in 2005 is due to a change in the production process in one plant in Austria. The average IEF for the years 2005 to 2022 (approx. 0.066 kt CO₂ per kt steel) is in the range of the IPCC default value of 0.08.

Table 141 presents iron, steel and electric steel production and CO₂ emissions from this category.

Table 141: Activity data and emissions for CO₂ and CH₄ from steel production 1990–2022

Year	Iron and Steel Production				Electric Steel Production		Total CO ₂ eq [kt]
	Iron [kt]	Steel [kt]	CO ₂ [kt]	CH ₄ [t]	Electric Steel [kt]	CO ₂ [kt]	
1990	3 444	3 921	6 821	231	370	20	6 847
1995	3 888	4 538	7 540	242	454	24	7 571
2000	4 320	5 183	8 391	263	541	29	8 427
2005	5 458	6 408	9 718	251	622	45	9 771
2010	5 644	6 570	10 341	123	637	47	10 391
2011	5 822	6 786	10 347	142	689	49	10 400
2012	5 751	6 746	9 999	140	674	46	10 049
2013	6 144	7 290	10 386	147	664	40	10 430
2014	6 015	7 185	10 318	144	691	39	10 361
2015	5 795	7 020	10 750	147	667	37	10 791
2016	5 634	6 766	10 315	143	672	36	10 356

^[3] Überwachungs-, Berichterstattungs- und Prüfungs-Verordnung, Federal Law Gazette II No. 339/2007, as amended

Year	Iron and Steel Production				Electric Steel Production		Total CO ₂ eq [kt]
	Iron [kt]	Steel [kt]	CO ₂ [kt]	CH ₄ [t]	Electric Steel [kt]	CO ₂ [kt]	
2017	6 326	7 412	11 069	148	723	40	11 113
2018	5 263	6 176	9 390	141	721	41	9 435
2019	5 741	6 882	10 300	139	710	39	10 343
2020	5 286	6 187	9 448	150	680	34	9 486
2021	6 131	7 195	10 962	146	687	40	11 006
2022	5 803	6 834	10 241	192	675	39	10 285
1990-2022	+69%	+74%	+50%	-17%	+82%	+100%	+50%

4.4.1.3 Category-specific QA/QC

Coke input from the energy balance is compared with coke input reported by the operator. Pig iron and steel production figures are compared with international published data (International Iron and Steel Institute) to ensure completeness. For 2005–2022, detailed information on the carbon mass balance applied by the company to calculate total emissions from pig iron and basic oxygen furnace steel were available from the EU ETS. Thus it was possible to validate CO₂ emissions with this background data.

The annual emission reports of the plant covered by the above mentioned ordinance regarding monitoring, reporting and verification of GHG emissions are checked by independent verifiers before submitting to the competent authority. On behalf of the Federal Ministry of Agriculture, Forestry, Environment and Water Management, the Umweltbundesamt conducts spot checks of the annual emissions and verification reports, time series consistency and consistency with monitoring plans.

In addition, the data included in the annual emission reports were checked regarding completeness and plausibility and they were also compared with national and international statistics (Statistic Austria and World Steel association⁷⁹).

4.4.1.4 Uncertainty Assessment

The iron and steel industry is related to the energy sector, as the major share of CO₂ emissions results from the use of fossil fuel as reducing agent and for combustion. Thus, the same uncertainty values as for solid fuel combustion in large point sources have been applied, namely 0.5% for activity data and 0.5% for emission factor; this leads to an overall uncertainty for CO₂ emissions of 0.7% (WINIWARTER 2007).

4.4.1.5 Recalculations

2.C.1.b Steel

CH₄ emissions for 2021 that were extrapolated in previous inventories have now been updated (recalculation difference 2021: - 0.11 kt CO₂e).

⁷⁹ World Steel Association statistics archive, <https://www.worldsteel.org/steel-by-topic/statistics.html>

4.4.2 Ferroalloys Production (2.C.2)

4.4.2.1 Source Category Description

Emissions: CO₂

Key source: No

Ferroalloy production involves a metallurgical reduction process which results in CO₂ emissions.

This category is a minor source of CO₂ emissions in Austria: in 2022, emissions from this source contributed 0.02% to national total emissions.

4.4.2.2 Methodological Issues

Emissions were estimated using the IPCC Tier 1b methodology.

Only one company produces ferroalloys in Austria. Activity data of ferro-molybdenum, ferro-vanadium and ferro-nickel production from 1995 to 2010 were taken from publications of the *British Geological Survey* (BRITISH GEOLOGICAL SURVEY 2001, 2005–2012). As no data were available for 1990–1994, the value from 1995 was taken as a proxy for these years. For 2011, data was directly obtained from industry (personal communication) due to the late publication of the relevant report by the British Geological Survey. Similarly, data for 2012 to 2022 were obtained via personal communication from the British Geological Survey (BRITISH GEOLOGICAL SURVEY 2023), as the report had not been published at the time of emission calculation and the producer does not directly pass on information to the Umweltbundesamt. The identical value reported for 2018 and 2019 was confirmed by the British Geological Survey as the company's data.

The emission factor for ferro-nickel of 1.36 t CO₂/t product was taken from SJARDIN (2003) and applied to all ferroalloys as no specific emission factors for ferro-molybdenum and ferro-vanadium were available. Investigations were carried out in order to find adequate emission factors for ferro-molybdenum and ferro-vanadium. However, other countries where the production of ferroalloys is relevant are using country/plant specific emission factors. Therefore the emission factor used at present (based on a company specific report) was maintained.

Table 142: Activity data and emissions from ferroalloys production 1990–2022

Year	Ferroalloys production [kt]	CO ₂ emissions [kt]
1990	15.3	20.8
1995	15.3	20.8
2000	13.9	18.9
2005	13.8	18.7
2010	14.5	19.7
2011	14.5	19.7
2012	14.5	19.7
2013	14.5	19.7
2014	14.5	19.7
2015	14.5	19.7
2016	14.5	19.7
2017	14.5	19.7
2018	13.5	18.4

Year	Ferroalloys production [kt]	CO ₂ emissions [kt]
2019	13.5	18.4
2020	12.5	17.0
2021	12.5	17.0
2022	12.5	17.0
1990–2022		-18%

4.4.2.3 Uncertainty Assessment

The uncertainty of activity data is assumed to be 5%. The uncertainty of the emission factor is estimated to be about 25%. This leads to a combined uncertainty of 25.5%.

4.4.2.4 Recalculations

No recalculations have been carried out since the last submission.

4.4.3 Aluminium Production (2.C.3)

4.4.3.1 Source Category Description

Emissions: PFCs, SF₆ and CO₂

Key Source: Yes (PFCs, SF₆ and CO₂)

This category includes emissions of CO₂, PFCs and SF₆ from aluminium production and is now a minor source of GHG in Austria: in 2021, emissions from this source amounted to 0.01% of the national total.

It is a key category for PFC emissions because of the contribution to the total level of greenhouse gas emissions in 1990; and a key source for both SF₆ and CO₂ emissions in terms of emission trends.

Primary aluminium production in Austria was terminated in 1992. Two PFCs, tetrafluoromethane (CF₄) and hexafluoroethane (C₂F₆) are emitted from the process of primary aluminium smelting. They are formed during the phenomenon known as the anode effect (AE). CO₂ emissions arise from the consumption of the anode in the production process.

During secondary aluminium production CO₂ emissions occur, arising from organic impurities of aluminium scrap.

Until 1999 SF₆ was used in aluminium casting as a fire quencher, and again in minor amounts for special applications (not on a regular basis) from 2006-2019.

Table 143 presents CO₂ and PFC emissions from primary aluminium production for the period from 1990 to 1992 and the SF₆ and CO₂ emissions from secondary aluminium production.

Table 143: CO₂ and PFC emissions from primary aluminium production from 1990 to 1992 as well as SF₆ and CO₂ emissions from secondary aluminium production from 1990 until 2022

Year	Primary aluminium production		Secondary aluminium production	
	CO ₂ emissions [kt]	PFC emissions [t]	CO ₂ emissions [kt]	SF ₆ emissions [kg]
1990	150	148	0.62	600.0
1995	NO	NO	0.62	600.0
2000	NO	NO	1.95	0.0
2005	NO	NO	1.38	0.0
2010	NO	NO	3.85	12.0
2011	NO	NO	3.96	6.8
2012	NO	NO	3.94	3.0
2013	NO	NO	4.09	1.5
2014	NO	NO	4.98	12.0
2015	NO	NO	4.92	1.5
2016	NO	NO	4.72	3.0
2017	NO	NO	5.43	3.0
2018	NO	NO	4.70	4.2
2019	NO	NO	4.93	0.3
2020	NO	NO	4.86	NO
2021	NO	NO	6.22	NO
2022	NO	NO	5.31	NO
1990–2022	-100%	-100%	+762%	-100%

4.4.3.2 Methodological Issues

For **primary aluminium production** CO₂ emissions were calculated by applying the IPCC default emission factor of 1.7 t CO₂/t aluminium produced taken from the IPCC 2006 Guidelines.

PFC emissions were estimated using the IPCC Tier 3b methodology. The specific CF₄ emissions (and C₂F₆ emissions respectively) of the anode effect were calculated by applying the following formula (BARBER 1996), (GIBBS & JACOBS 1996), (TABERAUX 1996):

$$\text{kg CF}_4/\text{t}_{\text{Al}} = (1.7 \times \text{AE}/\text{pot}/\text{day} \times F \times \text{AE}_{\text{min}})/\text{CE}$$

Where: *AE/pot/day* = frequency of occurrence of the anode effect (dependent on type of oxide supply (1,2/day)
t_{Al} = effective production capacity per year [t] *CE* = current efficiency (85%)
AE_{min} = anode effect duration in minutes (5 min) *1.7* = constant resulting from Faraday's law
F = fraction of CF₄ in the anode gas (13%)

In Austria so called "Søderberg" anodes were used. The technology applied was head to head HSS. The frequency of the anode effect (AE/pot/day) was about 1.2 per day. The duration of the anode effect (AE_{min}) was in the range of 4 to 6 minutes. The average fraction of CF₄ formed in percent of the anode gas (F) can be determined as a function of the duration of the anode effect. International values are about 10% after two minutes, 12% after three minutes and after that there is only a marginal increase. Therefore for Austrian aluminium production a CF₄ fraction in the anode gas of 13% was assumed.

Because C_2F_6 is formed only during the first minute of the anode effect, the rate of C_2F_6 is the higher the shorter the duration of the anode effect is. For the aluminium production in Austria the rate of C_2F_6 is about 8% and the current efficiency (CE) about 85.4%.

Activity data were taken from national statistics (88 021 t for 1990 and 1991, and 35 000 t in 1992).

By inserting these data into the formula mentioned above an emission factor of 1.56 kg CF_4 /t aluminium was calculated. The resulting emission factor for C_2F_6 was 0.1248 kg per tonne of aluminium produced.

For **secondary aluminium production**, process CO_2 emissions from one ETS installation for the years 2013 onwards are reported, they arise from organic impurities of aluminium scrap. These emissions are upscaled to total secondary aluminium production in Austria. For the years prior 2013, the implied emission factor of 2013 is used and applied to activity data obtained from national statistics and from industry representatives, respectively.

In secondary aluminium smelting works (**aluminium casting**) inert gases are used to remove, prior to casting, hydrogen as well as alkaline and alkaline earth metals and solids from smelt to prevent porosity in the cast pieces (aluminium cleaning). Until 2000 inert gases with SF_6 concentrations of 1–2.5% were used, it is assumed that all SF_6 is emitted during use.

From the (formerly) six secondary aluminium smelters only one started the use of SF_6 as cleaning gas again from 2006 onwards until 2019 when the plant was closed. For these recent years an EF of 1.5% of SF_6 consumed was applied. This EF is based on measurements in a German aluminium plant that have shown significant destruction of SF_6 (decomposition into sulphur and fluorine) during the process (SCHWARZ & GSCHREY 2009).

4.4.3.3 Uncertainty Assessment

AD uncertainty is assumed to be 20%.

The uncertainty for the PFC emission factors ("Söderberg" process) is between 30–80% according to the IPCC. Activity data do not influence the uncertainty of emissions to that extent, because PFCs are formed during the anode effect that is associated with the EF. Assuming a mean value for the emission factor, the uncertainty of the PFC EF is assumed to be 50%. This leads to a combined uncertainty for PFC emissions of 54%.

Uncertainty of CO_2 EF is assumed to be 5% (it is based on detailed ETS data), which results in an uncertainty of 21% for CO_2 emissions.

4.4.3.4 Recalculations

No recalculations have been carried out since the last submission.

4.4.4 Magnesium Production – Magnesium Foundries (2.C.4)

4.4.4.1 Source Category Description

Emissions: SF_6

Key Source: Yes (SF₆)

This category includes emissions of SF₆ from magnesium foundries. This source is a key category due to its trend in emissions.

In 2022, SF₆ emissions from magnesium foundries contributed 0.003% to the total amount of greenhouse gas emissions in Austria, whereas the contribution was 0.3% in 1990.

Molten magnesium spontaneously burns in the presence of atmospheric oxygen. Therefore, in magnesium casting SF₆ is used in small amounts in blends with carrier gases as a protective cover gas to prevent oxidation and ignition and to quench fires of molten magnesium. It has been a common assumption that the SF₆ in magnesium cover gas will not be destroyed but more or less completely emitted. Recent studies showed that SF₆ undergoes destruction to some degree. Industry introduced alternative cover gases in the last years.

Table 144 presents SF₆ emissions from magnesium for the period from 1990 to 2022.

As can be seen in the table below, SF₆ emissions have been fluctuating during the period, but the overall trend has been decreasing SF₆ emissions; from 1990 to 2022 they decreased by 99%. This decreasing trend is explained by technological advances (rebuilt magnesium foundry) and the replacement of SF₆ by other substances (N/CO₂/SO₂; SO₂/N₂) used as a cover gas; since 2008 the use of SF₆ per foundry is limited to 850 kg per year in Europe⁸⁰. Currently, only one magnesium foundry uses SF₆ as a cover gas for one particular magnesium alloy that is produced irregularly.

Table 144: SF₆ emissions from magnesium foundries 1990–2022

Year	SF₆ emissions [t] from magnesium production
1990	10.00
1995	17.94
2000	1.55
2005	0.20
2010	0.00
2011	0.00
2012	0.19
2013	0.39
2014	0.67
2015	0.10
2016	0.10
2017	0.67
2018	0.24
2019	0.14
2020	0.20
2021	0.20
2022	0.10
1990–2022	-99%

⁸⁰ Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases.

4.4.4.2 Methodological Issues

Emissions were estimated following the IPCC methodology using annual consumption data of SF₆.

Information about the amount of SF₆ used was obtained directly from the magnesium producer in Austria and thus represents plant-specific data. Actual emissions of SF₆ equal potential emissions and correspond to the annual consumption of SF₆ for magnesium casting. During the last ten years, two magnesium casting companies existed in Austria which at some point used SF₆ as fire-extinguishing cover gas. One company changed to a N₂/CO₂/SO₂-system. The other company changed to fluorinated ketone (Novec) as an alternative cover gas, but continued the use of SF₆ to quench fires.

4.4.4.3 Category-specific QA/QC

The IEFs for magnesium casting (based on the amount of magnesium cast) are below the value of 1.0 kg SF₆ emissions cited in the IPCC 2006 Guidelines (p. 4.66).

4.4.4.4 Uncertainty Assessment

According to the IPCC 2006 Guidelines the uncertainty associated with plant SF₆ use data is assumed to be 5%, the EF uncertainty is also estimated to be 5%, resulting in an overall uncertainty of 7%.

4.4.4.5 Recalculations

No recalculations have been carried out since the last submission.

4.4.5 Lead production (2.C.5)

4.4.5.1 Source Category Description

Emission: CO₂

Key Source: No

Primary lead production existed in Austria until 1993. CO₂ emissions originate from the use of coke as reducing agent. These emissions are reported in Sector 1, because this coke use is included in the energy balance together with the energetic use of coke.

In the secondary lead production CO₂ emissions are caused by the content of substances in the secondary raw material. The secondary lead production from 1990 until 2022 has a fluctuation range of ± app.20%.

This category is a minor source of CO₂ emissions in Austria: in 2022, emissions from this source contributed less than 0.01% to national total CO₂ emissions.

4.4.5.2 Methodological Issues

Activity data until 2016 are taken from the Montanhandbuch (BMFWF 2017), which provides annual data of the Austrian secondary lead production. The CO₂ emissions of secondary lead production are calculated with the IPCC default emission factor of 0.2 t CO₂/t lead produced. For the years 2018-2020 production figures are available in kt only – they were on a constant level of 27 kt. For 2021 and 2022 no data was available, thus the value of 2020 was used as proxy for subsequent years.

Table 145: Activity data and CO₂ emissions from secondary lead production 1990–2022

Year	Secondary lead production [t]	CO ₂ Emissions [kt]
1990	23 511	4.7
1995	21 869	4.4
2000	21 977	4.4
2005	24 357	4.9
2010	25 499	5.1
2011	26 208	5.2
2012	24 504	4.9
2013	24 971	5.0
2014	25 136	5.0
2015	24 399	4.9
2016	25 000	5.0
2017	26 000	5.2
2018	27 000	5.4
2019	27 000	5.4
2020	27 000	5.4
2021	27 000	5.4
2022	27 000	5.4
1990–2022		+15%

4.4.5.3 Uncertainty Assessment

The uncertainty of the emission factor is assumed to be 50% (IPCC default value) and the uncertainty of activity data to 5%. This leads to a combined uncertainty of 50.25%.

4.4.5.4 Recalculations

No recalculations have been carried out since the last submission.

4.5 Non-Energy Products from Fuels and Solvent Use (Category 2.D)

4.5.1 Source Category Description

Emissions: CO₂ (some of those are emitted indirectly)

Key category: Yes (CO₂)

This chapter entails CO₂ emissions from non-energy products from fuels and indirect CO₂ emissions from solvent use in Austria. The direct emissions arise from lubricant use and from paraffin waxes, indirect emissions are calculated from NMVOC emissions from solvent use.

In the year 2022, 0.2% of total GHG emissions in Austria (172.5 kt CO₂ equivalents) originated from category 2.D Non-Energy Products from Fuels and Solvent Use. The overall trend in greenhouse gas emissions in this sector shows decreasing emissions, with a decrease of 50.6% from 1990 to 2022, due to legal measures related to solvent use.

Figure 24: Emissions from Sector 2.D, Non-Energy Products from Fuels and Solvent Use, 1990–2022

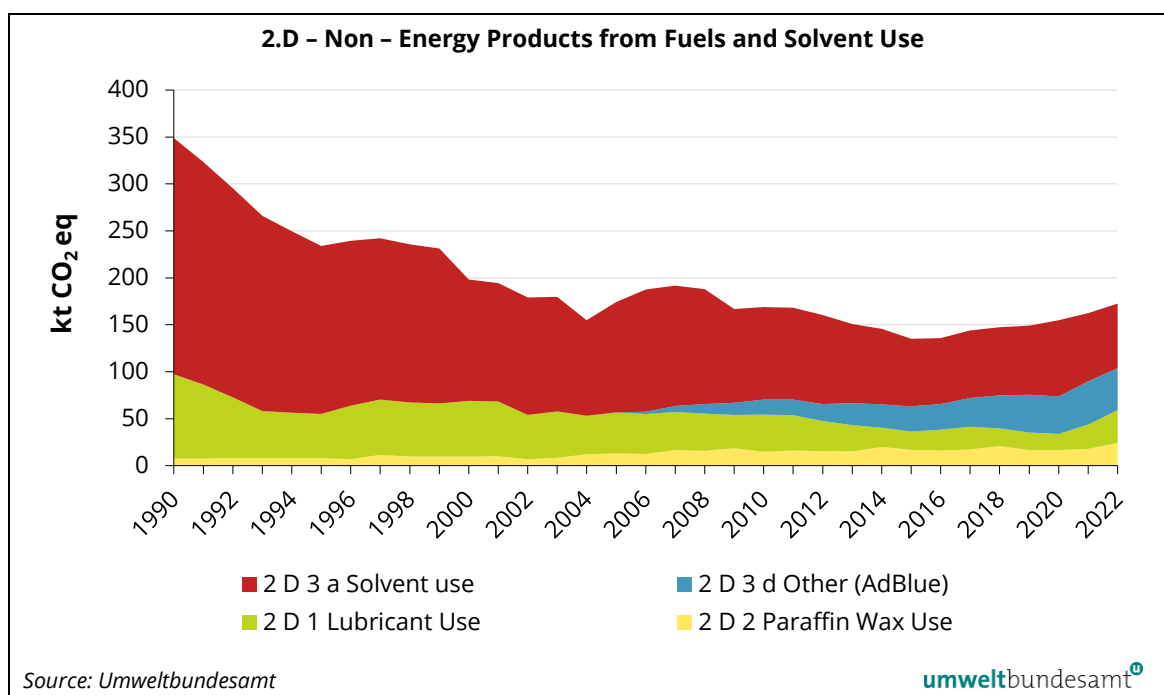


Table 146 presents the trend in total greenhouse gas emissions by subcategories.

Table 146: Total greenhouse gas emissions and trend from 1990–2022

	2.D.1	2.D.2	2.D.3.a	2.D.3.d
Year	Lubricant Use	Paraffin Wax Use	Solvent use	Other (AdBlue)
1990	89.5	7.7	251.8	NO
1995	47.2	8.0	178.8	NO
2000	59.5	9.5	129.4	NO
2005	43.4	13.1	117.5	0.4
2010	39.3	14.9	98.5	16.3
2011	37.5	16.2	97.8	16.6
2012	32.1	15.4	94.7	18.1
2013	27.9	15.2	84.4	23.4
2014	20.6	19.9	80.3	24.9
2015	19.5	16.9	71.9	26.9
2016	22.0	16.1	70.3	27.6

	2.D.1	2.D.2	2.D.3.a	2.D.3.d
Year	Lubricant Use	Paraffin Wax Use	Solvent use	Other (AdBlue)
2017	24.3	17.1	72.1	30.5
2018	18.6	21.0	72.6	35.1
2019	18.5	16.6	73.5	40.3
2020	17.1	16.6	81.0	40.2
2021	26.0	17.8	72.7	45.8
2022	34.7	24.4	68.8	44.6
1990–2022	-61%	+218%	-73%	

4.5.2 Methodological issues

4.5.2.1 Lubricant Use (2.D.1)

Emission calculation follows the methodology of the IPCC 2006 Guidelines: The amount of lubricants used in Austria was taken from the Energy Balance (total final non energy use consumption).

Lubricants used for 2-stroke engines were not reported separately due to lack of data. As a rough estimate of the amount of lubricants used in the 431 million km driven by 2 stroke engines per year amount to only 1 kt CO₂, these emissions are considered to be taken into account by using an ODU factor of 0.2 for the total lubricant use of Austria.

Lubricant Use was estimated according to the IPCC Tier 1 method described in the Guidelines:

$$\text{CO}_2 \text{ emissions} = \text{LC} * \text{CC}_{\text{Lubricant}} * \text{ODU}_{\text{Lubricant}} * 44/12$$

Where: *LC* = total lubricant consumption in TJ (taken from the Austrian Energy Balance)
CC_{Lubricant} = default value of carbon content of lubricants (20 t C/TJ)
ODU_{Lubricant} = ODU factor (0.2), based on default composition of oil and grease)
44/12 = mass ratio of CO₂/C

4.5.2.2 Paraffin Wax Use (2.D.2)

Paraffin waxes are used in applications such as: candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, surfactants and many others. Emissions from the use of waxes derive primarily when the waxes or derivatives of paraffins are combusted during use (e.g. candles) when they are incinerated with or without heat recovery or in wastewater treatment. In the cases of incineration and wastewater treatment, the emissions should be reported in the energy or waste sectors respectively. It is also assumed that boxes and papers, as well as food production are accounted for in the respective sectors.

Activity data for paraffin wax use is taken from the import and export statistics of candles and wax products, as well as the production statistics of candles. Production statistics on candles are only available for the past 8 years, for the years before the average of available data was used for the rest of the reporting period. As statistical data on the imports and exports was only available until 1995, the years before were correlated with population growth.

The amount of candles used in Austria was then converted into TJ, using a Net Calorific Value of 40.2 TJ/kt, from this CO₂ emissions were calculated according to the IPCC Guidelines Tier 1 method:

$$\text{CO}_2 \text{ Emissions} = \text{PW} * \text{CC}_{\text{wax}} * \text{ODU}_{\text{wax}} * 44/12$$

Where: PW = total wax consumption in TJ

ODU_{wax} = ODU factor for paraffin wax, fraction (0.2)

CC_{wax} = carbon content of paraffin wax (default, 20 t C/TJ)

$44/12$ = mass ratio of CO_2/C

4.5.2.3 Other: Solvent Use (2.D.3.a)

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 .

Please refer to Austria's IIR (UMWELTBUNDESAMT 2024b) for a detailed description of the methodologies used. For the calculation of CO_2 , the default conversion factor of 2.2 t CO_2 /t NMVOC (taken from the IPCC 2006 GL) was applied.

4.5.2.4 Other: Urea used as a catalyst (2.D.3.d)

This contains emissions of the additive 'AdBlue' which is used in transportation. 'AdBlue' is the generic name of a 32.5% urea-water solution used to reduce NO_x emissions in SCR catalytic converters used in road- and off-road transportation. During that process, CO_2 emissions occur that are taken into consideration in this sector. 'AdBlue' has been in use since 2004 for heavy vehicles, and since 2014 for passenger cars. In literature, the 'AdBlue' consumption is usually given as a volumetric ratio of the fuel consumption (litres of 'AdBlue' equivalent to litres of diesel). Common values for this are, for example, 3–5% for EURO IV vehicles and 4–6% for Euro V SNF. For the inventory a more detailed approach is used which considers the specific operating condition of the SCR exhaust gas after-treatment system in any driving condition (REXEIS et al. 2013).

4.5.3 Uncertainty Assessment

For the subcategory 2.D uncertainty for the emission factors is estimated to be 30%, and for activity data 20%. This results in a combined uncertainty of 36%.

4.5.4 Recalculations

2.D.3.ai Other: Solvent Use

Data on facility level that is prepared by the operators according to the VOC directive were collected and incorporated. During intensive QC of the data, which included comparison with the data of 2015 and 2019, some corrections of the data for 2015 and 2019 were made, leading to a recalculation for most sub-categories from 2015 onwards. Also, corrections on the top down data were made: besides correction of minor transcription errors for the years 2016ff, non-solvent use of a new company became available which was considered for 2021, leading to a decrease of total solvent use in Austria. As bottom up data is extrapolated to this value, this resulted in lower activity

data and thus lower emissions for 2021. Overall, the recalculation difference 2021 in this subcategory is –2.95 kt CO₂e.

4.5.5 Planned Improvements

2.D.3.ai Other: Solvent Use

It is planned to collect bottom up data reported by industrial installations under the Austrian Solvents Ordinance framework and to re-evaluate the emission estimate for domestic solvent use.

4.6 Electronics Industry (Category 2.E) – Integrated Circuit or Semiconductor Manufacturing (2.E.1)

4.6.1 Source Category Description

Emissions: HFC, PFC, SF₆, NF₃

Key Source: yes (SF₆-2.E)

All emissions from 2.E Electronics Industry arise from subcategory 2.E.1 Integrated Circuit or Semiconductor.

4.6.2 Methodological Issues

Three semiconductor manufacturing companies in Austria currently emit CF₄, CHF₃, C₂F₆, C₃F₈, C₄F₈, NF₃ and SF₆. Emissions are calculated by the companies from the annual consumption of each fluid by plant and the effectiveness of the respective abatement technologies (Tier 2a according to IPCC 2006). According to the reporting obligation under the Austrian Industrial Gas Ordinance (see next chapter for more information), semiconductor manufacturers have to report their use of fluorinated gases every year. Therefore, plant specific data is available since 1999. In the manufacturing plants of one operator, fluorinated gases are used in a closed system, where they are recycled for repeated use. These gases were reported as potential emissions in earlier years.

Because of confidentiality claimed for consumption data in this industry emissions are reported in the CRF only for the sum of HFC and PFC. Gases and their applications are presented below:

- SF₆: Isolation gas for high-voltage measurement / process gas for plasma-etching,
- CF₄, C₂F₆, C₃F₈, C₄F₈, NF₃: Process gas for plasma-etching / cleaning chemical vapour deposition,
- CHF₃: Process gas for plasma-etching

Emission Trends

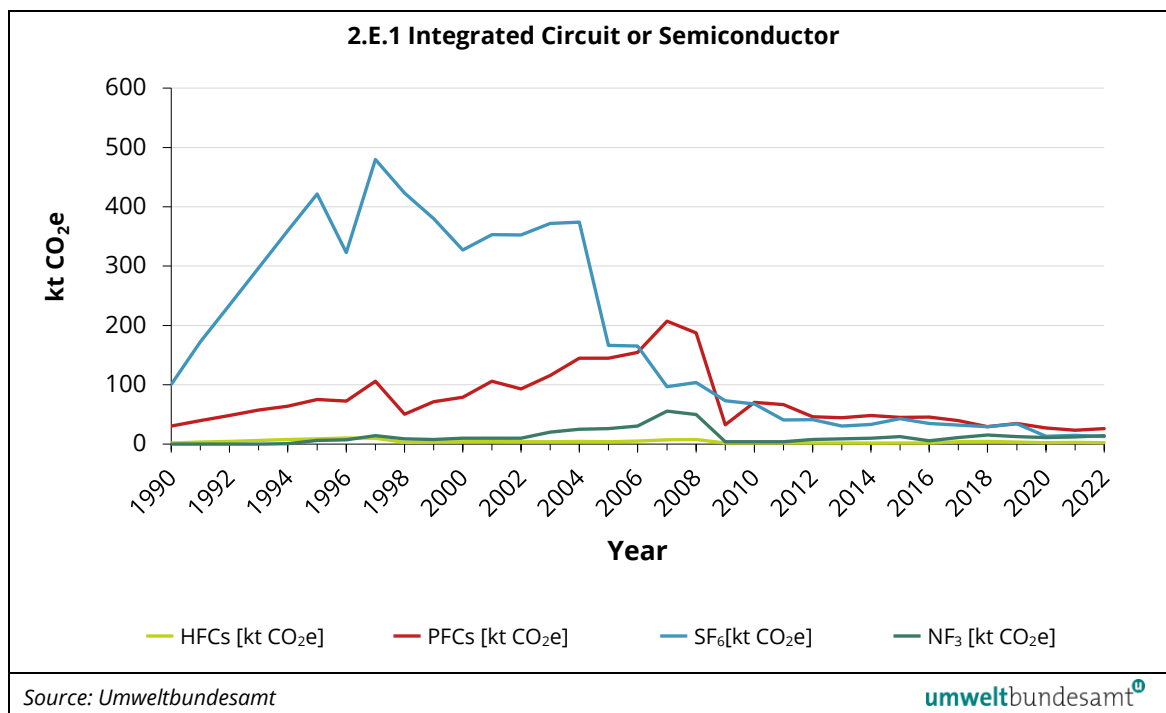
Emissions of this sector amount to 0.3% of the emissions of the IPPU sector, and to 0.08% of the national total. Emissions in 2022 were 58% lower than in 1990.

Emissions of PFCs and SF₆ were constantly increasing during the 1990s, until one semiconductor manufacturer quadrupled its exhaust air purification capacity between 1997 and 1998, reducing emissions remarkably. The increasing emissions of CF₄, C₂F₆ and SF₆ in the other years are due to an increase of semiconductor production. The lower emissions in 2009 compared to 2008 are due to the economic crisis that very strongly affected the manufacture of semiconductors. From 2019 to 2020, emission dropped by 36% due to the economic downturn as a result of the Covid 19 pandemic. In 2022, emissions levels are similar to the ones reported for 2020.

Table 147: Emissions of Sector 2.E Electronics Industry.

Year	HFCs	PFCs	SF ₆	NF ₃	Total
[kt CO ₂ e]					
1990	2.04	30.62	100.39	0.00	133.05
1995	9.04	75.28	421.59	6.03	511.93
2000	4.01	79.09	327.10	9.84	420.03
2005	4.22	144.93	166.31	26.36	341.82
2010	1.72	70.51	67.57	3.85	143.65
2011	1.73	66.43	40.69	3.84	112.69
2012	1.75	45.95	41.11	8.02	96.83
2013	1.77	44.62	30.62	9.13	86.14
2014	1.68	48.02	33.18	9.89	92.78
2015	1.98	44.89	42.95	12.60	102.43
2016	1.79	45.65	34.60	5.75	87.79
2017	3.77	39.75	32.17	11.24	86.93
2018	4.30	29.40	29.26	15.46	78.41
2019	3.39	34.70	34.31	12.74	85.13
2020	2.58	27.02	13.35	11.27	54.22
2021	2.90	23.40	15.02	11.96	53.28
2022	2.57	26.02	12.75	14.13	55.46
1990-2022	+26%	-15%	-87%		-58%

Figure 25: Emissions from 2.E.1 Integrated Circuit or semiconductor



According to the Association of Electronics Industry (FEEI – Fachverband der Elektro- und Elektronikindustrie), all three producers emphasized that no specific use of gases as ‘Heat Transfer Fluids’ can be reported, as these are competing processes. This is why there is no activity data reported under 2.E.4.

4.6.3 Category-specific QA/QC

EF obtained by industry inquiries were compared with the IPCC default values.

4.6.4 Uncertainty Assessment

Activity data (consumption) uncertainty is estimated to be low (5%) because information from all considered producers is used for inventory preparation. The uncertainty for emission factors is estimated to be 10%. This leads to a combined uncertainty of emissions of 11.2%.

4.6.5 Recalculations

No recalculations have been carried out since the last submission.

4.7 Product Uses as Substitutes for Ozone Depleting Substances (Category 2.F)

4.7.1 Source Category Description

Emissions: HFC, PFC

Key Source: yes (2.F.1: HFC)

This category includes the following emission sources:

- refrigeration and air conditioning equipment
- foam blowing
- fire extinguishers
- aerosols
- solvents

There is no production of Halocarbons in Austria.

On the European level, the so-called F-gas Regulation⁸¹ includes a number of measures to reduce emissions such as recovery of equipment containing F-gases for e.g. refrigeration, air conditioning and heat pump equipment, equipment containing F-gas based solvents, fire protection systems and fire extinguishers, high-voltage switchgear (Article 4 of the F-gas Regulation).⁸²

This Regulation is implemented by the Austrian Ordinance on Qualification and Certification measures. According to Article 2(2) of this Ordinance, personnel in charge of handling, refilling etc., have to prove their knowledge about recovery techniques and prevention of emissions.

The F-gas regulation was repealed in 2014, and replaced by Regulation (EU) No 517/2014 of the European Parliament and of the council of 16 April 2014 on fluorinated greenhouse gases. This new regulation provides, in addition to the above mentioned measures, the legislative background to cutting back the amount of F-gases placed on the market inside the EU. This will mostly affect emissions in sector 2.F.

Emission Trends

For the category *2.F Product Uses as Substitutes for Ozone Depleting Substances*, greenhouse gas emissions started to occur in 1993 due to the use of HFCs as substitutes for ozone depleting substance (ODS Substitutes⁸³) mainly for foam blowing. From 2000 onwards the main use is as a refrigerant.

⁸¹ Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases.

HFKW-FKW-SF6-Verordnung BGBl. II Nr. 447/2002 (Industriegasverordnung)

Ordinance on the limitation of emission during the use of solvents containing lightly volatile halogenated hydrocarbons in industrial facilities and installations Federal Law Gazette II No. 411/2005⁸².

F-Gas Regulation 2006, replaced by F gas regulation 2017/2014

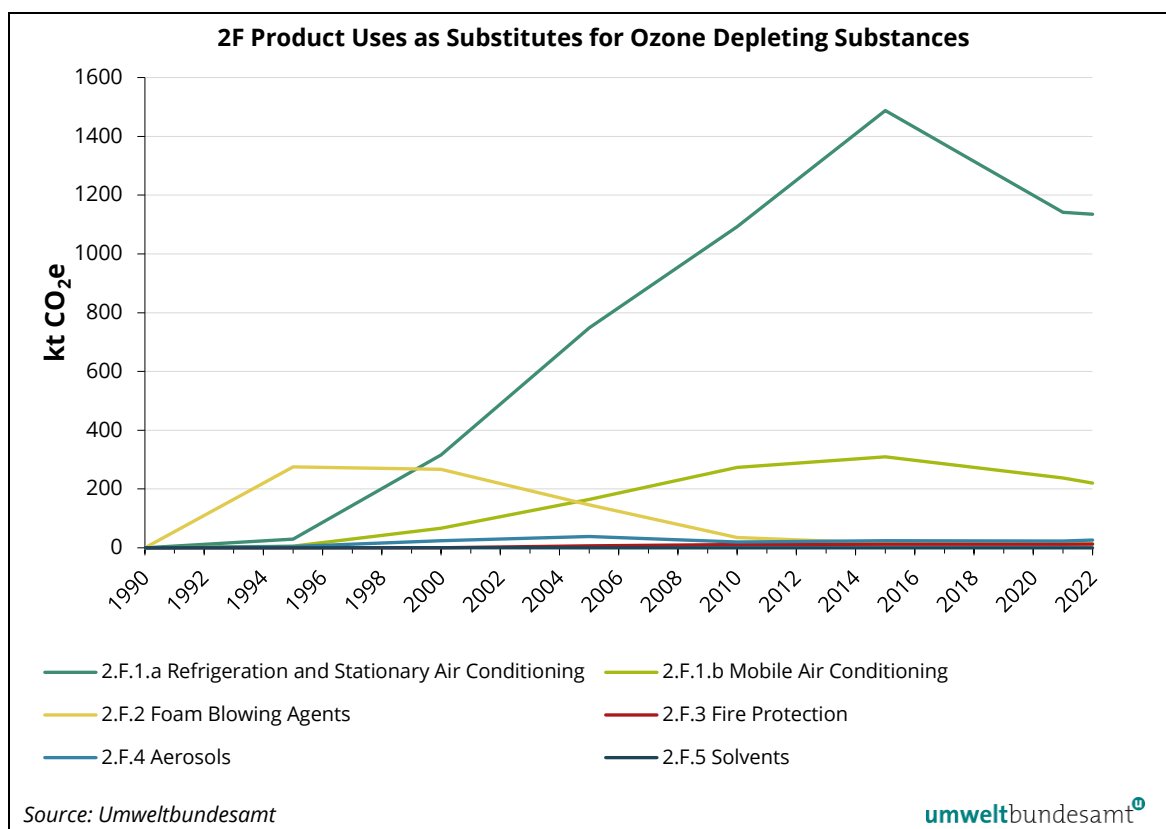
⁸³ ODS are regulated under the Montreal Protocol and are therefore not considered under the UNFCCC and the Kyoto Protocol

In 2022, F-Gas emissions from Category 2.F amounted to 1.41 Mio t CO₂ equivalents. Emissions strongly increased since 1993 as HCF have been used increasingly as refrigerant, as well as other uses described below. In 2019, emissions from this sector started to decline for the first time, which is due to the effects of the EU F-Gas regulation (Regulation No. 2017/2014) and the MAC directive.

Table 148: Emissions from 2.F Product Uses as Substitutes for Ozone Depleting Substances.

Year	2.F.1.a Refrigeration and Sta- tionary Air Conditioning	2.F.1.e Mobile Air Conditioning	2.F.2 Foam Blowing Agents	2.F.3 Fire Protection	2.F.4 Aerosols	2.F.5 Solvents
[kt CO ₂ e]						
1990	NO	NO	NO	NO	NO	NO
1995	29.96	5.74	275.30	NO	4.09	NO
2000	315.62	66.41	267.35	0.03	24.53	0.38
2005	748.83	164.88	146.12	6.40	38.44	NO
2010	1 092.94	273.40	34.70	11.00	19.89	NO
2011	1 187.82	288.29	15.99	13.14	19.93	NO
2012	1 258.87	296.74	15.83	12.92	20.51	NO
2013	1 327.18	300.32	15.66	10.67	22.31	NO
2014	1 396.57	303.72	15.50	11.58	23.26	NO
2015	1 487.61	309.53	15.34	11.67	23.84	NO
2016	1 462.12	313.26	15.19	11.12	24.87	NO
2017	1 499.88	301.63	15.03	12.23	24.92	NO
2018	1 535.15	286.51	14.88	23.51	25.83	NO
2019	1 433.79	265.26	14.73	12.16	25.70	NO
2020	1 349.96	248.82	14.58	10.71	23.62	NO
2021	1 141.76	237.09	14.44	11.74	23.26	NO
2022	1 134.98	220.27	14.30	12.47	26.51	NO
2005–2022	48%	+34%	-90%	+95%	-31%	

Figure 26: Emissions from 2.F Product Uses as Substitutes for Ozone Depleting Substances.



4.7.2 Methodological Issues

Data about consumption of HFC, PFC and SF₆ were mainly obtained directly from importers and end users.

Starting in 2004, there is also a reporting obligation under the Austrian Industrial Gas Ordinance⁸⁴ for users of fluorinated gases in the following applications: refrigeration and air-conditioning, foam blowing, semiconductor manufacture, electrical equipment, fire extinguishers and aerosols. Data is either reported electronically with a system set up by the Umweltbundesamt or per mail (electronic or letter) to the Ministry for Environment (these reports are then forwarded to the Umweltbundesamt to be combined with data from the electronic system).

The first reporting year is 2003, from this year on the end users of fluorinated gases are obliged to report annually about the amounts used and recycled. Theoretically, almost the entire activity data used for inventory preparation is covered by the reporting obligation. Data for semiconductor manufacture (2.E) and electrical equipment (2.G) and partly for other sub sectors are taken from this data base⁸⁵. However, especially the refrigeration sector is large and diverse, there are numerous small enterprises, and not all of them are organised in an industry association, they are hard to

⁸⁴ Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über Verbote und Beschränkungen teilfluorierter und vollfluorierter Kohlenwasserstoffe sowie von Schwefelhexafluorid (HFKW-FKW-SF₆-V), Federal Law Gazette II No. 447/2002

⁸⁵ For semiconductor manufacture, plant specific data is available for the whole time series; for the other categories the data had to be extrapolated for the other years (see respective sub chapters for description).

reach and to inform about the reporting obligation. In the course of an update of the model, this problem is currently being tackled. Therefore not all enterprises reported their consumption and it was necessary to apply a top down methodology for this sector: information on total import of refrigerants was obtained from all relevant importers, refrigerants used in other subsectors were subtracted and the remaining quantities were allocated in the refrigeration and air conditioning sector.

Actual emissions for all subcategories were estimated using a country specific methodology; emission factors are based on information from experts from the respective industries. For most sources, emissions are calculated from annual stocks using emission factors. Additionally emissions can occur during production or disposal of halocarbon/SF₆ containing products, and all these emissions have been accounted for. Annual stocks correspond to the amounts of FCs stored in applications in the previous year, minus emissions of the previous year, plus consumption of the previous year.

The following subchapters present emission factors and data sources used for the respective subcategories.

Methodologies have been developed in studies addressing the country-specific situation:

- UMWELTBUNDESAMT (2001b): All sub categories of Category 2.F for 1990 to 2000
- OBERNOSTERER et al. (2004): Re-evaluation of sub category foam blowing
- Austrian estimates of emissions from the sources 2.F.4 Aerosols and 2.F.5 Solvents, based on a European evaluation of emissions from this sector (HARNISCH & SCHWARZ (2003), disaggregated to provide a top-down estimate for Austria.
- LEISEWITZ & SCHWARZ (2010): All sub categories of Category 2.F for the years 2000 to 2007; some sub categories for 2008 as well.
- LEISEWITZ (2012): Category 2.F.1 for the year 2010, which served as a basis for a further re-evaluation of the model (which included several changes described above).

For the years 2008 to 2013, additional data updates were obtained from importers and companies using fluorinated gases, based on the same contacts and data sources as in LEISEWITZ & SCHWARZ (2010).

Table 149 provides the data sources and interpolation methods for each sub-category and each year.

Table 149: Data sources for categories 2.F.1 to 2.F.9.

Category	Data source	
	collected	Intra/extrapolation technique / remarks
Import data for total FC consumption in Austria	2000, 2004, 2007 ¹⁾	Expert judgement based on information from countries with similar structure ¹⁾ (1990–1999)
	2010–2022	Linear (other years)
2.E.1 Electronics Industry – Integrated Circuit or Semiconductor	1990–2022	Information on activity data and measured emissions from all producers

Category	Data source	
	collected	Intra/extrapolation technique / remarks
2.F Product Uses as Substitutes for Ozone Depleting Substances		
2.F.1 a Refrigeration and Stationary Air Conditioning		
Stationary refrigeration - parameters	2007 ¹⁾	Before 2007: expert judgement based on information from countries with similar structure ¹⁾
	2010	After 2010: value of 2010 is used, except for supermarkets where values for 2020 were updated.
	2022 (supermarkets)	Linear (other years)
Commercial refrigeration		
Room air conditioning	2000, 2017–2022	(linear) interpolation based on expert judgement No HFCs prior to 2000
Heat pumps	1990–2022	
Domestic refrigeration	1993, 1994, 2004, 2005	Linear No HFCs in new refrigerators prior to 1993 and after 2008
Transport refrigeration	2000 ⁵⁾ , 2007, 2011 ⁵⁾ , 2015–2022	before 2000: expert judgement based on information from countries with similar structure ¹⁾ Linear (other years)
2.F.1.b Mobile air conditioning	1993–2022	No HFCs in vehicles prior to 1993
2.F.2 Foam blowing agents	2000–2022	Value of 2000 was used for 1993–19992). No HFCs in foams prior to 1993.
2.F.3 Fire protection	1990–2022	
2.F.4 Aerosols	2000–2022	Proportional to GDP
2.F.5 Solvents	2001, 2002	Proportional to GDP
2.G. Other Product Manufacture and Use		
2.G.1. Electrical equipment	1990–1999, 2003–2022	Linear
2.G.2: SF ₆ and PFCs from Other Product Uses		
Noise insulating windows (2.G.2.a)	1999–2003	Based on production data ³⁾
Tyres (2.G.2.a)	1998–2003	No SF ₆ in tyres in other years
Research (2.G.2.b)	1990, 2000–2014, 2016	Linear
Shoes (2.G.2.a)	2003–2005 ⁴⁾	No PFCs in shoes in other years
¹⁾ Leisewitz & Schwarz (2010)		
²⁾ Obernosterer et al. (2004)		
³⁾ Production data and share of noise insulating windows		
⁴⁾ Using data from Germany		
⁵⁾ Using indicators (refilling volume, refilling rates)		

For more information on data sources and methods, please refer to the following subchapters. An overview of emissions of fluorinated gases by sub-category is presented in Table 150.

Table 150: Emissions of IPCC Category 2.F by sub-category 1990, 1995, 2000, 2005, 2010, 2015, 2021, 2022

GHG	GWP	Unit	1990	1995	2000	2005	2010	2015	2021	2022
2.F.1 Refrigeration and Air Conditioning Equipment										
2.F.1.a Refrigeration and Stationary Air Conditioning										
HFC-32	677	t	0.00	0.66	11.09	33.03	50.67	78.07	104.54	112.71

GHG	GWP	Unit	1990	1995	2000	2005	2010	2015	2021	2022
HFC-125	3170	t	0.00	2.66	31.06	81.52	127.65	177.95	142.57	147.81
HFC-134a	1300	t	0.00	7.24	77.32	164.48	187.13	262.29	330.06	325.98
HFC-152a	138	t	0.00	0.01	0.04	0.04	0.01	0.00	0.00	0.00
HFC-143a	4800	t	0.00	2.32	22.35	52.41	82.81	107.54	37.11	32.23
HFC-23	12400	t	0.00	0.04	0.15	0.21	1.07	1.09	0.96	0.94
C3F8	8900	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.F.1.b Mobile Air Conditioning										
HFC-134a	1300	t	0.00	4.42	51.08	126.83	210.31	238.10	182.38	169.44
2.F.2 Foam Blowing Agents										
HFC-134a	1300	t	0.00	203.10	140.56	84.85	9.66	9.34	8.96	8.90
HFC-152a	138	t	0.00	81.68	595.17	204.65	134.36	0.00	0.00	0.00
HFC-245fa	858	t	0.00	0.00	1.50	4.55	2.16	1.92	1.67	1.63
HFC-365mfc	804	t	0.00	0.00	1.50	4.57	2.17	1.94	1.69	1.65
2.F.3 Fire Protection										
HFC-23	12400	t	0.00	0.00	0.00	0.43	0.86	0.86	0.86	0.86
HFC-227ea	3350	t	0.00	0.00	0.00	0.31	0.09	0.30	0.31	0.53
2.F.4 Aerosols										
HFC-134a	1300	t	0.00	3.15	18.87	29.57	15.30	18.00	17.32	19.84
HFC-227ea	3350	t	0.00	0.00	0.00	0.00	0.00	0.13	0.22	0.21
2.F.5 Solvents										
HFC-43-10mee	1650	t	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Total		kt CO₂e	0	315	674	1105	1432	1848	1428	1382.01

4.7.2.1 Refrigeration and Air Conditioning (2.F.1)

This sub sector can be divided into:

- a. Category of stationary refrigeration covering large plants/facilities that are **filled on site**, emissions are estimated using a **top down model**:
 - Industrial refrigeration
 - Other commercial refrigeration (Part of CRF category commercial refrigeration)
- b. Rest of the sector 2.F.1 including parts that are, **for the most part, not filled in Austria (or at least not filled on site)**, emissions are estimated using a **bottom up approach**:
 - Domestic refrigeration
 - Transport refrigeration
 - Mobile air conditioning
 - Stationary air conditioning including heat pumps
 - Supermarkets (part of CRF category commercial refrigeration)
 - Commercial stand-alone refrigeration equipment manufacturing (part of CRF category commercial refrigeration)

Details on a) top down model

1. Total refrigerant imported/total refrigerant used

Data on total refrigeration imported is obtained from all relevant importers; values were available for the years 2000, 2004, 2007 and all years from 2010 onwards. There are a handful of large importers that cover about 95% of the market. Additionally there are several small importers that change over the years.

Annual consumptions estimated bottom up (e.g. use for filling of new mobile ACs and refilling of mobile ACs and transport refrigeration in Austria) were subtracted from the total.

For 2001 to 2009, the time series was established by interpolation for the years in between where no data on imports/use was available. For the years before 2000, the total consumed amounts were estimated based on information collected by LEISEWITZ & SCHWARZ (2010) in the Austrian industry on the use of HFCs in refrigeration equipment.

Based on their GWPs the refrigerants were grouped into three refrigerant groups (see the following table).

Table 151: Composition of blends (in percent) as used in the top-down model for category 2.F.1.

Groups of refrigerants/blends	Mean composition				GWP used in the model
	R32	R125	R134a	R143a	
Low (GWP up to 1500): R134a, R449a, R513a, R32, R448a, ...	5	6	81	0	1 402
Medium (1500 < GWP < 2500): R410A, R407C, R452A, ...	0	48	7	45	3 792
High (GWP over 2500): R404A, R422D, R507A, ...	37	38	26	0	1 952

Only very small quantities of HFC R-23 are placed on the market. R23 is being used as a replacement of R 13 as a high pressure refrigerant (Class A1) for very low temperatures (more than -50°C) in (medical) research and development and laboratories. R-23 is modelled and considered together with small amounts of other ultra high GWP blends separately.

For reporting of the final results a mean composition was estimated, based on the specific refrigerants used/imported over the time series. The groups of refrigerants and their mean composition are presented in Table 152.

This simplification of the model (grouping refrigerants with similar GWP) leads to a small error in total emissions (typically around 1%), which is negligible compared to total uncertainties. Furthermore, this is outweighed by the advantage of a simple and robust, and thus fully consistent model that also allows easy modelling of measures for projections.

2. Refrigerant consumption in sub categories considered

The total refrigerant use was broken down into the use in each sub category based on information from refrigeration service companies (LEISEWITZ & SCHWARZ 201).

3. Estimation of emissions

The refrigerant consumption equals the sum of refrigerants filled in the new equipment plus refrigerants used for refilling.

In the first year, total consumption is used for filling into new equipment. For the subsequent years a part is used for refilling, where the amount refilled has to equal the amount emitted, and the remaining amount is used for filling of new equipment.

Total consumption was allocated to first-fill and re-fill by an iterative methodology, where the resulting emissions from stock (= the amounts refilled) have to be in such a relation to the calculated stock that implied emission factors correspond to the EF (expert judgement by LEISEWITZ & SCHWARZ 2010).

Values for lifetime of equipment per sector, which are required to calculate the refrigerant stock, as well as EF for emissions from manufacturing (= emissions from first fill), and EF for disposal emissions were also taken from LEISEWITZ & SCHWARZ (2010).

Table 152: Emission factors used for the top down model (IPCC Category 2.F.1).

Sub category	Equipment lifetime	EF for first fill emissions	EF for emissions from stock*	IPCC default EF	EF for disposal
Industrial refrigeration	10	0.2%	9–7%	7–25%	30%
Stationary air conditioning	12	0.05%	10–9%	2–15%	30%
Other commercial refrigeration	14	0.2%	20–15%	10–35%	30%

* an improvement of equipment concerning leakage was considered: the first value is related to the EF for the beginning of HFC use as refrigerants in the mid-1990s, the latter value for 2010-2012.

No data on actually recovered amounts of F-gases is available, especially not based on singular blends. This is due to the fact that recovered gases are mixed and then destroyed most of the time, or increasingly, due to the shortage of refrigerants due to their phase-down, recycled, which is information that is not reported. Recovered amounts reported are calculated by subtracting the amount remaining in installations at decommissioning from end-of-life emissions.

For the sub-categories of 2.F.1 which are included in the top-down approach, time series of emissions are calculated for the three refrigerant groups.

In a final step, for reporting the blends are again split into their main components R32, R125, R134a and R143a according to Table 151.

Details on b) bottom up approach for the rest of the sub category 2.F.1

Domestic refrigeration

Refrigerators for domestic use are mainly imported to Austria (the little production that occurs is considered in commercial refrigeration manufacture).

R134a as refrigerant was introduced by industry at the end of 1993 as replacement of R12 which is a CFC. For this year it was assumed that 100% of the equipment operated with R134a. In the following years R134a was replaced by R600a (iso-butane), therefore – until 2005 – a share of 1% of R134a filled refrigerators was considered. For the years after the share was set to zero as the replacement in Europe was practically complete. An average charge of 0.1 kg per refrigerator was assumed.

The number of new equipment was estimated as approx. 10% of the total number of refrigerators/freezers (with 1.3 fridges/freezers per household) in 1995, amounting to 400.000 per year which was held constant from 1993 to 2005.

EF according to LEISEWITZ & SCHWARZ (2010):

- emissions from stock: 0.3%
- disposal: 30% (life time 15 years)

Transport refrigeration

This group includes refrigerated road vehicles (vans, trucks, trailers). Manufacturing of refrigeration units does not take place in Austria. Emissions occur from stock and from disposal.

LEISEWITZ & SCHWARZ (2010) estimated the stock and refilling of refrigeration units (share of stock = emissions from stocks: 29% for R134a and R410a, 15% for R404a and 10% for R422a) for the year 2007, based on information from a main furnisher of refrigeration units. For the years before 2007 data was extrapolated by LEISEWITZ & SCHWARZ (2010) using information on stock development from the industry expert. Data for 2008–2012 were extrapolated, taking into account additional data for 2011, obtained from the same industry contact person. Data on HFC amounts from 2013 onwards is based on information obtained from transport refrigeration service companies.

An EF for disposal of 30% and a life time of 10 years were estimated by LEISEWITZ & SCHWARZ (2010).

Mobile air conditioning

Sub categories considered were passenger cars, trucks, busses, agricultural machines, rail and manufacturing of vehicles for construction sites. In Austria the use of R134a for mobile AC started in 1994, for passenger cars it ended in 2017 due to the European MAC directive.

Passenger cars

Detailed data on brands and models of newly registered passenger cars was available for 2004. This information was combined by LEISEWITZ & SCHWARZ (2010) with information on HFC charge per AC and AC quota taken from a German study (SCHWARZ 2004). For the other years until 2008 data on new registrations per brand were combined with average fill levels and average AC quotas per brands taken from the same study. The fill levels and AC quotas of 2008 were also used for 2009 and 2010. For 2011 and again for 2012 the AC quotas for the main brands were updated using data from the Austrian subsidiaries. The detailed data covers 93–99% of the new registered cars, total charge for all newly registered cars were extrapolated assuming an average charge and quota of the cars with detailed data for the remaining cars.

Information on amounts filled in new cars within Austria was obtained directly from the producers.

EF estimated by LEISEWITZ & SCHWARZ (2010) applied for

- emissions from manufacturing: 0.7%
- emissions from stock: 10%
- disposal: 30% (life time 12 years)

Trucks

Vans, trucks and trailers were considered separately. R134a charge was taken from a typical model for the different types: For trucks, Mercedes Benz Atego and for trailers, Mercedes Benz Actros average values from SCHWARZ (2004) were used. AC quotas were also taken from SCHWARZ (2004).

Data on new registrations for 2004 was also used for the years until 2009. For the years before the data was estimated by LEISEWITZ & SCHWARZ (2010). From 2010 onwards data on new registrations from Austrian statistics have been used.

EF estimated by LEISEWITZ & SCHWARZ (2010) applied for

- emissions from manufacturing: 0.5%
- emissions from stock: 10%/15%
- disposal 30% (life time 10 years)

Buses

Data on new registrations were taken from Statistics Austria from 2003 onwards; for the years before the data was estimated by LEISEWITZ & SCHWARZ (2010). 55% were estimated to correspond to urban buses, and 45% to coaches. AC quotas and AC charges were taken from SCHWARZ (2004). EF estimated by LEISEWITZ & SCHWARZ (2010) applied for

- emissions from stock 15%
- disposal 30% (life time 10 years)

Agricultural machines

Tractors and harvesters were considered separately. Data on new registrations were taken from Statistics Austria from 2006 onwards, for the years before the data was estimated by LEISEWITZ & SCHWARZ (2010). AC quotas and AC charges were taken from SCHWARZ (2004).

Data on filling in newly manufactured agricultural machines (first fill) in Austria were obtained directly from producers.

EF estimated by LEISEWITZ & SCHWARZ (2010) applied for

- emissions from manufacturing: 0.3%
- emissions from stock: 15%/25%
- disposal: 30% (life time 10 years)

Rail

Rail includes railways, tramways and metro. Data for stocks and production (first fills) were directly obtained from operators and producers.

EF estimated by (LEISEWITZ & SCHWARZ 2010) applied for

- emissions from manufacturing: 0.04%
- emissions from stock: 5%
- disposal: 30%

Vehicles for construction sites

Figures on first fill of vehicles for construction sites were directly obtained from the producers. Emissions were calculated applying a product manufacturing factor of 0.3% (EF estimated by LEISEWITZ & SCHWARZ 2010).

Stationary air conditioning

This category includes small mobile room AC devices, split devices, Variable Refrigerant Flow (VRF), chillers as well as heat pumps.

Chillers and partly VRF devices are imported pre-filled, the assembled system is filled up, or topped up respectively, with refrigerants on site, whereas the other, smaller devices are imported prefilled.

Stationary air conditioning

Data on annual sales as well as the filling volumes, type of used refrigerants (R407C and R410A) and the market development were estimated based on information from the AC industry (LEISEWITZ & SCHWARZ 2010) for the years 2000–2008. Using further information and expert judgments from the AC industry in recent years (2019–2022) a consistent time series for all different devices was established.

Average charges were used for various types of equipment, ranging between 1 and 83 kg per unit, based on data from industry. An average lifetime of 10 years is assumed for small devices and 15 years for VRF and chillers. From this data stocks were estimated. Applied EF were taken from (LEISEWITZ & SCHWARZ 2010) combined with recent information from industry (2.5% for all years for pre-filled devices, and 10% for 1990 to 4% in 2010 for filled on-site devices).

Heat pumps

Heat pumps use energy stored in the ground, ground water or air. The installation of heat pumps with HFC started in Austria in the 1990s. The stock of equipment in 1995 was estimated to be > 50 000 units in total. About 75% of the newly installed equipment in 2017 was dedicated to space heating and about 24% to heating of water for domestic use as the main areas of application. Heat pumps are manufactured in Austria, exports roughly outweigh the imports, thus manufacture roughly equals newly installed systems. F-gases used are R-134a, R-404A, R-407C and R-410A, propane is also of importance.

Underlying data on installed heat pumps are obtained from an annual report (BIERMAYR et al. 2013–2023). The amounts of HFCs filled into the different types of heat pumps and the share of the individual HFCs were estimated by LEISEWITZ & SCHWARZ (2010) using information from industry experts; for 2017 the share of HFC used was updated. Average charges were used for various types of equipment, ranging between 0.7 and 2.5 kg per unit, based on data from industry. The Austrian Heat Pump Association is planning on commissioning a study for the inventory.

Applied EF were also estimated by LEISEWITZ & SCHWARZ (2010):

- product manufacturing 0.1%
- emissions from stock 2%
- disposal 30% (life time 15 years)

Commercial stand-alone refrigeration equipment manufacturing (part of CRF category commercial refrigeration)

Here emissions from manufacturing of small refrigeration equipment mostly for export (“stand-alone” commercial application including also some equipment for domestic refrigeration) are included.

Two Austrian companies manufacture smaller “stand-alone” equipment for commercial and domestic refrigeration (fridges, freezers) with HFC R-134a and R-404A. The equipment is mostly exported. Both companies communicated their data on F-gas consumption. Emissions from manufacturing are estimated to equal 0.1%.

Supermarkets (part of CRF category commercial refrigeration)

Data and information from (LEISEWITZ & SCHWARZ (2010)) was complemented with data from supermarkets from 2015 and 2020 resulting in a time series of consumption, stock and emissions. Information at that level is confidential. A life time of 15 years was applied, which is the upper level of the range given in the IPCC guidelines and is based on information by supermarkets.

4.7.2.2 Foam Blowing Agents (2.F.2)

According to the Austrian Industrial Gas Ordinance the usage of HFC in the area of foam manufacturing and placing on the market is generally prohibited (the ordinance established the possibility of exceptions under specific conditions which were in fact not applied).

Close Cell Foams (2.F.2.a)*XPS plates*

For many years the main blowing agent for manufacturing of XPS hard foam was CO₂. In Austria, from 1995 to 2004 also products blown with R134a were sold and from 2000 to 2010 one Austrian company used R152a as blowing agent for a small portion of about 3% of its XPS production in case of short-dated lots for which CO₂ driven XPS foam is not suitable due to longer storage needs with regard to shrinking behaviour.

Data on R152a consumption were obtained directly from the producer; the total amount consumed is assumed to be emitted during production.

R134a from XPS plates was calculated by LEISEWITZ & SCHWARZ (2010) based on information from industry experts (see Table 153).

25% of consumption is emitted in the production process. Stocks were calculated from the remainder; emissions from stocks were estimated based on information from producers.

Emissions from disposal are not yet to be expected as the lifetime of the foam products is long (around 50 years).

PU hard foam

PU plates and PU sandwich panels blown with R134a were sold in Austria from 2000 to 2004 (usually hydrocarbons and CO₂ are used as blowing agents). Emissions were calculated by LEISEWITZ & SCHWARZ (2010) from information from industry experts (see Table 153).

PU pipe insulation

About 10% of the market of PU insulating foam for pipes in Austria has been blown with HFC-245fa and HFC-365mfc during 2000–2004. Emissions were calculated by LEISEWITZ & SCHWARZ (2010) based on information from industry experts (see Table 153). From 2005 onwards usage of HFC in this foam sector is prohibited as well as in the other areas.

HFC-245fa and HFC-365mfc are F-gases that are not regulated under the Convention; this is why emissions of these gases are not included in national totals, but reported in CRF Table 9(b) as additional GHG.

Table 153: *PU pipe insulation.*

	XPS plates	PU plates	PU sandwich panels	PU pipe insulation
Sales in Austria (estimated from production/import/export)	350 000 to 480 000 m ³ /year	17 000 to 18 000 m ³ /year	350 000 m ³ in 2003 (2% growth per year)	41 000 to 62 000 m ³ /year
Average density	33 kg/m ³	33 kg/m ³	41 kg/m ³	62.5 kg/m ³
Market shares of R134a	15% until 1999 10% afterwards	10%	25%	5% each
Average propellant content	6.5% R134a	3% R134a	3% R134a	12% R245fa and R365mfc
Half life time	Until 2004 100mm plates: 85 years; since 2005 80mm plates: 60 years	150 years	200 years	30 years
Annual diffusion rate (EF)	1.15% (until 2004) and 0,81% (from 2005)	0.46%	0.35%	2.28%
EF (manufacturing)	25%	10%	10%	10%

Open Cell Foams (2.F.2.b)*PU one component foam*

For PU one component foam (OCF), propellants used include HFC-free formulations (flammable gases, propane and butane among others), blends of flammable gases and HFC-134a or HFC-152a. HFC-134a and HFC-152a were used as blowing agents for OCF from 1993 onwards in Austria. OCF without HFC was used in Austria for the first time in 1999. The Austrian Industrial Gas Ordinance prohibits the use of OCF with HFC from 2006 onwards. Exemptions according to Article 7(4) IV are possible for fire protection products. The European F-gas Regulation provides a ban on HFC in OCF with a GWP > 150 starting July 2008; HFC-152a (with a GWP of 140) is not affected by this ban. From 2004/2005 onwards the Industrial Gas Ordinance provoked a rigorous decrease of HFC consumption in OCF to a niche of about 5% of the OCF market.

PU OCF containing foams were produced in Austria from 1993 to 2008, data on consumption was obtained directly from industry; the EF applied for calculating manufacturing emissions is 1.5%.

The annual consumption in Austria was estimated to be 4.4 million cans in 1993 (where the first HFC containing cans were sold) 6 million cans from 2000–2010. 60% of these cans contain HFCs (from 2006 onwards only 5%); on average one can contains 660g of foam with a propellant content

of 13%. The share of R134a was 67% until 1999, 50% until 2005 and 0% thereafter; the remainder is R152a.

For estimating emissions from the OFC consumption in Austria it is assumed that the blowing agent is emitted completely in the first year.

4.7.2.3 Fire Protection (2.F.3)

Stationary fire protection systems for flooding indoor spaces today mainly use inert gases. Formerly used ozone layer depleting halones were replaced by HFCs in some cases. HFC-23 and HFC-227ea in fire extinguishers were first introduced to the Austrian market in 1993 and 1996, respectively. F-gases for fire-fighting are imported in cylinders and filled in fixed installed systems. Fire protection companies re-export recovered F-gas for disposal to the foreign traders/manufacturers.

For HFC-227ea, detailed data on consumption for new equipment, the stock in existing fixed flooding systems, annual losses (refilling) and recovered F-gases for disposal are obtained directly from the fire protection companies every year.

For HFC-23, due to lack of data from the one relevant company, data of 2008 was also used for the subsequent years, which probably overestimates emissions as the 2008 emissions from stock were higher than in all years before. However, no better methodology is available as emissions from stock result from fire incidents, and information on the fire extinguisher capacity where they occur is not available (only statistics on the insurance volume of fire incidents exists, but this only poorly correlates to emissions).

HFC emissions occur from filling in fixed systems, from stocks (in case of false alarm, fire, leakage, accidents etc.) and from disposal. Test flooding, in former times an important source of emissions, did not take place from 2000 onwards. The emission factor for filling of fixed systems is calculated as 0.05%, the EF for disposal as 1%, both figures accord with literature and reports from fire protection companies. The average implied EF from bank is 1.6% for HFC-227ea and 1% for HFC-23, which is within the range given in the IPCC 2006 guidelines (page 7.63) for installed flooding systems ($2 \pm 1\%$ per year).

4.7.2.4 Aerosols (2.F.4)

Metered dose inhalers

Production:

Metered dose inhalers containing R134a were produced in Austria from 1995 to 2010. Data on consumption was obtained directly from the producer from 2000 onwards, for the years before, production data was extrapolated using the Austrian GDP; the EF applied for calculating manufacturing emissions is 1.5%.

Import:

Additionally, metered dose inhaler are imported since 1995. Detailed data on imported metered dose inhalers and their R134a content from 2000 onwards is provided annually in a pharmaceutical market survey. Since 2012, a new product containing 227ea has been sold in Austria. Charges per unit are based on industry data and range between 6 and 15 g per container. Based on this data,

consumption is calculated, where all propellant is assumed to be released in the same year. For the years prior 2000 consumption was extrapolated using the Austrian GDP.

Aerosols

Technical aerosols

One Austrian company manufactured a technical aerosol for cleaning of cameras (use within the country, no export) until 2008. For the years 2000 and 2003 to 2008, data on consumption was obtained directly from the producer. For the years before and in between production data was extrapolated using the Austrian GDP; the EF applied for calculating manufacturing emissions is 1.5%. All propellant is assumed to be released in the year of production (product is assumed to be consumed in the year of purchase).

Novelty aerosols

The amount of imported novelty aerosols is estimated as 0.4% of the European Union market (estimated by the *European Organisation of Aerosol Manufacturers* to range between 940 t/year in 2000 and 100 t in 2009). The value of the year 2000 is also used for the years before. This share was verified by comparison with reported data from importers. From 2004 onwards, marketing of novelty sprays is prohibited in Austria. Under the assumption that certain exceptions are allowed and remainders are sold a continuous decrease in consumption is assumed. Emissions were estimated assuming that 100% are emitted in the first year. A further decrease in 2018 is assumed as a result of the ban established under the EU F-gas Regulation. It is planned to re-evaluate this category until next submission.

4.7.2.5 Solvents (2.F.5)

Information about HFC-43-10mee used as solvent was taken from a European evaluation of emissions from this sector (HARNISCH & SCHWARZ 2003) for the years 2001 and 2002, subsequently disaggregated to provide a top-down Austrian estimate. The other years were estimated using the Austrian GDP as indicator. Since 2004 the use of HFC in solvents is prohibited in Austria. Since then no further use occurred, which has been confirmed by industry during the latest inquiries.

Emissions were estimated assuming that 100% are emitted in the first year.

4.7.3 Category-specific QA/QC

EF obtained by industry inquiries were compared with the IPCC default values. The total consumption of HFC obtained by the main importers was checked against information from retailers, service companies and producers of equipment.

4.7.4 Uncertainty Assessment

2.F.1 Refrigeration and Air Conditioning

The uncertainty of the activity data was estimated to be 10%. Used activity data (information directly obtained from importers showed good correlation with official statistics.

The emission factor mainly depends on the allocation of the sub sectors which is relatively uncertain. Additionally the uncertainty of the emission factors of the sub-sectors is to be considered – the uncertainty of the EF is assumed to be 50%. This results in an overall uncertainty of 51%.

2.F.2 Foam

Activity data uncertainty is estimated to be 20%. The amounts used are well documented due to the reporting obligation under the Austrian Industrial Gas Ordinance. The amount of foam sold in Austria is an estimate and their share in specific years varies.

The uncertainty of the emission factor is set to 100% as emissions were estimated assuming that they are emitted in the first year, which results in a combined uncertainty of 102%.

2.F.3 Fire extinguishers

The uncertainty of the activity data is estimated to be 10%. To the stock reported by the plant operators, a rate increase of 10% is added in order to ensure that all activities are covered.

The emission factor for filling and suction at demolition is set at 20%, which results in a combined uncertainty of 22%.

2.F.4 Aerosols

Activity data uncertainty is estimated to be 20%. In Austria filled amounts are well documented, also the amounts of medical aerosols sold. Sale of novelty sprays is estimated based on data from the EU market, however there is a good conformity with the data reported for Austria.

Most of the aerosol used is emitted to 100%, the emissions from manufacturing are relatively uncertain, therefore total uncertainty of the emission factor is assumed to be 10%, resulting in a combined uncertainty of 22%.

4.7.5 Recalculations

2.F.1.a Commercial Refrigeration and 2.F.1.d Industrial Refrigeration

A previous double-counting error was identified and corrected. During extensive QA/QC it became obvious that amounts of F-gases placed on the Austrian market reported as import were not imported by the company itself, but bought from an importer. The amounts were therefore already included in the reported amounts for F-gas import of the selling company. This led to a reduction of import data for the years 2011 onwards, affecting the two residual sub-categories *2.F.1.a Commercial Refrigeration* and *2.F.1.d Industrial Refrigeration*.

Also, for supermarkets, which are considered separately in the calculation, an allocation error for one specific refrigerant was corrected, which also affected activity data and emissions from these two sub categories.

Overall, the recalculations led to a reduction of emissions of 68.48 kt CO₂e in 2021.

2.F.1.d Transport refrigeration

Data for 2021 were updated (recalculation difference 2021: - 0.11 kt CO₂e).

2.F.1.e Mobile Air Conditioning

Following the recommendation of the 2022 UNFCCC review, an estimate for emissions from air conditioning stock for construction site vehicles was included (recalculation difference 2021: +12.44 kt CO₂e).

For trains, refill data has become available for the years 2014ff and was used instead of calculation of emissions assuming a leakage of 5%. As data showed that the leakage factor was higher than the previously assumed value, the average leakage factor of 2014-2022 was applied for the years before 2014 (recalculation difference 2021: +3.97 kt CO₂e).

2.F.2.a Foam Blowing

The emission factor for 2020 and 2021 was corrected, it was a software generated artefact of extrapolating the methodology to the next year (recalculation difference 2021: -3.47 kt CO₂e).

2.F.3 Fire protection

In the previous submission, emissions from stock in fire protection units was extrapolated for 2021, now the actual value is used (recalculation difference 2021: + 1.04 kt CO₂e).

2.G.2 Other uses of SF₆ - particle accelerators.

Data for (medical) particle accelerators from 2012 onwards were updated (recalculation difference 2021: + 0.14 kt CO₂e).

4.7.6 Planned Improvements

Data on installation level was collected to update parameters for estimating emissions from **industrial and commercial refrigeration**, however, additional work will be necessary to ensure representativity of the results for use in inventory preparation.

Following a finding by the ERT, it is planned to further assess recovery of HFCs, and the amount destroyed or recycled.

Fire extinguishers: information on the use of R23 that is refused by the responsible company will be obtained.

It is planned to re-evaluate **novelty aerosols** until next submission.

4.8 Other Product Manufacture and Use (Category 2.G)

4.8.1 Source Category Description

Emissions: PFC, SF₆, N₂O

Key Source: yes (SF₆ – 2.G.2)

This category comprises SF₆ emissions from Electrical Equipment (2.G.1), SF₆ and PFC emissions from Other Product Uses (2.G.2), as well as N₂O emissions from Product Uses (2.G.3).

Emission Trends

Emissions from this category amount to 2.20% of the IPPU sector, which equals 0.5% of total emissions.

Table 154: Emissions from 2.G Other Product Manufacture and Use.

GHG	2.G.1 Other product manufacture and use – Electrical Equipment		2.G.2 Other product manufacture and use – SF ₆ and PFCs from other product use			2.G.3 N ₂ O from Product Use	Total
	SF ₆	kt CO ₂ e	SF ₆	C ₃ F ₈	kt CO ₂ e	N ₂ O	kt CO ₂ e
GWP	[23 500]		[22 800]	[8 830]		[298]	
1990	0.47	11.13	5.30	0.00	124.44	441.13	252.46
1995	0.63	14.74	11.14	0.00	261.86	441.13	393.5
2000	0.75	17.55	8.98	0.00	211.01	441.13	345.97
2005	0.97	22.88	13.40	0.00	314.87	251.13	409.48
2010	1.28	30.01	10.57	0.00	248.32	175.73	324.90
2011	1.28	30.17	10.46	0.00	245.77	163.83	319.35
2012	1.39	32.55	10.35	0.00	243.21	145.13	314.22
2013	1.43	33.61	10.27	0.00	241.40	152.52	315.43
2014	1.51	35.47	10.16	0.00	238.85	144.30	312.56
2015	1.59	37.44	10.06	0.00	236.31	138.99	310.58
2016	1.68	39.55	13.97	0.00	328.38	139.93	405.01
2017	1.69	39.64	13.81	0.00	324.55	132.00	399.18
2018	1.81	42.53	13.65	0.00	320.69	128.12	397.17
2019	1.86	43.71	15.68	0.00	368.48	133.61	447.60
2020	1.93	45.41	16.65	0.00	391.17	126.21	470.03
2021	1.99	46.67	12.95	0.00	304.28	122.45	383.40
2022	2.09	49.20	12.81	0.00	300.97	120.98	382.23
1990–2022		+342%			+142%		+51%

4.8.2 Methodological Issues

Due to the diversity of this sector, methodological issues are described in each sub-category.

4.8.2.1 SF₆ Electrical Equipment (2.G.1)

SF₆ is used as an arc quenching and insulating gas in high-voltage (> 36 kV [110–380 kV]) and medium-voltage (1–36 kV) switchgear and control gear. The equipment – mainly Gas-Insulates Systems (GIS) – has not been manufactured in Austria during the reporting period, all has been imported. High-voltage GIS (HV GIS) operate with a high operating pressure (up to 7 bar) and large gas quantities. They are imported with a transport filling and are filled up on site. The systems are “closed for life” and have to be replenished in their lifetime. Emissions from operating HV systems are higher than emissions from medium-voltage GIS (MV GIS). These operate with lower overpressure and small gas quantities of only some kg/system. They are already charged with SF₆ when imported and are hermetically closed (“sealed for life”). Both categories of equipment have lifetimes of 30–40 years.

According to Article 15(2) of the Austrian Industrial Gas Ordinance, the use of SF₆ is only allowed in electro-technical systems and appliances of voltage > 1 kV if specific reporting obligations are fulfilled (Article 15(4)). The sector of high and medium voltage switchgear is hence not subject to restrictions of the use of SF₆.

Information on SF₆ stocks in electrical equipment from 2003 onwards was obtained from energy suppliers and industrial facilities (as mentioned above, there is a reporting obligation for operators of SF₆ filled equipment since 2004). Data for 2000–2002: estimation based on an annual growth rate 2003–2007 of 16.9% for MV-GIS and 4.1% for HV-GIS. 2% was added to the reported stock to account for equipment used in industry that is not reported otherwise. For 1990–1999 the stock was calculated from consumption data of this sector.

Amounts of SF₆ refilled in equipment is reported each year by an association of energy suppliers; this information is the basis for the estimations. Manufacturing emissions from first filling were estimated to be 1% according to reported data, the disposal EF is assumed to equal 2%.

In Austria, no destruction of SF₆ in electrical equipment takes place when disposing. Disposed quantities are recovered, emissions from disposal are estimated to be 2%. The disposed amount is also reported by energy suppliers for the years 2004 onwards, the values 2000–2003 were estimated using average disposal rates of 2004–2008: 0.03% for HV and 0.1% for MV. For the years before the average value of 2000–2008 was used.

The amount of SF₆ used in switchgear is reported under the Austrian Industrial Gas Ordinance, by two umbrella organisations covering all switchgear in use. Thus, the amount of SF₆ currently in use, as well as SF₆ used for refill or filling of new equipment is reported.

4.8.2.2 SF₆ and PFCs from Other Product Uses (2.G.2)

Particle accelerators (Research)

SF₆ is used in particle accelerators (linear accelerators, linacs) as insulating gas to prevent electrical flash over. A small number of high voltage equipment (0.3→ 23 MV) is or has been used in Austria in academic research, in industry and medical therapy. The larger HV equipment for research and industrial purposes normally operates with an accelerator and HV generator situated in a tank insulated with SF₆ that is mostly pressurized. Gas losses occur at servicing, repair or adjustment of the device. SF₆ contained in one accelerator can amount up to 0.5 t.

Linear accelerators for medical radiotherapy (cancer therapy) are industrially made and prefilled. Their waveguide is SF₆ insulated; the filling volume (a value of 0.44 kg is assumed) is much smaller than the above-mentioned equipment in research and industry. Electronic microscopes (> 100 kV) have a high voltage tank filled with ~5 kg SF₆.

Manufacturers and operators provided the number of devices operating in Austria. Data on filling volume and refilling have been collected from the institutions and companies operating the equipment, from manufacturers and from service companies. Emissions from bank are equal to the amounts provided in company reports for refilling of losses.

The annual F-gas consumption (first filling of new products) normally is very small (in the order of kg) and exceeded 400 kg in one year only. The stock is about 1 t for recent years. The implied EF is in the order of 8%, but there is a wide difference between the several types of equipment.

Noise insulating windows

Nose insulating windows containing SF₆ were produced in Austria from 1980 to 2003, when the Austrian Industrial Gas Ordinance prohibited this use.

For the years before 1999 consumption and emissions from production were estimated from total production and the share of SF₆ production using the following information from industry:

- 16 mm gap results in about 16l/m² of which there are 8l SF₆ per m² window
- Filling from 1996 is only 6l SF₆/window
- Overfill of 3l per m² window (manual filling) = emissions from manufacture
- Density of SF₆: 6.18 kg/m³

SF₆ consumption was reported by industry for the years 1999–2003; one third of the consumption is overfill (thus equals emissions from manufacture).

The leakage per year is 1% of the initial fill (which considered premature breaking).

The residual amount after the lifetime of 25 years is assumed to be emitted immediately due to breaking of glass.

Tyres

SF₆ shows a low permeability through rubber (cf. IPCC GL 2006, p. 8.31). The German tyre manufacturer Continental AG exploited this property and offered in the 1990s tyres with SF₆ as filling gas instead of air. In Austria the national tyre and automotive trade sold tyres with SF₆ as filling gas filled within the country. The gas used for this purpose was supplied by only one SF₆ importer, who reported on the amount of SF₆ sold to the Austrian tyre and automotive trade. As of 2003, the Austrian Industrial Gas Ordinance abruptly stopped the usage of SF₆ as filling gas for tyres by legal prohibition.

According to IPCC GL 2006 it is assumed that SF₆ completely emits from car tyres with their disposal three years after filling. Filling emissions are regarded to be insignificant. Disposal emissions are therefore assumed to equal the amount consumed three years earlier.

Shoes

Nike introduced sport shoes with gas cushions filled with SF₆ in the early 1990s. From 2003 to 2006 the company used as alternative PFC (C₃F₈) for the same purpose. Shoes with F-gas cushions were not manufactured in Austria but imported. SF₆ emissions from sport shoe soles occurred in Austria up to 2006, C₃F₈ emission from 2006 to 2008.

Data on the import of these products to Austria were not provided by Nike. It was accepted as plausible that the German and the Austrian market could be regarded as comparable. Data on the German market are well documented. Austria has 10% of the population compared to Germany, hence the same percentage was assumed for annual consumption of such footwear in Austria. In case of perfluoropropane the European consumption in 2003–2005 is known and the Austrian market is estimated to be 2.5% (= 10% of the German market).

Operating emissions during use of the footwear are not considered. The lifetime of sport shoes is estimated to be 3 years. At the disposal of old shoes 100% of the initial filling is released to the atmosphere (i.e. EF=100%). Disposal emissions are therefore assumed to equal the amount imported in sport shoes three years earlier.

4.8.2.3 N₂O from Product Uses (2.G.3)

Medical Applications (2.G.3.a)

This subsector contains N₂O emissions from the use of anaesthesia. The numbers for 2001–2012 were formerly obtained through an industry inquiry (OIGV 2013) for the amount of N₂O used during those years. As this inquiry is not possible anymore, the importers/producers of N₂O were asked directly.

As N₂O is used as an anaesthetic, it is presumed that 100% are emitted during reporting years. But also the N₂O use has significantly decreased due to shorter duration of anaesthesia during operations and more local anaesthetics than general anaesthesia.

Propellant for Pressure and Aerosol Products (2.G.3.b)

N₂O is used as propellant for cream; it is applied in capsules or in ready to use cans.

For **capsules** all producers reported data on amounts sold in Austria, these values were used for all years as all three producers confirmed that the market in Austria is saturated and has been stable over the years.

For **ready to use cans**, data from supermarkets and wholesale were extrapolated to the overall market in Austria using market shares for retail trade. As for capsules, the estimation is reported by companies for the whole time series.

It is assumed that all N₂O from capsules and cans sold in one year are emitted in the same year. According to the main producers, Austria is a saturated market with only minor changes in use of propellant cream since the 1990s, and thus the same value of AD that was elaborated in 2020 can be used for the whole time series.

Organic Rankine Cycles (2.G.4.b)

So far, one plant in Austria has been identified, where Solkatherm (mixture containing HFC 365 mfc) has been in use since 2005. The plant opened in 2000, when 3 000 kg of 3m PF-5052 (PFC C5F12) were filled in. These 3 000 kg were then decommissioned in 2005, and 3 000 kg of 365mfc were filled in. Since then, no emissions (no refills) were recorded. No records are available for the time before 2005, but it is assumed that no emissions took place then.

According to expert judgement⁸⁶, 2% emissions were thus considered during filling in, and 20% at decommissioning. This results in emissions for the years 2000 and 2005.

It still cannot be ruled out that there are other ORC plants in operation in Austria, as not all ORC plant operators replied before this submission. As soon as this information is available it will be considered in the inventory.

⁸⁶ Implementierung der ab dem Berichtsjahr 2013 gültigen IPCC Guidelines for National Greenhouse Gas Inventories 2006 in die Inventurerhebung fluorierter Treibhausgase (HFKW, FKW, SF₆, NF₃), Climate Change 17/2015, Öko-Recherche

4.8.3 Category-specific QA/QC

EF obtained by industry inquiries were compared with the IPCC default values. The total consumption of N₂O, PFC and SF₆ was obtained by the main importers and this data was checked against information from professional organisations and statistics.

For N₂O used as cream propellant the estimation for capsules was estimated by two approaches: on the one hand based on data from producers, on the other hand based on retail sale data; the difference of the approaches is within the assumed uncertainty.

4.8.4 Uncertainty Assessment

2.G.1 Electrical Equipment

Activity data uncertainty is estimated to be low (5%) as data are reported from industry and additionally 2% is added to the calculation to account for equipment not covered in the reported figures. As for the emission factor, uncertainty is estimated to be very high (100%).

2.G.2 SF₆ and PFCs from Other Product Uses

According to emissions levels, the most important sub source is noise insulating windows. The uncertainty for activity data is estimated to be 25%, emission factor uncertainty is assumed to be relatively high (50%) because it is based on several assumptions.

2.G.3 N₂O from Product Uses

Uncertainty for emissions from this category is assumed to be at 20% for Activity Data, for the EF the uncertainty was assumed to be 0%, as all N₂O contained is assumed to be emitted. This resulted in a combined uncertainty of 20%.

4.8.5 Recalculations

No recalculations have been carried out since the last submission.

5 AGRICULTURE (CRF SECTOR 3)

5.1 Sector Overview

This chapter gives information about the estimation of greenhouse gas emissions from Sector *Agriculture* in correspondence to the data reported under the Sector 3 in the Common Reporting Format.

The following sources exist in Austria: domestic livestock activities with enteric fermentation and manure management, agricultural soils, field burning of agricultural residues, liming, urea application and other carbon-containing fertilizers.

As a result of previous UNFCCC reviews the ERT recommended Austria to update its information on manure management system (MMS) distribution (ARR 2006, ARR 2008). Hence, in 2008 the Umweltbundesamt commissioned the University of Natural Resources and Applied Life Sciences with the revision of the national emission model of the sector agriculture (AMON & HÖRTENHUBER 2010). Data on MMS distribution was taken from the research project “Animal husbandry and manure management systems in Austria” (AMON et al. 2007), a comprehensive survey on the agricultural practice in Austria. This study was followed by a new study in 2018 (PÖLLINGER et al. 2018).

In 2013 the Umweltbundesamt commissioned the University of Natural Resources and Applied Life Sciences with the update of the national emission model of the whole sector agriculture by using the methodologies according to the IPCC 2006 Guidelines (AMON & HÖRTENHUBER 2014).

In submission 2019, the agricultural model has been revised by implementing new input data on agricultural practices in Austria, taken from the research project “Surveys on manure management from agricultural livestock farming in Austria (TIHALO II) (PÖLLINGER et al. 2018)”. For this project, as for the previous one (AMON et al. 2007), a comprehensive survey has been carried out. Furthermore, the N flow has been improved according to the EMEP/EEA methodologies (EEA 2019), which also effected Austria's GHG emissions (AMON & HÖRTENHUBER 2019). In submission 2021 Austria included CO₂ emissions from calcium ammonium nitrate (CAN) in its inventory as encouraged during the ESD Review 2020.

In response to questions raised during the comprehensive ESD Review 2020 (EEA 2020) and the NEC Review 2021 (EC 2021) on Austria's feeding assumptions, the Umweltbundesamt initiated a new representative study. The feeding of cattle and swine has changed substantially in the last two decades and it was decided to update the national inventory on the basis of latest available science. Thus, from 2020 to 2022 the University of Natural Resources and Life Sciences Vienna carried out a specific research project on country-specific animal feeding and nutrition (“MiNuTE” study, HÖRTENHUBER et al. 2022b; HÖRTENHUBER et al. 2023). In submission 2022, Austria included updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) into the inventory.

Austria follows the N-flow approach by using country specific methodologies for the calculation of direct N₂O emissions from animal manure applied to soils (3.D.a.2.a) and indirect N₂O emissions from leaching and run-off (3.D.b.2). In response to a recommendation of the ERT (ARR 2013, para 51 and 52) additional descriptions have been included from NIR 2014 onwards (Annex 3). Methodological details regarding the calculation of gaseous N losses of NH₃, NO_x and N₂ are extensively described in Austria's Informative Inventory Report 2024 (UMWELTBUNDESAMT 2024b).

To give an overview of Austria's agricultural sector some information is provided below (according to the 2020 Farm Structure Survey – full survey) (BML, 2000–2023): Agriculture in Austria is rather small-scaled: 154 593 farms are managed, 54.9% of these farms manage less than 20 ha, whereas only 5.7% of the Austrian farms manage more than 100 ha cultivated area. 118 432 holdings are classified as situated in less favoured areas. Related to the federal territory Austria has the highest share of mountainous areas in the EU (70%). The structural change of Austria's Agriculture is continued: the number of agricultural holdings decreased between 2010 and 2020 by 11% whereas the size of holdings increased in this period. In 2010, an average total area of 42.6 ha was managed on a holding, in 2020 it increased to 44.9 ha.

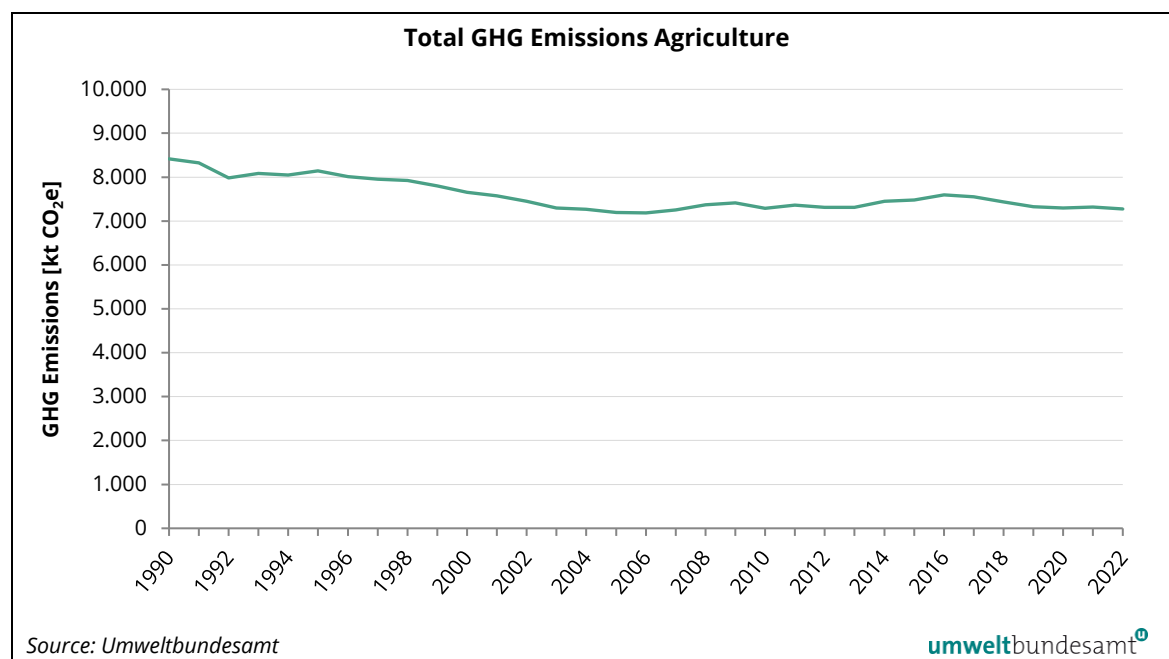
The agricultural area comprises 2.60 million hectares that is a share of ~ 31% of the total territory (forestry ~ 41%, other area ~ 11%). The shares of the different agricultural activities are as follows:

- 51% arable land,
- 22% grassland (meadows mown several times and seeded grassland),
- 24% extensive grassland (meadows mown once, litter meadows, rough pastures, alpine pastures and mountain meadows),
- 3% other types of agricultural land-use (vineyards, orchards, house gardens, vine and tree nurseries).

5.1.1 Emission Trends

In the year 2022 the sector agriculture contributed 10.0% to the total of Austria's greenhouse gas emissions (without LULUCF). The trend of GHG emissions from 1990 to 2022 shows a decrease of 13.5% for this sector (see Figure 27 and Table 156) due to a decrease in activity data.

Figure 27: Trend of total GHG emissions from agriculture.



The main drivers for the trend shown in Figure 27 are decreasing livestock numbers and lower amounts of N-fertilizers applied on agricultural soils. From 2021 to 2022 GHG emissions decreased slightly by 0.6%, mainly due to falling emissions from mineral fertilizer application (–8.7%). The reasons for this are lower sales volumes due to the significant increase in prices on the fertilizer market resulting from the considerable rise in energy and raw material prices.

Emission trends per gas

From 1990 to 2022 CH₄ emissions from agriculture decreased by 13.6%. N₂O emissions fell by 16.3% and CO₂ emissions increased by 73.6%. Trends are presented in Table 155.

Table 155: Emissions of greenhouse gases from 1990–2022 from agriculture.

Year	GHG emissions [kt]		
	CH ₄	N ₂ O	CO ₂
1990	203.14	9.97	85.92
1995	199.90	9.30	84.22
2000	186.99	8.80	89.33
2005	175.47	8.25	95.54
2010	179.27	8.13	112.35
2011	177.52	8.55	125.99
2012	176.51	8.44	133.67
2013	177.39	8.37	127.21
2014	178.57	8.73	132.78
2015	179.12	8.75	145.49
2016	179.97	9.07	151.61
2017	180.76	8.82	150.71
2018	178.32	8.63	154.83
2019	175.81	8.49	150.78
2020	174.51	8.53	148.94
2021	175.04	8.57	149.29
2022	175.54	8.35	149.17
Trend 1990–2022	-13.6%	-16.3%	73.6%

Emission trends per sub category

Table 156 presents total GHG emissions and trend 1990–2022 from agriculture by sub-categories as well as the contribution to the overall inventory emissions. Important categories are 3.A *Enteric Fermentation* (5.9%) and 3.D *Agricultural Soils* (2.4%) followed by 3.B *Manure Management* (1.5%).

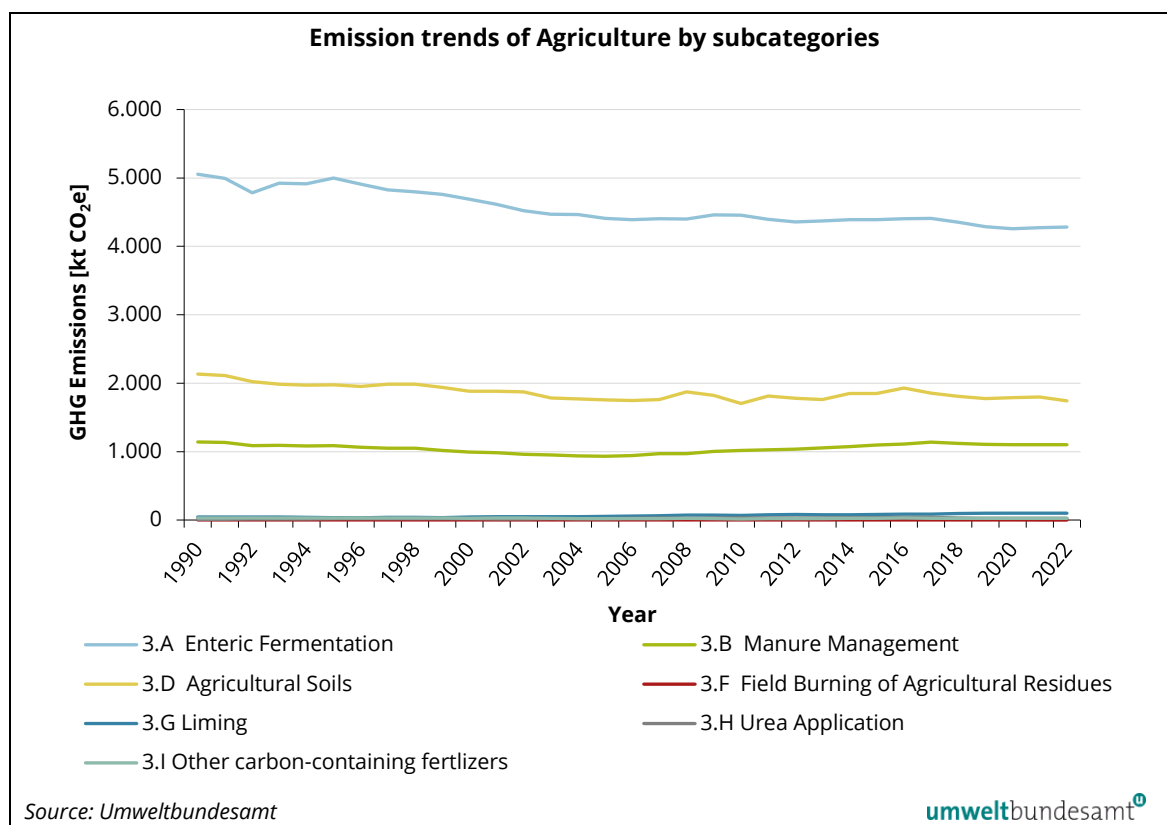
Table 156: GHG emissions 1990–2022 of agriculture by sub categories.

Year	GHG emissions [kt CO ₂ equivalent] by sub categories							
	3	3.A	3.B	3.D	3.F	3.G	3.H	3.I
1990	8 416.29	5 054.58	1 141.11	2 133.53	1.14	45.67	9.60	30.66
1995	8 144.98	4 998.26	1 085.50	1 975.89	1.11	35.68	19.79	28.76
2000	7 657.07	4 691.74	994.32	1 880.67	1.00	42.60	19.36	27.37
2005	7 196.25	4 410.15	931.90	1 757.73	0.93	53.62	21.89	20.03
2010	7 287.07	4 453.92	1 016.94	1 703.14	0.73	68.61	28.85	14.89
2011	7 363.15	4 394.51	1 027.96	1 814.21	0.47	77.15	27.47	21.37

Year	GHG emissions [kt CO ₂ equivalent] by sub categories							
	3	3.A	3.B	3.D	3.F	3.G	3.H	3.I
2012	7 311.78	4 358.69	1 037.59	1 781.57	0.27	80.84	30.63	22.20
2013	7 310.99	4 370.10	1 054.15	1 759.30	0.22	75.34	30.28	21.60
2014	7 447.38	4 388.14	1 075.03	1 851.14	0.29	75.14	34.04	23.59
2015	7 478.71	4 389.62	1 095.42	1 847.98	0.20	83.43	34.90	27.15
2016	7 594.75	4 402.04	1 112.20	1 928.70	0.21	83.80	39.26	28.55
2017	7 549.35	4 408.11	1 136.83	1 853.56	0.14	86.03	38.30	26.38
2018	7 434.63	4 350.99	1 119.93	1 808.77	0.11	96.50	32.03	26.30
2019	7 324.23	4 288.43	1 108.11	1 776.81	0.10	99.40	26.77	24.61
2020	7 296.69	4 257.64	1 099.33	1 790.77	0.00	98.94	24.54	25.47
2021	7 321.68	4 271.07	1 102.43	1 798.89	NO	99.11	23.12	27.06
2022	7 276.88	4 283.68	1 101.48	1 742.56	NO	99.20	25.54	24.43
Share in Austrian Total 2022	10.0%	5.9%	1.5%	2.4%	0.0%	0.1%	0.0%	0.0%
Trend 1990–2022	-13.5%	-15.3%	-3.5%	-18.3%	-100.0%	117.2%	166.2%	-20.3%

As can be seen in Figure 28 and Table 156 the overall trend concerning emissions from most of the sub categories is decreasing with the exception of liming and urea application. The main reason for the decrease of emissions from enteric fermentation is the decrease in cattle numbers. In manure management only a slight decrease of emissions can be observed mainly due to the rising share of liquid systems, which compensates the falling cattle numbers. Fluctuations of emissions from agricultural soils are mainly due to varying underlying activity data (especially the sales figures of mineral fertilizers). Emissions from liming and urea application follow the increased application from 1990 onwards. The declining emissions trend of calcium ammonium nitrate (CAN) can be explained with decreasing activity data.

Figure 28: Emission trends of agriculture by subcategories.



As can be seen in Table 157, in 2022 about 58.9% of emissions from agriculture originate from enteric fermentation and 23.9% from agricultural soils. Manure management contributes about 15.1% and the source categories liming, urea application and other carbon-containing fertilisers are emitting only a negligible part (1.4%, 0.4% and 0.3%, respectively in 2022). Field burning of agricultural wastes did not occur in 2022 anymore ("NO").

Table 157: Share of sub categories of agriculture, 1990 and 2022.

GHG emissions [%] by sub categories								
Year	3	3.A	3.B	3.D	3.F	3.G	3.H	3.I
1990	100%	60.1%	13.6%	25.3%	0.0%	0.5%	0.1%	0.4%
2022	100%	58.9%	15.1%	23.9%	NO	1.4%	0.4%	0.3%

5.1.2 Key Categories

The key category analysis is presented in Chapter 1.5.

5.1.3 Methodology

For enteric fermentation the IPCC Tier 1 method was used, except for key categories (cattle and swine). In manure management the Tier 2 method and country specific emission factors were used

for cattle and swine. For the other livestock sub categories, the Tier 2 approach and default parameters were used. N₂O emissions from animal manure applied to soils were calculated using a country specific methodology following the N-flow approach.

For the calculation of emissions from enteric fermentation – poultry, Tier 2 emission factors from Switzerland (net energy ingested, methane conversion rate) were used as Tier 1. Farming practices in Switzerland are very similar to the Austrian ones.

2020 to 2022 a new research project on country-specific animal feeding and nutrition (“MiNutE” study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) has been carried out by the University of Natural Resources and Life Sciences, Vienna. In submission 2022 Austria included the updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) into its agriculture inventory.

MMS distributions used in manure management were taken from (KONRAD 1995), (AMON et al. 2007) and (PÖLLINGER et al. 2018). New study results of the so-called TIHALO II survey (PÖLLINGER et al. 2018) were implemented in submission 2019 within a specific project for the revision of the national inventory (AMON & HÖRTENHUBER 2019).

Country specific methane conversion factors (MCF) were applied for liquid systems of cattle and swine. The MCFs are based on studies carried out at the University of Natural Resources and Applied Life Science (BOKU), Department for Sustainable Agriculture, Division of Agricultural Engineering (DAE) (AMON et al. 2002, AMON et al. 2006, AMON et al. 2007). For all other systems emission factors of the 2006 IPCC Guidelines were used.

As recommended in the Centralized Review 2003, for the estimation of emissions from field burning of agricultural wastes the IPCC methodology using default emission factors was applied. In response to an encouragement of the ERT in the Centralized Review 2010, Austria provided a refined estimate on the basis of relevant crops.

In submission 2015 Austria introduced a national value for Frac_{Leach} (0.15154) based on a national study (EDER, A. et al 2014) for the calculation of indirect emissions from nitrogen leaching and run-off.

The following table presents an overview of the country specific data used in agriculture including a short indication on the sources for this data as recommended in the ARR 2013, Table 8 (para 49).

Table 158: Information on country specific data.

Category	Parameter	Source
3.A Enteric Fermentation		
3.A.1 Cattle	GE-Intake	HÖRTENHUBER et al. (2022b), HÖRTENHUBER et. al. 2023
3.A.3 Swine	GE-Intake	HÖRTENHUBER et al. (2022b), HÖRTENHUBER et. al. 2023
3.A.4 Poultry	CH ₄ EF	SBV (2007, 2021), HADORN & WENK (1996)
3.B Manure Management		
3.B (all livestock)	MMS distribution	AMON & HÖRTENHUBER (2010) AMON & HÖRTENHUBER (2019)

Category	Parameter	Source
3.B (cattle, swine, chicken, horses)	Anaerobic digestion	AMON (2002), E-CONTROL (2006-2021, 2022, 2023b), KOMPOST-UND BIOGASVERBAND ÖSTERREICH (2023), HÖRTENHUBER (2022)
3.B.1 Cattle	VS excretion	HÖRTENHUBER et al. (2022b), HÖRTENHUBER et. al. 2023
3.B.3 Swine	VS excretion	HÖRTENHUBER et al. (2022b), HÖRTENHUBER et. al. 2023
3.B.1 Cattle, 3.B.3 Swine	MCF liquid systems	AMON et al. (2006), AMON et al. (2007a)
3.B (cattle, swine, chicken)	MCF anaerobic digestion	FNR (2010); AMON, T. (2011)
3.B (cattle, swine)	N excretion	HÖRTENHUBER et al. 2022b, HÖRTENHUBER et. al. 2023
3.B (all other livestock)	N excretion	UNTERARBEITSGRUPPE N-ADHOC (2004), BML (2022)
3.D. Agricultural Soils		
Austria's N-flow model	Country-specific consideration of N-losses	(AMON et al. 2002, 2008, 2010, 2014 & 2019)
3.D.a Direct Soil Emissions		
Sewage sludge spreading	N content data	UMWELTBUNDESAMT (1997)
Compost application		Expert judgement by UMWELTBUNDESAMT (2015)
Mineralization/immobilization of soil organic matter		C losses reported in sector LULUCF (4.B.1.3)
Cultivation of organic soils		Derived from soil inventory data, see sector LULUCF
3.D.b Indirect Soil Emissions		
Austria's N-flow model	Country-specific consideration of N-losses	(AMON et al. 2002, 2008, 2010, 2014 & 2019) (EDER, A. et al 2014)

Background information on the parameters listed above is provided in the methodological descriptions of the respective chapters of NIR.

5.1.4 Quality Assurance and Quality Control (QA/QC)

The following sector specific QA/QC procedures have been carried out:

1. Activity data check

- ✓ Check for transcription errors, comparison with published data (BML 2023b),
- ✓ Consistency checks of sub-categories with totals,
- ✓ Plausibility checks of dips and jumps,

2. Emission factors

- ✓ Check of implied emission factors (time series) and CRF background data,
- ✓ Comparison with IPCC default values and factors reported by other countries;

3. Calculation by spread sheets

- ✓ 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 spread sheets,
- ✓ 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.

Due to the revision of the Austrian inventory model for sector agriculture according to the 2006 IPCC GL and the EMEP/EEA GB 2013 an external review by Austrian Agricultural experts within the framework of a stakeholder meeting was held in 2014. Applied values and parameters were discussed and validated by the national experts.

In submission 2019 the agricultural model was revised as new data on the agricultural practice in Austria became available from the TIHALO II survey (PÖLLINGER et al. 2018) as well as due to improvements of the N-flow according to the EMEP/EEA GB 2016 (AMON & HÖRTENHUBER 2019). Within the framework of this revision a stakeholder meeting (so-called “inventory talks”) was held in 2018 in order to discuss applied values, parameters, time series and study results with Austrian agricultural experts (UMWELTBUNDESAMT 2010, 2014 & 2018).

In submission 2022, Austria included updated and representative values for nitrogen and energy intake, excretion of nitrogen (Nex) and volatile solids (VSex) into the inventory taken from a specific research project on country-specific animal feeding and nutrition (“MiNutE” study, HÖRTENHUBER et al. 2022b; HÖRTENHUBER et al. 2023). The results were presented and discussed with Austrian agricultural experts as well.

In submission 2022, emission calculations of *3.I (Other carbon-containing fertilizers)* have been validated. Austria's import statistics were checked with regard to the assumptions on limestone and dolomite contents. The investigations confirmed the current approach using the arithmetic mean of limestone and dolomite.

In 2023, Austria verified its NH₃ estimates by comparing them with the calculations and results of the *3.B Manure Management N flow tool* from the European Environment Agency (EEA, 2023c).

Basically, the comparison showed a good correlation of trends and emission levels between the two calculations. The Austrian N-flow model for cattle and swine is much more complex and there was a need to simplify the calculations in order to be able to use the EEA N-flow tool. One of the conclusions therefore was that the national circumstances in terms of feeding and agricultural practices would not be represented adequately by standardized tools. Minor issues found in the national inventory during this verification exercise (mainly affecting air emissions) have already been implemented into the 2024 submission.

Source specific procedures are presented in the respective sub-chapters. A general description of Austria's QMS (Quality Management System), activities and improvements 2023 is presented in Chapter 1.2.3.

5.1.5 Uncertainty Assessment

The following chapter gives an estimate of uncertainties with respect to N₂O, CH₄ and CO₂ emissions from enteric fermentation, manure management, agricultural soils, field burning, liming, urea application as well as carbon-containing fertilisers. Overall uncertainties result from uncertainties in the activity data and from uncertainties in the emission factors.

Manure management system distribution (MMS)

MMS distribution is based on the following surveys: (KONRAD 1995), TIHALO I (AMON et al. 2007) and TIHALO II (PÖLLINGER et al. 2018). Uncertainties are estimated with $\pm 10\%$.

Country specific MCF for liquid manure systems:

MCF values have a great impact on estimation of methane emissions from manure management. Default MCF values given in the 2006 IPCC GL are derived from a limited number of laboratory studies and theoretical considerations. Following the guidelines, the default values may have a large uncertainty for an individual country because they may not reflect the specific manure management conditions present within the country. For that reason it is highly necessary to measure MCF values under field conditions.

At the University of Natural Resources and Applied Life Sciences a three-year measurement campaign on emissions from manure stores financed by the Federal Ministry of Agriculture, Forestry, Environment, and Water Management and the Federal Ministry for Education, Science, and Culture was carried out (AMON et al. 2002a, 2006, 2007a). Published results have been integrated into the revised GHG inventory. The country specific MCFs reflect the agricultural practice and the climate conditions in Austria better than the default values. The uncertainty range for the country specific MCF is estimated to be $\pm 20\%$ (AMON & HÖRTENHUBER 2010).

Activity data and emission factors

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 cattle of 1% and for swine of 4%.

Uncertainties of emission factors for CH₄ emissions of enteric fermentation were considered 20% for cattle and swine as these livestock categories are calculated by using a Tier 2 methodology (IPCC 2019) and 40% for all other animals calculated with Tier 1 methodology (IPCC 2006). This is consistent with more detailed knowledge for those animals that contribute more to the emissions. Uncertainties of emission factors for CH₄ from manure management were assessed at 20% for livestock categories calculated with Tier 2 methodology and country specific parameters (cattle and swine) and 30% for all other animal categories following IPCC 2006. An uncertainty of 100% was taken for direct N₂O emissions (IPCC 2006). Uncertainty of indirect N₂O emissions from manure management was treated like indirect N₂O emissions from agricultural soils, as described in detail below.

WINIWARTER & RYPDAL (2001) noted that the largest contributor to uncertainty for several existing GHG inventories is N₂O emissions from soils. Thus it is worthwhile to consider this source in some more detail – even if no real improvement of the situation should be expected at this time. While IPCC (2000) assumes two orders of magnitude as the uncertainty margin, re-evaluation of basically the same data leads to a considerable improvement of the situation to estimated 30%–300% of the best estimate, lognormal distribution (IPCC 2006). This range is closer but still higher compared to the one estimated by WINIWARTER & RYPDAL (2001), who assumed uncertainty in a triangular distribution between 50 and 200%.

The IPCC methodology (IPCC 2006) recommends separate treatment of direct and indirect emissions. Uncertainties of emission factors of indirect emissions are not significantly different from those of direct emissions, and the underlying processes (microbial nitrification/denitrification) are identical. Thus it was decided to treat the uncertainties of direct and indirect emissions as being correlated.

Table 159 presents uncertainties for emissions as well as for activity data and the EFs of the key categories of agriculture according to the error propagation method (Tier 1).

Table 159: *Uncertainties of emissions and emission factors (key categories agriculture).*

Categories		CH ₄ Emissions	N ₂ O Emissions	CO ₂ Emissions	EF CH ₄	EF N ₂ O	EF CO ₂
3.A.1	Cattle	+/-20.0%	–	–	+/-20%	–	–
3.B.1.1	Cattle	+/-20.0%	+/- 100.0%	–	+/-20%	+/-100%	–
3.D.a	Direct Soil Emissions	–	+/- 200.1%	–	–	+/-200%	–
3.D.b	Indirect Emissions	–	+/- 200.1%	–	–	+/-200%	–
Activity Data							
Animal Population – Cattle					+/- 1%		
Animal Population – Swine					+/- 4%		
Animal Population – Sheep and Other					+/- 10%		
Area Data & Fertilizer Input (combined)					+/- 5%		

5.1.6 Recalculations

Update of activity data

3.A Enteric Fermentation, 3.B Manure Management, 3.D Agricultural Soils

Livestock data – cattle < 1 year

The livestock category cattle < 1 year comprises slaughtering calves < 1 year, other male calves and cattle < 1 year, and other female calves and cattle < 1 year according to the official statistics (Statistics Austria). The breakdown by type of use is determined by Statistics Austria using model calculations. Methodological improvements resulted in shifts between the cattle < 1 year sub-categories in the years 2003–2021 and thus led to revised average values for gross energy intake, N_{excretion} and V_{Sexcretion} for cattle < 1 year.

Background data for feeding and nutrition of dairy and suckling cows

New figures for the protein and fat content of milk for the year 2021 became available (AMA 2023a). This update resulted in minor revisions of the values for gross energy intake, $N_{\text{excretion}}$ and $VS_{\text{excretion}}$ of dairy and suckling cows.

Biogas plants

New data on input materials for Austria's biogas plants became available from the compost and biogas association (Kompost- und Biogasverband Österreich). The update resulted in slightly revised CH_4 and N_2O emissions with an impact on the source categories *3.B Manure Management*, *3.D.a.2.a Animal manure applied to soils* and *3.D.a.2.c Other organic fertilizers applied to soils* for 2020 and 2021.

3.A Enteric Fermentation (CH_4)

This category has been revised due to updated activity and nutrition data (GE-intake; revision in category cattle <1 year – see above). The improvements resulted in updated emission amounts for the years 2003–2021 (+2.8 kt CH_4 for 2021).

3.B Manure Management (CH_4 , direct and indirect N_2O)

Methane and N_2O emissions have been revised for the years 2003–2021 (+0.3 kt CH_4 for 2021, +0.004 kt N_2O for 2021), because of updated activity and nutrition data.

3.D.a.2.a Animal Manure Applied to Soils

Updates and improvements as described above resulted in revised emissions from animal manure application for the years 2003–2021 (+0.01 kt N_2O for 2021).

3.D.a.2.c Other organic fertilisers

As a result of updated activity data on input materials for biogas plants, N_2O emissions have been revised for the years 2020 and 2021 (-0.003 kt N_2O for 2021).

3.D.a.3 Urine and dung deposited by Grazing Animals

Livestock related updates as already described before, led to recalculated N_2O emissions for the years 2003–2021 (+0.002 kt N_2O for 2021).

3.D.a.5 Mineral Soils (N_2O)

Revisions of activity data (perennial cropland remaining perennial cropland, perennial cropland converted to annual cropland, annual cropland remaining annual cropland; for more information see chapter 6.3 on LULUCF) resulted in slightly revised N_2O emissions for the entire time series (-0.00001 kt N_2O for 2021).

Improvements of methodologies and emission factors*3.D Agricultural Soils (N_2O)**3.D.b Agricultural Soils (indirect soil emissions – N_2O)*

Atmospheric deposition: The main reasons for revised emissions are the application of updated Tier 2 NH_3 EFs for mineral fertilisers and the update of the NH_3 EF for grazed sheep and deer according

to the EMEP/EEA GB 2023 in the ammonia inventory as well as the revised activity data ($N_{\text{excretion}}$ values for cattle and biogas). As a result, the indirect N_2O emissions from atmospheric deposition have been revised upwards for the entire time series (+0.04 kt N_2O for 2021).

N leaching and run-off: Reasons for the minor recalculations are the revised amounts of animal manure applied to soils (+0.001 kt N_2O for 2021).

5.1.7 Completeness

Table 160 gives an overview of the IPCC 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 160: Overview of sub-categories of agriculture: transformation into SNAP codes and status of estimation.

IPCC Category		SNAP		CO ₂	CH ₄	N ₂ O
3.A	ENTERIC FERMENTATION	1004	ENTERIC FERMENTATION	NA	✓	NA
3.A.1	Cattle	–	–	NA	✓	NA
3.A.1.a	Dairy Cattle	100401	Dairy cows	NA	✓	NA
3.A.1.b	Non-Dairy Cattle	100402	Other cattle	NA	✓	NA
3.A.2	Sheep	100403	Ovines	NA	✓	NA
3.A.3	Swine	100404	Fattening pigs	NA	✓	NA
3.A.4	Other Livestock			NA	✓	NA
	Buffalo	100414	Buffalos	NO	NO	NO
	Camels	100413	Camels	NO	NO	NO
	Deer	100415	Other	NA	✓	NA
	Goats	100407	Goats	NA	✓	NA
	Horses	100405	Horses	NA	✓	NA
	Mules and asses	100406	Mules and asses	IE ¹⁾	IE ¹⁾	IE ¹⁾
	Poultry	100408 /09/10	Laying hens, broilers, other poultry	NA	✓	NA
	Other (Rabbit, Reindeer, Ostrich, fur-bearing animals, Other)	100415	Other	NO	NO	NO
3.B.	MANURE MANAGEMENT	1005	MANURE MANAGEMENT REGARDING ORGANIC COMPOUNDS	NA	✓	NA
		1009	MANURE MANAGEMENT REGARDING NITROGEN COMPOUNDS	NA	NA	✓
3.B.1	Cattle	–	–	NA	✓	✓
3.B.1.a	Dairy Cattle	100501	Dairy cows	NA	✓	✓
3.B.1.b	Non-Dairy Cattle	100502	Other cattle	NA	✓	✓
3.B.2	Sheep	100505	Ovines	NA	✓	✓
3.B.3	Swine	100503	Fattening pigs	NA	✓	✓
3.B.4	Other Livestock	–	–	NA	✓	✓
	Buffalo	100514	Buffalos	NO	NO	NO

IPCC Category		SNAP		CO ₂	CH ₄	N ₂ O
	Camels	100513	Camels	NO	NO	NO
	Deer	100515	Deer	NA	✓	✓
	Goats	100511	Goats	NA	✓	✓
	Horses	100506	Horses	NA	✓	✓
	Mules and asses	100506	Mules and asses	IE ²⁾	IE ²⁾	IE ²⁾
	Poultry	100507 /08/09	Laying hens, broilers, Other poultry (ducks, geese,...)	NA	✓	✓
	Other (Rabbit, Reindeer, Ostrich, fur-bearing animals, Other)	100415	Other	NO	NO	NO
3.B.5	Indirect N ₂ O emissions			NO	NO	✓
3.C	RICE CULTIVATION	100103 100103	Rice Field (with fertilizers) Rice Field (without fertilizers)	NO	NO	NO
3.D	AGRICULTURAL SOILS	1001 1002	Cultures with fertilizers Cultures without fertilizers	NA	NA	✓
3.D.a	Direct N ₂ O emissions from managed soils	1001/1002	Cultures with and without fertilizers	NA	NA	✓
3.D.a.1	Inorganic N fertilizers	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.2	Organic N fertilizers	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.2.a	Animal manure applied to soils	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.2.b	Sewage sludge applied to soils	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.2.c	Other organic fertilizers applied to soils	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.3	Urine and dung deposited by grazing animals	1002	Cultures without fertilizers	NA	NA	✓
3.D.a.4	Crop residues	1001	Cultures with fertilizers	NA	NA	✓
3.D.a.5	Mineralization/immobilization associated with loss/gain of soil organic matter	1002	Cultures without fertilizers	NA	NA	✓
3.D.a.6	Cultivation of organic soils (i.e. histosols)	1002	Cultures without fertilizers	NA	NA	✓
3.D.a.7	Other	–	–	NO	NO	NO
3.D.b	Indirect N ₂ O Emissions from managed soils	1001	Cultures with fertilizers	NA	NA	✓
3.D.b.1	Atmospheric deposition	1001	Cultures with fertilizers	NA	NA	✓
3.D.b.2	Nitrogen leaching and run-off	1001	Cultures with fertilizers	NA	NA	✓
3.E	PRESCRIBED BURNING OF SAVANNAS	–	–	NO	NO	NO
3.F	FIELD BURNING OF AGRICULTURAL RESIDUES	1003	ON-FIELD BURNING OF STUBBLE, STRAW, ...	NA	✓	✓
3.F.1	Cereals	100301	Cereals	NA	✓ ²⁾	✓ ²⁾
3.F.2	Pulses	100302	Pulse	NO	NO	NO
3.F.3	Tubers and Roots	100303	Tuber and Root	NO	NO	NO
3.F.4	Sugar Cane	100304	Sugar Cane	NO	NO	NO
3.G	Liming	1006	Use of pesticides and limestone	✓	NA	NA

IPCC Category		SNAP		CO ₂	CH ₄	N ₂ O
3.G.1	Limestone CaCO ₃	1006	Use of pesticides and limestone	✓	NA	NA
3.G.2	Dolomite CaMg(CO ₃) ₂	1006	Use of pesticides and limestone	✓	NA	NA
3.H	Urea application	1006	Use of pesticides and limestone	✓	NA	NA
3.I	Other carbon-containing fertilisers	1006	Use of pesticides and limestone	✓	NA	NA

¹⁾ included in 3.A.4 Horses, SNAP 100406; ²⁾ included in 3.B.4 Horses, SNAP 100506

²⁾ emissions reported for 1990-2020; for 2021 and 2022 "not occurring"

In response to a recommendation of the UNFCCC Review 2023 (ARR 2023), Austria provides further information on mules and asses: Official statistics and farmstructure surveys do not report mules and asses separately ("horses and other solipeds"). Legal framework for these surveys at EU level is regulation (EU) 2018/1091. However, animal numbers of donkeys are only of very little importance in Austria. The Association of Austria's "donkey friends" (IA-AUSTRIA Interessensgemeinschaft österr. Esselfreunde) estimates for Austria a donkey population of about 1 500 to 2 000 animals. This corresponds to a share of about 1% of the total number of horses and solipeds (130 000) and is far below the uncertainty of activity data (+/-10%). The reporting of IE for donkeys and considering them in the horse category is therefore a conservative approach to prevent Austria's inventory from underestimation.

5.1.8 Planned Improvements

A new survey on animal husbandry and manure management systems ("TIHALO III" study) is currently carried out. Work is in progress and the study results will be implemented in submission 2025. Additionally, the implementation of the 2019 Refinement to the 2006 IPCC GL for sectors 3.B *Manure Management* and 3.D *Agricultural Soils* is planned for the next submission.

For the horses category, Austria will examine the options for updating the activity data in accordance with the recommendation in the UNFCCC Review 2023.

5.2 Enteric fermentation (Category 3.A)

Key source: CH₄ 3.A.1 Cattle

This chapter describes the estimation of CH₄ emissions from enteric fermentation. In 2022 87.2% of agricultural CH₄ emissions arose from this category.

5.2.1 Source Category Description

CH₄ emissions amounted to 180.5 kt in 1990 and have decreased by 15.3% to 153.0 kt in 2022. Almost all emissions of category 3.A (94.2% in 2022) are caused by cattle farming, thus CH₄ emissions from *Cattle (3.A.1)* are a key source. The contribution of *Dairy Cattle (3.A.1.1)* decreased from 54.2% in 1990 to 46.8% in 2022.

Table 161: Greenhouse gas emissions from enteric fermentation by sub-categories 1990–2022.

Year	CH ₄ emissions [kt] per Livestock Category								
	3.A	3.A.1.1	3.A.1.2	3.A.2	3.A.3	3.A.4.1	3.A.4.2	3.A.4.3	3.A.4.4
	Total	Dairy Cattle	Non-Dairy	Sheep	Swine	Other/ Poultry	Other/ Horses	Other/ Goats	Other/ Deer
1990	180.52	97.88	75.47	2.48	3.13	0.19	0.89	0.19	0.30
1995	178.51	80.38	90.11	2.92	3.00	0.19	1.30	0.27	0.32
2000	167.56	73.23	86.66	2.71	2.71	0.16	1.49	0.28	0.32
2005	157.51	65.15	84.64	2.61	2.64	0.18	1.67	0.28	0.34
2010	159.07	65.98	84.74	2.87	2.63	0.20	1.91	0.36	0.38
2011	156.95	65.63	82.99	2.89	2.55	0.20	1.96	0.36	0.37
2012	155.67	65.80	81.49	2.92	2.53	0.21	2.01	0.37	0.35
2013	156.08	66.67	81.11	2.86	2.47	0.21	2.06	0.36	0.33
2014	156.72	67.91	80.56	2.79	2.44	0.22	2.11	0.35	0.33
2015	156.77	67.65	80.75	2.83	2.44	0.23	2.16	0.38	0.33
2016	157.22	68.99	79.66	3.03	2.40	0.24	2.16	0.41	0.33
2017	157.43	69.60	78.82	3.21	2.44	0.24	2.34	0.46	0.32
2018	155.39	68.91	77.46	3.25	2.41	0.25	2.34	0.46	0.32
2019	153.16	67.92	76.22	3.22	2.41	0.26	2.34	0.46	0.31
2020	152.06	68.42	74.69	3.15	2.43	0.27	2.34	0.46	0.31
2021	152.54	68.56	74.93	3.22	2.42	0.27	2.34	0.50	0.31
2022	152.99	71.61	72.49	3.21	2.28	0.27	2.34	0.50	0.31
Share 2022	100%	46.8%	47.4%	2.1%	1.5%	0.2%	1.5%	0.3%	0.2%
1990–2022	-15.3%	-26.8%	-4.0%	29.3%	-27.1%	42.9%	164.2%	165.2%	3.2%

The overall reduction is caused by a decrease in total numbers of cattle and swine. However, in the case of dairy cows the reduction of animals is partly counterbalanced by an increase in emissions per animal (because of the increasing milk yield and the connected gross energy intake since 1990).

Following a recommendation of the centralized review 2008 CH₄ emissions from *Non-Dairy Cattle* are reported separately:

Table 162: Greenhouse gas emissions from non-dairy cattle (3.A.1.2) by sub-categories 1990–2022.

Year	CH ₄ emissions [kt] of Non-Dairy Cattle (3.A.1.2) sub-categories					
	3.A.1.2 Total	Suckling Cows > 2 yr	Young Cattle < 1 yr	Breeding Heifers 1–2 yr	Fattening Heifers 1–2 yr	Other Cattle > 2 yr
1990	75.47	4.65	19.96	18.47	22.51	9.88
1995	90.11	21.23	17.66	19.13	21.94	10.16
2000	86.66	26.11	16.35	17.57	16.09	10.54
2005	84.64	28.55	15.61	16.26	14.97	9.25
2010	84.74	27.79	15.79	13.29	18.44	9.42
2011	82.99	27.40	15.52	13.09	17.72	9.26
2012	81.49	26.58	15.68	13.18	17.27	8.78
2013	81.11	25.34	15.69	13.65	17.67	8.76
2014	80.56	24.67	15.79	13.68	17.56	8.87
2015	80.75	24.12	15.67	13.96	17.82	9.18
2016	79.66	23.35	15.91	13.85	17.46	9.10

Year	CH ₄ emissions [kt] of Non-Dairy Cattle (3.A.1.2) sub-categories					
	3.A.1.2 Total	Suckling Cows > 2 yr	Young Cattle < 1 yr	Breeding Heifers 1-2 yr	Fattening Heifers 1-2 yr	Other Cattle > 2 yr
2017	78.82	22.30	15.74	13.73	18.11	8.94
2018	77.46	21.59	15.60	13.65	17.50	9.11
2019	76.22	21.05	15.27	13.31	17.76	8.83
2020	74.69	20.55	15.11	13.03	17.21	8.77
2021	74.93	20.02	15.47	13.11	17.64	8.70
2022	72.49	17.00	15.36	14.51	16.93	8.69
Share 2022	100%	23%	21%	20%	23%	12%
1990–2022	-4.0%	265.8%	-23.1%	-21.5%	-24.8%	-12.0%

The rise in suckling cow numbers (see Table 163) nearly counterbalances the decreasing emission trend of all the other non-dairy cattle sub-categories. These sub-categories include both, female cattle and bulls.

5.2.2 Methodological Issues

The IPCC Tier 1 Method was applied for sheep, goats, horses and ‘other animals’. For *Cattle* and *Swine* the more detailed Tier 2 method was applied. The 2006 IPCC Guidelines do not provide methodologies for the categories poultry and other.

The animal category “deer”, reported under category ‘*other livestock*’ (3.A.4.4), corresponds to red deer, sika deer and fallow deer in Austria according to the farmstructure survey (STATISTIK AUSTRIA 2022a). As the contribution to the overall emissions is very small, the default emission factor of sheep has been used because sheep is the most similar animal category to deer.

For the calculation of CH₄ emissions from poultry the emission factors (net energy ingested, methane conversion rate) applied by Switzerland have been chosen to be applied in the Austrian emission inventory as Tier 1. Agricultural practices in Switzerland are very similar to those in Austria: Both countries have a small structured agriculture due to similar alpine conditions and comparable traditions. In both countries high shares of farms manage less than 20 ha (in Austria 55% and in Switzerland about 56%). No default values are available for poultry, neither in the 2006 IPCC Guidelines nor in the 2019 IPCC Refinement.

Activity data

The Austrian official statistics (STATISTIK AUSTRIA 2023g) provides national data of annual livestock numbers on a very detailed level. These data are based on livestock counts held in December each year⁸⁷.

Table 163 and Table 164 presents applied animal data. Background information is 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.

⁸⁷ For cattle livestock counts are also held in June, but seasonal changes are very small (between 0% and 2%). Livestock counts of sheep are only held in December (sheep is only a minor source for Austria and seasonal changes of the population are not considered relevant).

1998–2000; 2006–2008: increasing/decreasing swine numbers: The production of swine has a high elasticity to prices: Swine numbers are changing due to changing market prices very rapidly. Market prices change due to changes in consumer behaviour, saturation of swine production, epidemics etc.

Table 163: Domestic livestock population and its trend 1990–2022 (I).

Year	Population size [heads] * Livestock category						
	Dairy	Non-Dairy	Suckling Cows	Young Cattle < 1 yr	Breeding Heifers 1–2 yr	Fattening Heifers, Bulls, Oxen 1–2 yr	Other Cattle > 2 yr
1990	904 617	1 679 297	47 020	925 162	254 883	305 920	146 312
1995	706 494	1 619 331	210 479	691 454	266 108	298 244	153 046
2000	621 002	1 534 445	252 792	655 368	246 382	220 102	159 801
2005	534 417	1 476 263	270 465	628 426	229 874	206 429	141 069
2010	532 735	1 480 546	260 883	634 052	187 386	256 266	141 959
2011	527 393	1 449 134	256 831	623 364	184 160	245 770	139 009
2012	523 369	1 432 249	248 438	628 715	184 932	238 968	131 196
2013	529 560	1 428 722	236 655	626 970	191 002	243 546	130 549
2014	537 744	1 423 457	229 986	629 401	191 049	241 408	131 613
2015	534 098	1 423 512	224 348	624 483	194 493	244 588	135 600
2016	539 867	1 414 524	216 678	632 150	192 455	239 588	133 653
2017	543 421	1 400 055	207 007	623 517	190 364	248 227	130 940
2018	532 873	1 379 935	200 475	618 218	188 698	239 685	132 859
2019	524 068	1 355 452	195 480	605 322	183 402	243 023	128 225
2020	524 783	1 330 649	190 685	598 598	179 120	235 277	126 969
2021	526 461	1 343 639	185 692	611 007	180 083	240 992	125 865
2022	550 554	1 310 517	157 811	596 990	199 330	230 800	125 586
Trend 90–22	-39.1%	-22.0%	235.6%	-35.5%	-21.8%	-24.6%	-14.2%

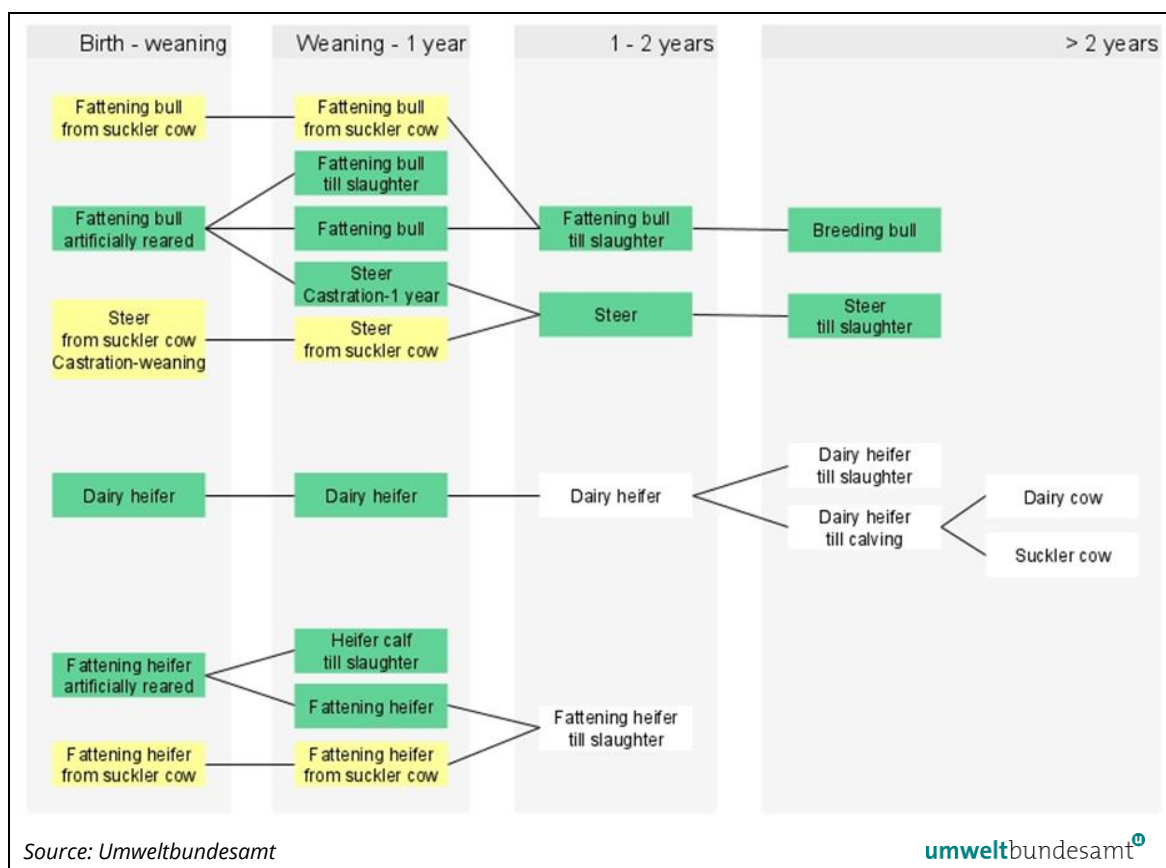
The FAO agricultural data base (FAOSTAT) provides worldwide harmonized data (FAO AGR. STATISTICAL SYSTEM 2001). In the case of Austria, these data come from the national statistical system (Statistik Austria). However, there are inconsistencies between these two data sets. Analysis shows that there is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

Cattle numbers decreased by 0.5 % in 2022 compared to the year before (dairy cows: + 4.6 %; other cattle: - 2.5 %). According to the Green Report 2023 (BML 2023b) the reason for this decline is the ongoing structural change; the number of cattle farms also decreased by 2.1 % compared to 2021.

Splitting of cattle categories for background calculations

In order to be able to take more precise feeding assumptions and energy requirement calculations into account, the livestock categories “cattle <1 year”, “cattle 1–2 years, breeding animals”, “cattle 1–2 years, fattening animals”, “dairy cows”, “suckling cows” and “other cattle > 2 years” were further subdivided. For this subdivision additional data from AgrarMarkt Austria (AMA) were used. However, the numbers of animals per superordinate category (see Table 163) based on (STATISTIK AUSTRIA 2023g) were not changed.

Figure 29: Allocation of the cattle numbers for determining energy requirements.



Reallocation of swine categories

The number of pigs was reclassified to allow a more accurate calculation of energy requirements by dividing them into three categories: “breeding sows (including suckling piglets up to 8 kg live weight) and boars”, “piglets 8 to 32 kg live weight” and “fattening pigs” (see Table 164).

Breeding sows and boars

The livestock numbers of category “breeding pigs over 50 kg”, taken from livestock census data of Statistics Austria, also include gilts above 50 kg until first insemination, which make up approximately 19% of this category. In terms of feed intake and nutrient excretion they correspond more to category “fattening pigs” and have therefore been assigned to that category. Breeding boars, which comprise just about 2% of “breeding pigs (over 50 kg)” were calculated similarly as sows in terms of feed intake and excretions.

Piglets 8 to 32 kg

In the official Austrian livestock census, piglets between 8 and 32 kg live weight are divided into the categories “up to 20 kg” and “young pigs 20–50 kg”. The number of piglets 8 to 32 kg used for emission calculations was determined on the basis of rearing days and body weight.

Fattening pigs

As the category “fattening pigs above 32 kg to the end of fattening” is not provided in the livestock census, it had to be derived from the categories “piglets 20–50 kg” and “pigs 50 kg to end of fattening”. In addition, the category “gilts above 50 kg before first insemination” was added, since these were subtracted from the breeding sows category.

The total number of pigs according to Statistics Austria (STATISTIK AUSTRIA 2023g) exceeds the total number of pigs used in the inventory calculations as they do not consider litters <8kg. This can be explained by the emission factors of breeding sows which already take into account the emissions of suckling piglets up to 8 kg live weight. The Austrian swine numbers are presented in the following table:

Table 164: Domestic livestock population and its trend 1990–2022 (II).

Year	Livestock category – Population size [heads]*									
	Total Swine (including litter <8kg)**	Total Swine (excluding litter <8kg)	Young & Fattening Pigs incl. gilts	Breeding Sows with- out replace- ment gilts	Young Swine 8–32 kg	litter <8kg ³⁾	Sheep	Goats	Horses ¹⁾	Deer ²⁾
1990	3 687 981	3 470 006	2 002 846	374 956	1 092 204	217 975	309 912	37 343	49 200	37 100
1995	3 706 185	3 262 871	1 878 195	368 616	1 016 060	443 314	365 250	54 228	72 491	40 323
2000	3 347 931	2 948 771	1 723 098	307 020	918 653	399 160	339 238	56 105	82 943	39 612
2005	3 169 541	2 812 822	1 694 649	287 570	830 604	356 719	325 728	55 100	92 560	43 014
2010	3 134 156	2 776 522	1 696 999	261 410	818 113	357 634	358 415	71 768	106 280	47 575
2011	3 004 907	2 669 093	1 643 448	249 725	775 920	335 814	361 183	72 358	109 024	45 654
2012	2 983 158	2 646 917	1 635 956	239 999	770 962	336 241	364 645	73 212	111 768	43 733
2013	2 895 841	2 575 599	1 594 771	231 750	749 078	320 242	357 440	72 068	114 512	41 812
2014	2 868 191	2 544 151	1 577 174	224 983	741 994	324 040	349 087	70 705	117 256	41 600
2015	2 845 451	2 525 795	1 572 529	225 158	728 108	319 656	353 710	76 620	120 000	41 388
2016	2 792 803	2 483 812	1 549 287	218 773	715 751	308 991	378 381	82 735	120 000	41 176
2017	2 820 082	2 507 701	1 570 251	221 197	716 252	312 381	401 480	91 134	130 000	40 457
2018	2 776 574	2 471 234	1 562 976	210 675	697 584	305 340	406 336	91 536	130 000	39 738
2019	2 773 225	2 468 737	1 557 498	211 058	700 181	304 488	402 658	92 504	130 000	39 018
2020	2 806 461	2 495 809	1 571 571	208 364	715 874	310 652	393 764	92 758	130 000	38 299
2021	2 785 587	2 479 172	1 568 407	205 556	705 209	306 415	402 345	100 601	130 000	38 299
2022	2 650 151	2 352 717	1 489 800	191 188	671 729	297 434	400 664	99 019	130 000	38 299
Trend 90–22	-28.1%	-32.2%	-25.6%	-49.0%	-38.5%	+36.5%	29.3%	165.2%	164.2%	3.2%

* from 1990 to 1992 adjusted age class split for swine as recommended in the centralized review (October 2003)

** total number of Swine according to (STATISTIK AUSTRIA 2023g) and published in (BML 2023b)

¹⁾ for the years 2000–2002 and 2004–2014: interpolated values

²⁾ for the years 1991–1993, 2000–2002, 2004–2009, 2011–2012, 2014–2015 and 2017–2019: interpolated values

³⁾ not applied because already considered in the emission factors of breeding sows

Goat and sheep numbers decreased in 2022 compared to 2021. For swine a decrease in livestock numbers could be observed in 2022.

Horse numbers for 2015, 2016, 2017, 2018, 2019, 2020, 2021 and 2022 are annually published in the Ministry of Agriculture's Green Reports in (BML 2023b, p. 53) and based on an estimate by the Austrian Horse Breeding Association which includes both agricultural and leisure horses. Horse numbers used for the years before 2004 are based on livestock accountings and are assessed to be representative for Austria. Data for the years 2004 to 2014 were derived by interpolation.

Table 165: Domestic livestock population and its trend 1990–2022 (III).

Year	Livestock category – Population size [heads]*					
	Total Poultry	Chicken*	Laying hens*	Broilers*	Turkeys**	Other Poultry**
1990	13 820 961	13 139 151	8 392 369	4 746 782	524 616	157 194
1995	13 959 316	13 157 078	7 899 011	5 258 067	679 477	122 761
2000	11 786 670	11 077 343	6 555 815	4 521 528	588 522	120 805
2005	13 489 222	12 801 345	6 678 696	6 122 650	568 854	119 022
2010	14 644 413	13 918 813	7 061 377	6 857 436	615 813	109 787
2011	15 020 126	14 305 565	7 373 407	6 932 158	610 708	103 853
2012	15 395 838	14 692 317	7 685 438	7 006 879	605 602	97 919
2013	15 771 551	15 079 069	7 997 468	7 081 601	600 497	91 985
2014	16 334 620	15 634 432	8 356 808	7 277 624	597 071	103 117
2015	16 897 690	16 189 796	8 716 148	7 473 648	593 645	114 249
2016	17 460 759	16 745 159	9 075 488	7 669 671	590 219	125 381
2017	18 033 026	17 309 548	9 190 513	8 119 035	584 503	138 975
2018	18 605 292	17 873 937	9 305 538	8 568 399	578 787	152 569
2019	19 177 559	18 438 326	9 420 563	9 017 763	573 070	166 162
2020	19 749 825	19 002 715	9 535 588	9 467 127	567 354	179 756
2021	19 749 825	19 002 715	9 535 588	9 467 127	567 354	179 756
2022	19 749 825	19 002 715	9 535 588	9 467 127	567 354	179 756
Trend 90–22	42.9%	44.6%	13.6%	99.4%	8.1%	14.4%

* interpolated values for the years 2004–2009, 2011–2012, 2014–2015 and 2017–2019

** value for 1999 is not available – value derived from the average share of previous and following 5 years of total other poultry; interpolated values for the years 2004–2009, 2011–2012, 2014–2015 and 2017–2019

Animal numbers of poultry and deer are not included in the livestock counts held in December each year but gathered within Austria's farm structure surveys carried out as complete surveys every 10 years. The latest farm structure survey was carried out in 2020. Livestock data for poultry (layers, broilers, turkeys and other poultry) as well as for deer was included on the basis of the final results of the 2020 survey (STATISTIK AUSTRIA 2022a). The 2020 figures were taken for the years 2021 and 2022.

5.2.2.1 Cattle (3.A.1)

Key Source: Yes (CH₄)

CH₄ emissions from enteric fermentation – cattle (sum of dairy and non-dairy cattle) are a key source due to the contribution to total greenhouse gas emissions in Austria and also due to its contribution to the total inventory's trend. In the year 2022, emissions from enteric fermentation – cattle contributed 5.5% to total greenhouse gas emissions in Austria.

CH₄ emissions were calculated using the IPCC Tier 2 methodology. In submission 2022 new study results of the research project "MiNutE" (HÖRTENHUBER et. al. 2022b, HÖRTENHUBER et. al. 2023) carried out by the University of Natural Resources and Life Sciences, Vienna, have been implemented. Within the framework of this country specific study refined calculations for cattle and swine were elaborated establishing a dynamic use of national parameters on the basis of latest

available science. Activity data were obtained from national statistics and are presented in Table 163 and Table 164.

Emission factors

Country specific emission factors were used. They were calculated from the specific gross energy intake and the methane conversion factor (2019 Refinement to the 2006 IPCC GL, Equation 10.21).

$$EF = \frac{GE * (\frac{Y_m}{100}) * 365}{55.65}$$

EF = emission factor, kg CH₄ head⁻¹ yr⁻¹

GE = gross energy intake, MJ head⁻¹ day⁻¹

Y_m = Methane conversion factor, per cent of gross energy in feed converted to methane

The factor 55.56 (MJ/kg CH₄) is the energy content of methane

Table 166: Methane conversion factors (*Y_m*) 1990–2022 for cattle categories in Austria.

Year	Methane conversion factor (<i>Y_m</i>)					
	Dairy cows	Suckling cows	Breeding heifers 1–2 years	Fattening heifers 1–2 years	Cattle <1 year	Cattle >2 years
1990	6.50	6.50	6.30	6.30	4.34	6.30
1995	6.47	6.50	6.30	6.30	4.68	6.30
2000	6.43	6.50	6.30	6.30	4.58	6.30
2005	6.40	6.50	6.30	6.30	4.51	6.30
2010	6.36	6.50	6.30	6.30	4.38	6.30
2011	6.36	6.50	6.30	6.30	4.36	6.30
2012	6.35	6.50	6.30	6.30	4.36	6.30
2013	6.34	6.50	6.30	6.30	4.37	6.30
2014	6.33	6.50	6.30	6.30	4.37	6.30
2015	6.33	6.50	6.30	6.30	4.36	6.30
2016	6.32	6.50	6.30	6.30	4.35	6.30
2017	6.31	6.50	6.30	6.30	4.35	6.30
2018	6.31	6.50	6.30	6.30	4.34	6.30
2019	6.30	6.50	6.30	6.30	4.32	6.30
2020	6.30	6.50	6.30	6.30	4.31	6.30
2021	6.30	6.50	6.30	6.30	4.32	6.30
2022	6.30	6.50	6.30	6.30	4.41	6.30

As explained in Chapter 5.2.2, the feeding assumptions and energy demand calculations were developed on the basis of a very detailed analysis of the Austrian livestock population (see Figure 29). These detailed considerations elaborated in (HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) made it necessary to proceed on the basis of the latest available scientific literature. For emission calculation Austria therefore uses the most updated information on methane conversion factors (*Y_m*) provided in the 2019 Refinement to the 2006 IPCC GL, Table 10.12.

*Methane conversion factor (*Y_m*) dairy cows*

For 2022, a methane conversion factor for “medium producing cows” of 6.3 was applied based on the annual milk yield of 7 250 kg and feed digestibility of 71.6% of Austrian dairy cows. For 1990, a

methane conversion factor for low producing cows of 6.5 was taken based on the annual milk yield of 3 791 kg of Austrian dairy cows and considerations on feed digestibility.

The average methane conversion factor for all the other non-dairy cattle categories resulted in a value of 5.47 for 2022.

Methane conversion factor (Y_m) suckling cows

A methane conversion factor for “low producing cows” of 6.5 was applied. Despite higher feed digestibility of the average feed ration of Austrian suckler cows, suckling cows can be counted as low producing cows due to their low milk yield.

Methane conversion factor (Y_m) breeding and fattening cattle

A methane conversion factor of 0 was applied for unweaned calves fed mainly with milk. For all other categories of breeding and fattening cattle, a methane conversion factor of 6.3 was taken. This value is recommended for cattle feed rations consisting of more than 75% high quality forage, mixed rations and for a feed digestibility of 62-71%. Although the average feed digestibility of breeding and fattening cattle in Austria is higher, the proportion of high-quality basic feed is mostly 75% or higher.

For the Gross Energy Intake country specific values were applied. The estimation was made separately for all cattle categories.

Gross energy intake of dairy cows (3.A.1.a):

In previous submissions the Austrian specific values for dairy cows were derived from (GRUBER & STEINWIDDER 1996, PÖTSCH 2005 and GRUBER & PÖTSCH 2006). Calculations on gross energy intake used since submission 2022 were elaborated within a country-specific study on animal feeding and nutrition (“MiNutE” study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023).

Gross energy intake of dairy cattle is calculated using equation 10.16 taken from the 2019 Refinement to the 2006 IPCC GL, which is derived based on the summed net energy requirements and the energy availability characteristics of the feed.

The following information has been used for feed intake estimates:

Body mass

Data on body mass form the basis for the calculation of the maintenance net energy. The body mass of the most common breeds Fleckvieh, Braunvieh and Holstein for the years from 2016 onwards were derived from the Efficient Cow project (EGGER-DANNER et al. 2016). In this project, body mass was assessed as part of the dairy performance tests. Data from cows in or after their first lactation were used. The cows' weight was evaluated repeatedly (46 896 weight assessments in total) and increases with rising milk yield.

Animal husbandry

The parameters of animal husbandry are used to calculate the net energy for activity. This depends on how much time the animals spend in the barn, on the pasture or on the mountain pasture. The proportion of grazed cows was derived from country specific studies “TIHALO I and II” and weighted with the average number of grazing hours per day and the number of grazing days per year (AMON et al. 2007; PÖLLINGER et al. 2018). For the proportion of dairy cows on pasture in

1990 an expert estimate by Alfred Pöllinger was used. Data for the years between (1990, 2005, 2017) were interpolated.

Milk yield

The milk yield and the fat content of the milk are needed for the calculation of net energy for lactation. The protein content of the milk is used in the calculation of N retention. Austrian dairy cattle show average milk yields from 3 791 kg/cow (1990) to 7 250 kg/cow (2022). The time series of average milk yields per dairy cow was taken from national statistics and are presented in Table 168. Data on the average fat content and protein content of milk were derived from information provided by AgrarMarkt Austria (AMA).

Gestation

The proportion of animals that experience gestation in a year is used to calculate the net energy for gestation. The percentage of gestating cows is calculated by dividing 365 days by the days between calvings. For the years 2007-2021, the days between two subsequent calvings were calculated per breed and weighted accordingly, based on the data of the annual breeding data reports (RINDERZUCHT AUSTRIA 2023). For small-framed breeds, the calving interval of Grauvieh was used, for medium- and large-framed breeds the calving interval of Pinzgauer was used. In 2021, Fleckvieh cows had a calving interval of 392 days, Brown Swiss of 422 days, Holstein of 412 days, Grauvieh of 405 days and Pinzgauer of 399 days. For 2022 the figures of 2021 have been taken.

Feeding

The average crude protein content in dry matter and the proportion of crude ash in dry matter were derived from the Efficient Cow project (EGGER-DANNER et al. 2016) for the years 2016-2019. The value for 2002 is based on the mean value of two national studies (STEINWIDDER & GUGGENBERGER 2003; GRUBER & STEINWENDER 1992). The years in between were derived by interpolation. The average feed digestibility in Austria for dairy cows was estimated by nutrition expert Dr. Erich Pötsch (2005) based on model calculations from (GRUBER & STEINWIDDER 1996) on feed intake, performance and excretion. Feed digestibility is expressed as a percentage and adjusted to the level of the annual milk yield.

Table 167: Parameters for calculating GE intake for dairy cattle in Austria 1990–2022.

Year	net energy for maintenance	net energy for animal activity	net energy for lactation	net energy for work	net energy for pregnancy	ratio net energy for maintenance to digestible energy	digestibility of feed
	MJ day ⁻¹	MJ day ⁻¹	MJ day ⁻¹	MJ day ⁻¹	MJ day ⁻¹		%
1990	49.88	1.03	31.97	0.00	4.63	0.52	66.48
1995	50.14	0.86	39.25	0.00	4.65	0.52	67.70
2000	50.70	0.69	44.56	0.00	4.69	0.52	68.58
2005	51.22	0.52	49.91	0.00	4.73	0.53	69.43
2010	51.74	0.51	52.64	0.00	4.78	0.53	69.89
2011	51.82	0.50	53.60	0.00	4.78	0.53	70.08
2012	51.89	0.50	55.39	0.00	4.80	0.53	70.37
2013	52.00	0.49	55.68	0.00	4.81	0.53	70.43
2014	52.10	0.49	56.31	0.00	4.82	0.53	70.55
2015	52.18	0.49	56.78	0.00	4.86	0.53	70.60

Year	ratio net energy for						digestibility of feed
	net energy for maintenance	net energy for animal activity	net energy for lactation	net energy for work	net energy for pregnancy	ratio net energy for maintenance to digestible energy	
	MJ day ⁻¹	MJ day ⁻¹	MJ day ⁻¹	MJ day ⁻¹	MJ day ⁻¹		
2016	52.28	0.48	58.41	0.00	4.86	0.53	70.87
2017	52.26	0.48	59.17	0.00	4.86	0.53	71.03
2018	52.24	0.48	61.23	0.00	4.86	0.53	71.38
2019	52.19	0.48	61.96	0.00	4.83	0.53	71.49
2020	52.18	0.48	63.04	0.00	4.82	0.53	71.65
2021	52.17	0.48	62.80	0.00	4.81	0.53	71.59
2022	52.17	0.48	62.65	0.00	4.81	0.53	71.60

For dairy cattle there was a 24.0% increase of GE intake between 1990 and 2022 mainly due to an increase of the milk yield per dairy cow in this time (lactation performance). The resulting emission factor is presented in the following table:

Table 168: Annual milk yield, gross energy intake and CH₄ emission factors of dairy cattle 1990–2022.

Year	Average live body weight	Milk Yield	Gross Energy Intake	Emission Factor
	kg	[kg/cow*yr]	[MJ/head*day]	[kg CH ₄ /head*yr]
1990	676	3 791	253.8	108.20
1995	681	4 619	268.3	113.78
2000	691	5 210	279.6	117.92
2005	700	5 783	290.6	121.92
2010	710	6 100	296.8	123.86
2011	711	6 227	298.6	124.44
2012	713	6 418	302.0	125.73
2013	715	6 460	302.7	125.89
2014	716	6 542	304.0	126.29
2015	718	6 579	305.2	126.66
2016	720	6 759	308.2	127.79
2017	719	6 865	309.3	128.08
2018	719	7 104	312.6	129.31
2019	718	7 179	313.7	129.61
2020	718	7 286	315.5	130.37
2021	718	7 249	315.2	130.22
2022	718	7 250	314.8	130.06

¹⁾ From 1995 onwards data have been revised by Statistik Austria.

Up to the early 1990ies Austrian dairy husbandry was determined by traditional Austrian green feeding and traditional Austrian breeds. From the mid 1990ies onwards milk production has been intensified: diets with higher energy concentration were fed and the share of high yield breeds (e.g. Holstein Friesian) in dairy farming was increased. Anyhow, the traditional Austrian breed “Fleckvieh” (about 700 kg live weight) still dominates the herd.

*GE Gross energy intake of non-dairy cattle (3.A.1.b)**Suckling cows*

In the framework of the national study on country-specific animal feeding and nutrition ("MiNuTE" study, HÖRTENHUBER et al. 2022b; HÖRTENHUBER et al. 2023) the gross energy intake was calculated by applying equation 10.16 taken from the 2019 Refinement to the 2006 IPCC GL (IPCC 2019). The parameters for calculating GE intake for suckling cows are provided in Table 169.

Body mass

A comparison of the body mass of suckling cows and dairy cows showed that suckling cows have about 50 kg less body mass than dairy cows (GRUBER et al. 2001, 2015; HÄUSLER et al. 2015).

Animal husbandry

Similar to the dairy cows, the proportion of grazed suckling cows was derived from the TIHALO studies (AMON et al., 2007; PÖLLINGER et al., 2018) and from expert judgement (PÖLLINGER 2008) for the year 1990. The proportion of suckling cows was weighted with the grazing time and the grazing days per year. Data for the years between (1990, 2005, 2017) were interpolated.

Milk yield

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. A new born calf has around 40 kg and suckles until it weighs about 350 kg. As a rule of thumb under the national circumstances in Austria 10 kg milk are needed for 1 kg gain in weight for a calf.

The study „Mutterkuh und Ochsenhaltung 2003“ in which 56 holdings in Styria, Lower Austria, Carinthia and Salzburg were investigated, reports daily rates of weight increases of 1 020 g (2002) and 1 060 g (2003). Calves were suckled about 300 days (GRABNER et al. 2004). An experiment based on measurements made from 1978 to 1987 (STEINWENDER & GOLD 1989) shows similar results: The daily increase of weight of young bulls was 1 225 g and of young cows 1 044 g.

Thus, for 1990 in the Austrian Greenhouse Gas Emission Inventory an average milk yield of 3 000 kg was applied (see Table 170).

In a study with Austrian suckling cows (Simmental) carried out from 2004 to 2008, the influence of duration of suckling period (180 days and 270 days) on milk yield and body weight of cows and weight gain of calves was determined (STEINWIDDER et al. 2006). Cows were fed with forage of low quality. Anyhow, the average milk yield per suckling period was on a high level: For 6 months of suckling an average milk yield of 2 245 kg, and for 9 month of suckling an average milk yield of 3 351 kg per cow has been measured (HÄUSLER 2009). The daily gains of the beef cattle (Simmental x Limousin steers and heifers) were 1.27 and 1.28 kg for the 180 or 270 days of suckling, respectively.

In consideration of the low forage quality identified in the study mentioned above, the suckling periods of up to 300 days and a calculated demand of 3 500 kg milk per calf, an average milk yield of 3 500 kg has been assumed for the years from 2004 onwards. Values between 1990 and 2004 have been derived by interpolation (see Table 170).

Gestation

Information on the calving interval were derived from the 2012, 2014 and 2019 suckling cow and steer husbandry working group reports ("Arbeitskreisberichte" zu Mutterkühen und Ochsen).

Feeding

For the year 1990 a crude protein content of 11.9% was applied, which is the crude protein requirement for a milk yield of 3 000 kg milk per year according to (GRUBER & PÖTSCH 2006). Starting in 2004, a milk yield of 3 500 kg milk per year is assumed, for which a crude protein content of 12% is taken, corresponding to the feeding recommendation for suckler cows (STEINWIDDER 2003).

The percentage of crude ash in dry matter was derived from national studies (STEINWIDDER & GUGGENBERGER 2003; GRUBER & PÖTSCH 2006) and corresponds to the values used in previous inventories. Based on these studies, a crude ash content of 11% was adopted for milk yields up to 7 000 kg. A crude ash content of 11% in DM was therefore adopted for suckling cows from 1990 to 2022.

The average feed digestibility was assessed in an expert evaluation for dairy cows by (PÖTSCH 2005), based on model calculations taken from (GRUBER & STEINWIDDER 1996) on feed intake, performance and excretions. The values for dairy cattle were adopted and adjusted to the level of annual milk yield for suckling cows.

Table 169: Parameters for calculating GE intake for suckling cows in Austria 1990–2022.

Year	net energy for maintenance	net energy for animal activity	net energy for lactation	net energy for work	net energy for pregnancy	ratio net energy for maintenance to digestible energy	digestibility of feed
	MJ day ⁻¹	MJ day ⁻¹	MJ day ⁻¹	MJ day ⁻¹	MJ day ⁻¹		%
1990	47.09	1.19	25.30	0.00	4.36	0.51	65.31
1995	47.36	1.28	27.01	0.00	4.37	0.52	65.57
2000	47.93	1.37	28.72	0.00	4.41	0.52	65.84
2005	48.46	1.50	30.21	0.00	4.44	0.52	66.05
2010	48.99	1.70	30.21	0.00	4.47	0.52	66.05
2011	49.05	1.75	30.13	0.00	4.56	0.52	66.05
2012	49.12	1.80	30.21	0.00	4.61	0.52	66.05
2013	49.25	1.86	30.17	0.00	4.54	0.52	66.05
2014	49.34	1.90	30.13	0.00	4.57	0.52	66.05
2015	49.44	1.95	30.21	0.00	4.57	0.52	66.05
2016	49.54	2.00	30.24	0.00	4.57	0.52	66.05
2017	49.52	2.06	30.17	0.00	4.56	0.52	66.05
2018	49.51	2.10	30.17	0.00	4.55	0.52	66.05
2019	49.45	2.12	30.21	0.00	4.54	0.52	66.05
2020	49.44	2.12	30.28	0.00	4.53	0.52	66.05
2021	49.42	2.12	30.32	0.00	4.53	0.52	66.05
2022	49.43	2.12	30.24	0.00	4.53	0.52	66.05

For suckling cows, net energy for maintenance accounts for the largest share of energy demand. In the following table it can be observed that the GE-intake increased over the time series which is largely influenced by rising net energy for maintenance and lactation.

Table 170: Annual milk yield, gross energy intake and CH₄ emission factors of suckling cows 1990–2022.

Year	Average live body weight	Milk Yield	Gross Energy Intake	Emission Factor
	kg	[kg/cow*yr]	[MJ/head*day]	[kg CH ₄ /head*yr]
1990	626	3 000	231.81	98.83
1995	631	3 179	236.61	100.87
2000	641	3 357	242.31	103.30
2005	650	3 500	247.64	105.57
2010	660	3 500	249.87	106.52
2011	661	3 500	250.20	106.67
2012	663	3 500	250.92	106.97
2013	665	3 500	251.18	107.09
2014	666	3 500	251.56	107.25
2015	668	3 500	252.20	107.52
2016	670	3 500	252.76	107.76
2017	669	3 500	252.63	107.70
2018	669	3 500	252.65	107.71
2019	668	3 500	252.64	107.71
2020	668	3 500	252.81	107.78
2021	668	3 500	252.88	107.81
2022	668	3 500	252.67	107.72

Other non-dairy cattle categories:

As for dairy and suckling cows, the gross energy intake for all other cattle categories were calculated using equation 10.16 taken from the 2019 Refinement to the 2006 IPCC GL. The other non-dairy cattle categories were further subdivided (see Figure 29) within the new study on feeding and nutrition in order to be able to take more precise feeding assumptions and energy requirement calculations. Detailed information on the parameters used for the calculations and the relevant country-specific background data on weight, growth, husbandry and feeding is extensively described for the different cattle categories in (HÖRTENHUBER et al. 2022a).

As a result of the updated information from the new study on animal feeding and nutrition (“Mi-NutE” study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) and the application of the 2019 IPCC Refinements, a dynamic time series could be generated. In previous submissions emissions from enteric fermentation of Non-Dairy Cattle were calculated with a constant gross energy intake for the whole time series.

In the following tables the GE intakes and the resulting CH₄ EF of the different other non-dairy cattle categories are indicated. For cattle < 1 year GE intake and EF are significant lower due to the unweaned calves fed mainly with milk. Dairy calves do not yet excrete relevant amounts of methane and, due to the methane conversion factor of YM = 0, have no influence on the calculation during the milk suckling and drinking phase.

Table 171: Gross energy intake of other cattle categories 1990–2022.

Year	Breeding heifers 1–2 years	Fattening heifers, bulls & oxen 1–2 years	Cattle <1 year	Cattle >2 years
[MJ GE day ⁻¹]				
1990	175.42	178.09	75.88	163.35
1995	174.00	178.00	83.20	160.60
2000	172.58	176.91	83.11	159.61
2005	171.16	175.49	84.02	158.62
2010	171.66	174.17	86.73	160.54
2011	172.07	174.45	86.99	161.17
2012	172.48	174.94	87.16	161.88
2013	172.90	175.58	87.28	162.44
2014	173.31	175.99	87.47	163.16
2015	173.72	176.28	87.77	163.86
2016	174.14	176.35	88.12	164.74
2017	174.55	176.58	88.48	165.32
2018	175.07	176.71	88.67	166.00
2019	175.59	176.89	89.04	166.60
2020	176.12	177.07	89.36	167.14
2021	176.12	177.12	89.38	167.19
2022	176.12	177.53	88.86	167.46

The resulting emission factors are presented in the following table:

Table 172: CH₄ emission factors of other cattle categories 1990–2022.

Year	Breeding heifers 1–2 years	Fattening heifers, bulls & oxen 1–2 years	Cattle <1 year	Cattle >2 years
[kg CH ₄ /head*yr]				
1990	72.48	73.59	21.58	67.50
1995	71.90	73.55	25.54	66.36
2000	71.31	73.10	24.94	65.95
2005	70.72	72.51	24.84	65.54
2010	70.93	71.97	24.91	66.34
2011	71.10	72.08	24.90	66.60
2012	71.27	72.29	24.94	66.89
2013	71.44	72.55	25.03	67.12
2014	71.61	72.72	25.08	67.42
2015	71.78	72.84	25.10	67.71
2016	71.95	72.87	25.16	68.07
2017	72.12	72.96	25.24	68.31
2018	72.34	73.02	25.24	68.59
2019	72.56	73.09	25.23	68.84
2020	72.77	73.17	25.25	69.06
2021	72.77	73.19	25.33	69.08
2022	72.77	73.35	25.73	69.20

5.2.2.2 Swine (3.A.3)

Key Source: No

Methane emissions from enteric fermentation – swine contributed 1.5% to total emissions from enteric fermentation in 2022.

Feeding assumptions and energy demand calculations were developed on a very detailed level elaborated in (HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023). Activity data are obtained from national statistics and are presented in Table 164.

Emission factors

Country specific emission factors were used, calculated from the specific gross energy intake in line with Equation 10.21 of IPCC 2019 and IPCC 2006.

$$EF = [GE * (Y_m/100) * 365 \text{ days}] / 55.65$$

EF = emission factor, kg CH₄ head⁻¹ yr⁻¹

GE = gross energy intake, MJ head⁻¹ day⁻¹

Y_m = Methane conversion factor, per cent of gross energy in feed converted to methane

The factor 55.56 (MJ/kg CH₄) is the energy content of methane

Methane Conversion factors taken from (DÄMMGEN et al. 2012) are indicated in Table 173.

Table 173: Methane conversion factors (Y_m) for swine

Swine category	Methane conversion factor (Y _m)
Breeding sows	0.71
Fattening pigs	0.46
Piglets 8–32 kg	0.44
Swine total	0.47 (weighted average)

Feed intake data was derived from the new country-specific study on animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023). Based on (PRILLER 2004) typical rations for Austrian pig farming were compiled in 2020 by national nutrition experts.

Detailed information on performance indicators, feed quantities and components of feed rations as well as ingredients of the feed components are described in (HÖRTENHUBER et al. 2022a).

Table 174: GE-intake and CH₄ emission factors of swine categories 1990–2022.

Year	Breeding sows		Fattening pigs		Piglets 8–32 kg	
	GE-intake	EF	GE-intake	EF	GE-intake	EF
	[MJ GE day ⁻¹]	[kg CH ₄ /head*yr]	[MJ GE day ⁻¹]	[kg CH ₄ /head*yr]	[MJ GE day ⁻¹]	[kg CH ₄ /head*yr]
1990	43.7	2.04	10.9	1.00	1.9	0.33
1995	44.2	2.06	10.9	1.01	1.9	0.34
2000	44.6	2.08	10.8	1.02	1.9	0.35
2005	45.1	2.10	10.8	1.03	1.9	0.36
2010	47.3	2.20	10.9	1.04	1.9	0.35
2011	47.7	2.22	10.9	1.05	1.9	0.35
2012	48.1	2.24	10.9	1.05	1.9	0.35

Year	Breeding sows		Fattening pigs		Piglets 8–32 kg	
	GE-intake	EF	GE-intake	EF	GE-intake	EF
	[MJ GE day ⁻¹]	[kg CH ₄ /head*yr]	[MJ GE day ⁻¹]	[kg CH ₄ /head*yr]	[MJ GE day ⁻¹]	[kg CH ₄ /head*yr]
2013	48.6	2.26	10.9	1.05	1.9	0.35
2014	49.0	2.28	11.0	1.06	1.9	0.35
2015	49.4	2.30	11.0	1.06	1.9	0.35
2016	49.9	2.32	11.0	1.06	1.8	0.34
2017	50.3	2.34	11.0	1.07	1.8	0.34
2018	50.7	2.36	11.0	1.07	1.8	0.34
2019	51.2	2.38	11.1	1.07	1.8	0.34
2020	51.2	2.38	11.1	1.07	1.8	0.34
2021	51.2	2.38	11.1	1.07	1.8	0.34
2022	51.2	2.38	11.1	1.07	1.8	0.34

5.2.2.3 Sheep (3.A.2), and Other livestock (3.A.4: Poultry, Horses, Goats and Deer)

Key Source: No

As presented in Table 161, CH₄ emissions from sheep, and other livestock (poultry, horses, goats and deer) are only minor emission sources of enteric fermentation in Austria. Together they contributed 4.3% to total emissions from this category in 2022. The most important sub-category is sheep, with a contribution of 2.1%, followed by horses (1.5%), goats (0.3%), poultry as well as deer with each about 0.2% (figures are also presented in Table 161).

The IPCC Tier 1 methodology and default emission factors have been used (see Table 175):

Table 175: IPCC Default Emission Factors for Categories estimated by Tier 1.

IPCC Category	Emission Factor* (Developed Countries) [kg CH ₄ /head*yr]	IPCC Category	Emission Factor* (Developed Countries) [kg CH ₄ /head*yr]
3.A.2 Sheep (+ Deer)	8.0	3.A.4.2 Horses	18.0
3.A.4.3 Goats	5.0		

* Source: IPCC 2006 Guidelines, Table 10.10, p.10.28

Deer:

According to the farmstructure survey (Statistik Austria 2022a), this animal category covers red deer, sika deer and fallow deer. As the contribution to the overall emissions is very small, a simple conservative approach has been chosen: emissions from deer were estimated applying the default emission factor of sheep, which is the most similar animal category to deer.

Poultry:

The IPCC Guidelines do not provide specific methodologies for the estimation of emissions from poultry. For the calculation of emissions from poultry the Swiss values (Gross Energy Intake (GE), Methane Conversion Rate (Y_m), conversion factor metabolisable energy to gross energy) were used as Tier 1.

Y_m :	0.16%
Conversion factor:	0.7
GE:	1.80 MJ/head/yr

Swiss data on energy intake (see Swiss NIR 2021, FOEN 2021) are taken from (SBV 2020 based on the same method from SBV 2007). The Y_m value is based on an in vivo trial with broilers (HADORN & WENK 1996). Activity data were obtained from national statistics and are presented in Table 165.

Agricultural practices in Switzerland are very similar to those in Austria: Both countries have a small structured agriculture due to similar alpine conditions and comparable traditions. In both countries high shares of farms (in Austria 55% and in Switzerland about 56%) manage less than 20 ha.

5.2.3 Category-specific QA/QC

In category 3.A.1 the following source specific QA/QC procedures have been carried out:

- ✓ Gross energy intake data elaborated by scientific experts from the Agricultural Research and Education Centre (AREC) Raumberg-Gumpenstein, derived from peer reviewed sources;
- ✓ External review by Austrian agricultural experts (stakeholder meeting “inventory talks” 2010);
- ✓ Audit of data supplier: milk yield data (Statistik Austria), livestock data;
- ✓ Differences to default values checked, explained and documented;
- ✓ Expanded QA and verification activities in 2012: in-depth review of the agriculture model.
- ✓ Expanded QA/QC of the software tool (calculation sheets) for new and revised sources (e.g. crop residues, energy crops performed in 2015)
- ✓ External review of the revised agricultural model according to the 2006 IPCC GL by Austrian agricultural experts: stakeholder meeting “inventory talks” 2014.
- ✓ External review of the revised agricultural model (AMON & HÖRTENHUBER 2019) according to the new data on the agricultural practice (PÖLLINGER et al. 2018) by Austrian agricultural experts: stakeholder meeting “inventory talks” 2018.
- ✓ External review of the updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) based on the research project on country-specific animal feeding and nutrition (“MiNutE” study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) by Austrian agricultural experts.

Sector specific routine control procedures are provided in chapter 5.1.4.

5.2.4 Uncertainties

Uncertainties are presented in Table 159.

5.2.5 Recalculations

Update of activity data

Livestock data – cattle < 1 year

The livestock category cattle < 1 year comprises slaughtering calves < 1 year, other male calves and cattle < 1 year, and other female calves and cattle < 1 year according to the official statistics (Statistics Austria). The breakdown by type of use is determined by Statistics Austria using model calculations. Methodological improvements resulted in shifts between the cattle < 1 year sub-categories in the years 2003-2021 and thus led to revised average values for gross energy intake, $N_{\text{excretion}}$ and $VS_{\text{excretion}}$ for cattle < 1 year.

Background data for feeding and nutrition of dairy and suckling cows

New figures for the protein and fat content of milk for the year 2021 became available (AMA 2023a). This update resulted in minor revisions of the values for gross energy intake, $N_{\text{excretion}}$ and $VS_{\text{excretion}}$ of dairy and suckling cows.

The improvements resulted in updated emission amounts for the years 2003–2021 (+2.8 kt CH₄ for 2021).

5.3 Manure management (Category 3.B)

Key source: CH₄ and N₂O from 3.B.11 Cattle

This chapter describes the estimation of CH₄ and N₂O emissions from animal manure. In 2022 12.8% of the agricultural CH₄ emissions and 16.2% of the agricultural N₂O emissions were caused by this category.

5.3.1 Source Category Description

CH₄ and N₂O emissions from manure management are presented in the following tables:

Table 176: CH₄ emissions from manure management 1990–2022.

Year	CH ₄ emissions from manure management [kt]								
	Livestock categories								
	3.B Total	3.B.1.1 Dairy Cattle	3.B.1.2 Non- Dairy	3.B.2 Sheep	3.B.3 Swine	3.B.4.1 Other/ Poultry	3.B.4.2 Other/ Horses	3.B.4.3 Other/ Goats	3.B.4.4 Other/ Deer
1990	22.58	10.24	6.45	0.10	5.28	0.35	0.14	0.01	0.01
1995	21.36	8.14	7.71	0.11	4.80	0.36	0.20	0.01	0.01
2000	19.40	7.23	7.37	0.10	4.14	0.30	0.23	0.01	0.01
2005	17.94	6.27	7.16	0.10	3.80	0.33	0.26	0.01	0.01
2010	20.18	7.34	8.45	0.11	3.60	0.35	0.30	0.02	0.01
2011	20.56	7.62	8.66	0.11	3.48	0.36	0.31	0.02	0.01
2012	20.83	7.81	8.77	0.11	3.42	0.37	0.31	0.02	0.01
2013	21.31	8.14	9.02	0.11	3.31	0.38	0.32	0.02	0.01
2014	21.84	8.51	9.24	0.11	3.24	0.39	0.33	0.02	0.01
2015	22.35	8.71	9.55	0.11	3.20	0.41	0.34	0.02	0.01
2016	22.75	9.02	9.68	0.12	3.15	0.42	0.34	0.02	0.01
2017	23.32	9.32	9.88	0.12	3.17	0.43	0.37	0.02	0.01

Year	CH ₄ emissions from manure management [kt]								
	Livestock categories								
	3.B Total	3.B.1.1 Dairy Cattle	3.B.1.2 Non- Dairy	3.B.2 Sheep	3.B.3 Swine	3.B.4.1 Other/ Poultry	3.B.4.2 Other/ Horses	3.B.4.3 Other/ Goats	3.B.4.4 Other/ Deer
2018	22.92	9.12	9.73	0.12	3.12	0.44	0.37	0.02	0.01
2019	22.65	8.97	9.59	0.12	3.11	0.44	0.37	0.02	0.01
2020	22.45	8.96	9.39	0.12	3.13	0.45	0.37	0.02	0.01
2021	22.50	8.97	9.43	0.12	3.12	0.45	0.37	0.03	0.01
2022	22.55	9.41	9.22	0.12	2.95	0.45	0.37	0.03	0.01
Share 2022	100%	41.7%	40.9%	0.5%	13%	2.0%	1.6%	0.1%	0.0%
1990– 2022	-0.1%	-8.1%	42.8%	29.3%	-44.1%	28.3%	164.2%	165.2%	3.2%

From 1990 to 2022 CH₄ emissions from manure management decreased by 0.1% to 22.55 kt.

Table 177: Direct N₂O emissions from manure management per livestock category 1990–2022.

Year	Direct N ₂ O emissions from manure management [kt]								
	Livestock categories								
	Direct Total	3.B.1.1 Dairy	3.B.1.2 Non- Dairy	3.B.2 Sheep	3.B.3 Swine	3.B.4.1 Other/ Poultry	3.B.4.2 Other/ Horses	3.B.4.3 Other/ Goats	3.B.4.4 Other/ Deer
1990	1.533	0.544	0.565	0.021	0.372	0.012	0.015	0.003	0.001
1995	1.448	0.433	0.619	0.024	0.331	0.012	0.022	0.005	0.001
2000	1.329	0.388	0.599	0.023	0.278	0.010	0.025	0.005	0.001
2005	1.248	0.346	0.587	0.022	0.248	0.011	0.028	0.005	0.001
2010	1.310	0.362	0.636	0.024	0.236	0.012	0.032	0.007	0.001
2011	1.314	0.367	0.637	0.024	0.233	0.012	0.033	0.007	0.001
2012	1.320	0.374	0.639	0.024	0.229	0.012	0.034	0.007	0.001
2013	1.331	0.384	0.646	0.024	0.222	0.013	0.034	0.007	0.001
2014	1.349	0.398	0.654	0.023	0.218	0.013	0.035	0.006	0.001
2015	1.368	0.404	0.667	0.024	0.216	0.014	0.036	0.007	0.001
2016	1.384	0.416	0.669	0.025	0.215	0.014	0.036	0.008	0.001
2017	1.411	0.428	0.676	0.027	0.217	0.014	0.039	0.008	0.001
2018	1.390	0.422	0.665	0.027	0.213	0.015	0.039	0.008	0.001
2019	1.375	0.416	0.655	0.027	0.213	0.015	0.039	0.008	0.001
2020	1.360	0.415	0.640	0.026	0.214	0.016	0.039	0.008	0.001
2021	1.363	0.415	0.643	0.027	0.213	0.016	0.039	0.009	0.001
2022	1.355	0.438	0.624	0.027	0.202	0.016	0.039	0.009	0.001
Share 2022	100%	32.3%	46.1%	2.0%	14.9%	1.2%	2.9%	0.7%	0.1%
1990– 2022	-11.6%	-19.6%	10.5%	29.3%	-45.8%	27.0%	164.2%	165.2%	3.2%

From 1990 to 2022 the direct N₂O emissions from manure management decreased by 11.6% to 1.36 kt. Emissions of cattle dominate the trend. The reduction of dairy cow numbers is partly counterbalanced by an increase in emissions per animal (because of the increasing gross energy intake, milk production and N excretion of dairy cattle since 1990).

Table 178: Direct, indirect and total N₂O Emissions from manure management 1990–2022.

Year	N ₂ O emissions from manure management [kt]			
	3.B	3.B. direct	3.B.5 indirect	
	Total	Total	Atm. deposition	Leaching
1990	1.920	1.533	0.387	NO
1995	1.840	1.448	0.392	NO
2000	1.702	1.329	0.373	NO
2005	1.621	1.248	0.373	NO
2010	1.705	1.310	0.396	NO
2011	1.707	1.314	0.393	NO
2012	1.714	1.320	0.394	NO
2013	1.727	1.331	0.396	NO
2014	1.749	1.349	0.400	NO
2015	1.773	1.368	0.404	NO
2016	1.793	1.384	0.408	NO
2017	1.826	1.411	0.415	NO
2018	1.804	1.390	0.414	NO
2019	1.789	1.375	0.414	NO
2020	1.776	1.360	0.416	NO
2021	1.783	1.363	0.420	NO
2022	1.774	1.355	0.419	NO
Share 2022	100%	76.4%	23.6%	NO
1990–2022	-7.6%	-11.6%	8.2%	-

Total N₂O emissions (direct and indirect) from sector 3.B *Manure Management* decreased by 7.6% between 1990 and 2022. The share of direct N₂O emissions in total N₂O emissions from sector 3.B is 76.4% and 23.6% of indirect N₂O emissions in 2022.

Higher volatilization losses due to increased cattle husbandry in loose housing systems are responsible for the increase of indirect N₂O emissions from atmospheric deposition compared to 1990.

5.3.2 Methodological Issues

For the estimation of CH₄ emissions from manure management, cattle (identified as key category) and swine, the IPCC-Tier 2 methodology and country specific parameters were used. In submission 2019 the CH₄ emission estimates for the other livestock categories have been improved by moving from the Tier 1 to the Tier 2 methodology using country-specific MMS distributions and IPCC default parameters.

Within the inventory update carried out for submission 2010 the following improvements were made:

- implementation of more accurate data on manure management system distribution gathered through an Austrian survey (AMON et al. 2007);
- improved consideration of the amount of slurry stored under cool and under warm conditions;
- new country specific emission factors for slurry storage;
- introduction of deep litter systems with best available emission factors.

Inventory revision 2015 (AMON & HÖRTENHUBER 2014) concentrated on implementing the IPCC 2006 Guidelines.

In 2018 another revision of the agricultural model has been carried out (AMON & HÖRTENHUBER 2019) by implementing the new input data on agricultural practices in Austria from the research project “Surveys on manure management from agricultural livestock farming in Austria (TIHALO II) (PÖLLINGER et al. 2018)” and by improving the N flow according to the EMEP/EEA GB 2016. Although the biggest revisions were recorded in Austria's ammonia inventory, there were some inventory updates with significant impacts to Austria's GHG inventory:

- Increased share of liquid systems (cattle)
- Introduction of the system ‘deep litter < 1 month’
- Improved calculations for the non-key animals sheep, goats and poultry

In submission 2020 Austria's agricultural N-flow model was further improved by implementing the EMEP/EEA Guidebook 2019.

In submission 2022 updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}), taken from a new research project on country-specific animal feeding and nutrition (MiNutE study, HÖRTENHUBER et al. 2022b; HÖRTENHUBER et al. 2023) have been included into the inventory.

Manure Management Systems (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 current 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 Tourism⁸⁸ 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 adopted. 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). MMS data from 2006–2016 were derived by linear extrapolation. Taking into account the existing provisions of animal welfare, adjustments were necessary for the years after 2017. Trend extrapolation resulted in increased shares of loose housing systems and decreased shares of tied systems. However, the overall shares of liquid and solid systems based on (PÖLLINGER et al. 2018) remained unchanged.

Information on anaerobic digestion is based on data published by the Austrian Energy Regulator (E-CONTROL 2006-2021, 2022, 2023b) and (KOMPOST- UND BIOGASVERBAND ÖSTERREICH 2023). 1990 data are based on (AMON 2002).

For the livestock categories sheep, poultry, horses, goats and deer country specific MMS data has been applied. Data are based on the TIHALO II results (PÖLLINGER et al. 2018) and expert judgement (PÖLLINGER 2018), carried out in (AMON & HÖRTENHUBER 2019). Except for chicken, the MMS distribution of these animal categories has been kept constant over the entire time series.

Austria's MMS data are provided in Table 179 and Table 180.

Table 179: Manure Management System distribution in Austria 2022.

Livestock category	Liquid/ Slurry	Solid Storage	Pasture/ Range/ Paddock	Composting	Anaerobic Digestion	Other Systems
	[%]	[%]	[%]	[%]	[%]	[%]
Dairy cattle	53.8	28.8	3.7	1.9	2.7	9.0
Non-dairy cattle	33.7	21.5	7.5	1.5	2.7	33.1
Suckling cows	27.4	26.2	17.8	2.1	2.7	23.9
Cattle < 1 year	20.2	17.1	6.2	1.3	2.7	52.5
Breeding heifers 1–2 years	39.9	23.6	4.0	1.6	2.7	28.2
Fattening heifers, bulls and oxen 1–2 years	51.3	17.2	3.4	1.2	2.7	24.2
Other cattle > 2 years	39.9	29.8	7.4	1.8	2.7	18.5
Sheep	0.0	65.0	35.0	0.0	0.0	0.0
Goats	0.0	94.4	5.6	0.0	0.0	0.0
Horses	0.0	80.0	20.0	0.0	0.0	0.0

⁸⁸ From 2020 onwards „The Federal Ministry for Agriculture, Regions and Tourism“

Livestock category	Liquid/ Slurry	Solid Storage	Pasture/ Range/ Paddock	Composting	Anaerobic Digestion	Other Systems
	[%]	[%]	[%]	[%]	[%]	[%]
Swine (Total)	88.2	5.1	0.0	0.4	0.6	5.8
Breeding sows	81.0	12.1	0.0	0.7	0.6	5.7
Young and fattening pigs	89.6	3.7	0.0	0.3	0.6	5.9
Chicken	0.0	96.5	3.0	0.0	0.5	0.0
Layers	0.0	95.5	4.0	0.0	0.5	0.0
Broilers	0.0	99.2	0.3	0.0	0.5	0.0
Other poultry	0.0	99.8	0.2	0.0	0.0	0.0
Turkeys	0.0	99.8	0.2	0.0	0.0	0.0
Other Poultry	0.0	99.8	0.2	0.0	0.0	0.0
Deer	0.0	20.0	80.0	0.0	0.0	0.0

Table 180: Other systems 2022 in detail.

Livestock category	Yard	Deep Litter < 1 month	Deep Litter > 1 month	Aerobic Treatment
	[%]	[%]	[%]	[%]
Dairy cattle	5.0	1.7	1.7	0.7
Non-dairy cattle	3.2	10.6	18.9	0.4
Suckling cows	6.5	8.6	8.6	0.2
Cattle < 1 year	1.8	15.1	35.4	0.3
Breeding heifers 1–2 years	5.6	9.0	13.1	0.5
Fattening heifers, bulls and oxen 1–2 years	0.7	9.0	13.8	0.7
Other cattle > 2 years	2.6	7.2	8.3	0.3
Sheep	0.0	0.0	0.0	0.0
Goats	0.0	0.0	0.0	0.0
Horses	0.0	0.0	0.0	0.0
Swine (Total)	0.8	1.7	2.3	1.0
Breeding sows	1.0	1.6	2.4	0.7
Young and fattening pigs	0.8	1.7	2.3	1.1
Chicken	0.0	0.0	0.0	0.0
Layers	0.0	0.0	0.0	0.0
Broilers	0.0	0.0	0.0	0.0
Other poultry	0.0	0.0	0.0	0.0
Turkeys	0.0	0.0	0.0	0.0
Other Poultry	0.0	0.0	0.0	0.0
Deer	0.0	0.0	0.0	0.0

Small farms more frequently use solid manure systems, whereas large farms make more use of slurry systems. The time series on MMS shows for cattle a decreasing share of solid systems, pasture and composting but increasing shares of liquid systems, anaerobic digestion and 'other systems'. Deep litter dominates the other system category for non-dairy cattle and swine. Young and fattening pigs as well as breeding sows are increasingly held on liquid systems, whereas in the young and fattening pig category a stronger trend to liquid systems was identified. The rearing of

sheep, goats, horses and deer is of minor importance in Austria. In general, these livestock categories are pastured and their housings are based on solid systems (straw).

Influence of application time on stored liquid slurry

Cattle

The evaluation of the TIHALO questionnaires (AMON et al. 2007) produced the following results: 32% of the slurry is applied in spring, 42% in summer and 25% in autumn (n=933 farms, projected by Statistik Austria to representative Austrian conditions). Following data on the storage of slurry were derived:

On average are

- in spring 55% of the stores' capacity filled,
- in summer 45% of the stores' capacity filled,
- in autumn 37.5% of the stores' capacity filled,
- in winter 62.5% of the stores' capacity filled.

Swine

The evaluation of the TIHALO questionnaires (AMON et al. 2007) produced the following results: 57% of the slurry is applied in spring, 27% in summer and 16% in autumn (n=628 farms, projected by Statistik Austria to representative Austrian conditions). Following data on the storage of slurry were derived:

On average are:

- in spring 43% of the stores' capacity filled,
- in summer 41% of the stores' capacity filled,
- in autumn 50% of the stores' capacity filled,
- in winter 75% of the stores' capacity filled.

Emission measurements under field conditions showed, that an increase in methane emissions during slurry storage was only observed during the summer season. The following table presents the slurry stored in cold and warm season per animal category as used in the national inventory.

Table 181: Liquid slurry – percentage storage in cold and warm season for 2022.

Livestock category	Liquid slurry storage	
	warm season [%]	cold season [%]
Dairy cattle	21.6	78.4
Suckling cows	17.3	82.7
Cattle < 1 year	20.9	79.1
Breeding heifers 1–2 years	21.5	78.5
Fattening heifers, bulls and oxen 1–2 years	21.6	78.4
Non-dairy cattle > 2 years	20.6	79.4
Breeding sows	19.6	80.4
Young and fattening pigs	19.6	80.4

Derivation of manure digested in biogas plants

In submission 2022, the calculation of the amounts and proportions of digested manure (VS_{ex} and N_{ex}) was restructured together with the calculation of N from plant-based substrates. The same or comparable data sources were used as in previous submissions.

Data basis for the estimation are published numbers of biogas plants under contract for electricity supply, annual energy amounts (kWh) produced from Austrian biogas plants and the energy-related distribution of the substrates used. Below additional information on the derivation of manure digested in biogas plants is provided as recommended in the ARR 2013, para 49.

Biogas plant numbers have been obtained from (AMON et al 2002) for the years 1990 to 2000 and from the annual reports of the Austrian Energy Regulator E-Control for the years from 2005 to 2021. For 2022, plant numbers could be directly obtained from the Herkunftsnachweisdatenbank (Guarantees of origin (GO)-database) of E-Control (E-CONTROL 2023b). Plant numbers between the years 2000 and 2005 have been derived by interpolation.

Energy amounts (kWh) from animal manure were taken from the annual reports of E-Control and from 2020 onwards from (KOMPOST- UND BIOGASVERBAND ÖSTERREICH 2023). As before 2007 the energy shares of animal manures were not reported, those of the year 2007 have been used backwards to the year 1990. The total annual mass of manure used as substrates was calculated from the total annual energy amounts from manure with factors for kWh per t of substrate (cattle slurry and solid manure, pig slurry and solid manure, chicken manure) and by using default values of (AGENCY FOR RENEWABLE RESOURCES 2021).

The following default values have been used: 1 m³ methane = 9.97 kWh energy, 1 density methane = 0.72 kg/m³, CHP electric efficiency = 28 to 47 %. For the latter value, not a simple average value between the minimum and the maximum of the range was used, but a weighted average, which evaluates the minimum value two thirds and the maximum value one third. Thus, a better agreement with alternative and previously used values on kWh per t substrate could be determined. For this purpose, values from (LFL BAYERN 2021) were taken to calculate the amount of bioas-CH₄ per t substrate. IPCC default B₀ values were applied

Table 182 Characteristic values for the calculation of the VS_{ex} amounts and substrate amounts in biogas plants

	cattle slurry	cattle solid	pig slurry	pig solid	chicken manure
kg VS_{ex} per kg CH ₄	12.92	12.92	5.53	5.53	6.85
kg CH ₄ per t fresh matter (FM) manure input	14.21	49.50	12.24	44.58	32.19

Table 183: Numbers of biogas plants and amounts of digested manure 1990–2022.

Year	Biogas plant	Energy amounts from animal manure	Annually digested manure	VS_{ex} cretion anaerobically digested
	[number]	[kWh /yr]	[t DM/yr]	[t /yr]
1990	5	458 707	3 764	615
1995	38	3 486 177	28 610	4 672
2000	120	11 008 980	90 347	14 753
2005	231	21 192 286	173 918	28 400
2010	289	45 962 844	441 240	69 427

Year	Biogas plant	Energy amounts from animal manure	Annually digested manure	VSexcretion anaerobically digested
	[number]	[kWh /yr]	[t DM/yr]	[t /yr]
2011	288	28 639 327	232 831	42 290
2012	291	29 640 442	242 322	43 628
2013	293	30 658 365	252 004	44 993
2014	289	31 693 096	261 877	46 385
2015	291	32 082 582	266 911	46 087
2016	287	34 130 324	250 290	58 844
2017	288	32 215 830	238 378	55 165
2018	288	33 509 640	245 082	59 340
2019	283	26 947 680	188 089	52 528
2020	280	34 230 000	238 917	66 723
2021	272	38 003 000	265 252	74 078
2022	275	31 048 106	216 709	60 521

Table 183 shows increasing biogas plant numbers along with rising amounts of digested amounts of manure. However, since 2018 plant numbers and digested amounts are decreasing.

Activity data

(STATISTIK AUSTRIA 2023g) provides national data of annual livestock numbers on a very detailed level (see Table 163, Table 164, Table 165). These data are basis for the estimation.

5.3.2.1 Estimation of CH₄ Emissions

CH₄ emissions of cattle and swine are estimated with the Tier 2 approach. This method requires detailed information on animal characteristics and on the manner in which the manure is managed. The following formula has been used (2006 IPCC GL, Equation 10.23):

$$EF_T = (VS_{(T)} * 365) * [B_{0(T)} * 0.67 \text{ kg m}^{-3} * \sum_{S,k} MCF_{S,k}/100 * MS_{(T,S,k)}]$$

$EF_{(T)}$ = annual CH₄ emission factor for livestock category T, kg CH₄ animal⁻¹yr⁻¹

$VS_{(T)}$ = daily volatile solid excreted for livestock category T, kg dry matter animal⁻¹yr⁻¹

$B_{0(T)}$ = maximum methane producing capacity for manure produced by livestock category T, m³ CH₄ kg⁻¹ of VS excreted

0,67 = conversion factor of m³ CH₄ to kilograms CH₄

$MCF_{(S,k)}$ = methane conversion factors for each manure management system S by climate region k, %

$MS_{(T,S,k)}$ = fraction of livestock category T's manure handled using manure systems S in climate region k, dimensionless

Methane conversion factors (MCF)

The default MCF values for 'cool climate regions' presented in the IPCC 2006 GL (Table 10.17) were used for the following systems:

- Pasture, Range, Paddock (MCF: 1%),
- Solid Storage (MCF: 2%),
- Anaerobic digester (MCF: 2%),
- Composting (MCF: 0.5%),
- Aerobic Treatment (MCF: 0.0%),

- Yard: the MCF of Pasture, Range, Paddock was applied (MCF: 1%).

As recommended by the UNFCCC Review 2023 (ARR 2023), Austria provides the following additional information on its country-specific MCF values for liquid manures of cattle and swine: According to the IPCC 2006 Guidelines, cool climates have an average temperature below 15°C. In 2022, the average temperature varied in Austria's cities from 10.3°C in Klagenfurt to 13.4 °C in Vienna; the coldest regions in Austria's mountains recorded an average of -6°C (ZAMG, Yearbook 2022). The overall mean temperature in Austria was 8.6°C in 2022.

The following table provides the mean temperatures for Austria and for the village of Gross-Enzersdorf from 1990 to 2022. The Gross-Enzersdorf research station, in which the emission measurements for the development of the national MCFs have been carried out, is thus located in one of the warmest regions in Austria.

Following the 2006 IPCC Guidelines default values may not encompass the potentially wide variation within the defined categories of management systems, therefore country-specific MCFs that reflect the specific management systems used in particular countries or regions should be developed. If possible, field measurements should be conducted for each climate region to replace the default MCF values.

In order to improve the accuracy of the inventory, a three-year measurement campaign was therefore carried out in Austria by the University of Natural Resources and Applied Life Sciences from 1999 to 2002 (AMON et al. 2002a, 2006, 2007a). In order to prevent the inventory from under-estimation, one of the warmest regions in Austria was selected for this purpose. Table 184 shows that average temperatures of the years of the measurement campaign (10.6 °C, 11.5 °C and 10.4°C) are within the range of all other years and well below the 15°C threshold for a temperate climate according to the 2006 IPCC Guidelines.

Table 184: Average temperature of Austria since 1990

year	Mean temperature	Mean temperature	year	Mean temperature	Mean temperature
	Austria [°C]*	Gross-Enzersdorf [°C]**		Austria [°C]*	Gross-Enzersdorf [°C]**
1961-1990	6.2				
1990	7.0	10.3	2007	7.9	11.5
1991	6.1	9.3	2008	7.8	11.4
1992	7.4	10.9	2009	7.6	11.0
1993	6.8	NR	2010	6.8	9.8
1994	8.1	11.3	2011	7.8	10.9
1995	6.8	10.2	2012	7.7	11.3
1996	5.9	8.8	2013	7.5	10.8
1997	7.0	9.8	2014	8.6	11.8
1998	7.2	10.6	2015	8.3	11.8
1999	7.1	10.6	2016	8.0	11.3
2000	7.9	11.5	2017	7.8	11.4
2001	7.2	10.4	2018	8.7	12.2
2002	7.9	11.2	2019	8.5	12.1
2003	7.4	10.7	2020	8.1	11.6

2004	6.9	10.3	2021	7.3	10.9
2005	6.5	10.0	2022	8.6	11.9
2006	7.1	10.6			

* the average temperature for Austria from 1990 onwards is determined by adjusting the mean temperature 1961-1990 with the yearly deviation taken from the HISTALP database⁸⁹ provided by (GEOSPHERE AUSTRIA, 2023). Please refer also to <https://www.umweltbundesamt.at/klima/dashboard>

**Yearbook of the ZAMG <https://www.zamg.ac.at/cms/de/klima/klimauebersichten/jahrbuch> (GEOSPHERE AUSTRIA, 2024)

Country specific MCF for anaerobic digesters

In Austria, safety regulations for the building and operation of agricultural biogas plants are rather strict. Investment costs for the building of the biogas plants are only granted, if the farmer proves that the strict safety regulations have been followed. The safety regulations have been developed and documented in the frame of the EU-ALTENER standard for the building and operation of agricultural biogas plants. The safety regulations do not suggest that there is a significant probability for substantial CH₄ losses through leakage.

Anyhow, there is no national study available that estimates CH₄ leakage losses from Austrian biogas plants. A study worked out in Germany (FNR 2010) shows that CH₄ losses of biogas plants are about 1–2% of the gas produced under cold climate conditions.

In response to a question raised by the ERT during the Centralized Review 2011, the estimations now consider methane losses from anaerobic digesters. Following the results of the study mentioned above and national expert judgment (AMON T. 2011) the methane conversion factor (MCF) for anaerobic digesters was increased from 0% to 2%, resulting in higher CH₄ emissions.

Country specific MCF for liquid systems of cattle and swine

IPCC encourages measurements of emissions from manure management under field conditions in order to improve the basis of emission estimates. The Division of Agricultural Engineering (DAE) at the University of Natural Resources and Applied Life Sciences (BOKU) has carried out a three-year measurement campaign on emissions from manure stores financed by the Federal Ministry of Agriculture, Forestry, Environment, and Water Management and the Federal Ministry for Education, Science, and Culture. Emission rates have now been published in peer reviewed publications (AMON et al. 2002a, 2006, 2007a). They can therefore be used for calculating MCF values for liquid manure systems.

Table 185: Country specific MCFs for liquid systems (AMON et al. 2006, AMON et al. 2007a).

Animal Category	cold season [%]	warm season [%]
Cattle	0.97	37.22
Swine	3.27	3.87

The country specific MCFs have been applied to the amounts of liquid manure storage under cold and warm climate conditions (see Table 185). The extensive emission measurements under field conditions showed, that an increase in methane emissions during slurry storage was only observed during the summer season. The low temperature in all other seasons in Austria reduces methane

⁸⁹ The HISTALP-database of homogenized, monthly climatic records enables to analyse the climate change in the alps from the middle of the 18th century (AUER et al. 2007)

formation significantly during slurry storage. Emission measurements were carried out in one of the warmest Austrian regions (research station Gross-Enzersdorf, located in the pannonian region) and therefore may tend to overestimate MCF values. As presented in Table 184 Austria's average temperature is well below 10°C for the entire time series. Since 1990 the average temperature at the Gross-Enzersdorf research station varies between 9.8 and 12.2 °C indicating that the national MCFs from (AMON et al. 2006, AMON et al. 2007a) are representative for the entire time series.

The following table presents country-specific average MCF values for liquid systems (cattle and swine) for the years 1990 to 2022. There are small annual variations of the average MCFs due to slightly changing MMS distributions from year to year, depending on the proportion of liquid manure stored under warm conditions in summer (June, July, August) and under cold conditions (during the rest of the year): an increased proportion of liquid manure stored under cold conditions leads to slightly lower average MCFs, an increased proportion of liquid manure stored under warm conditions in summer leads to slightly higher average MCFs.

Table 186: Average MCFs of dairy and other cattle as well as swine for liquid systems 1990–2022.

year	Dairy Cattle	Other Cattle	Swine
	[%]	[%]	[%]
1990	8.7	8.7	3.4
1995	8.7	8.6	3.4
2000	8.7	8.5	3.4
2005	8.7	8.4	3.4
2010	8.7	8.3	3.4
2011	8.8	8.4	3.4
2012	8.8	8.4	3.4
2013	8.8	8.4	3.4
2014	8.8	8.4	3.4
2015	8.8	8.4	3.4
2016	8.8	8.3	3.4
2017	8.8	8.3	3.4
2018	8.8	8.3	3.4
2019	8.8	8.3	3.4
2020	8.8	8.3	3.4
2021	8.8	8.3	3.4
2022	8.8	8.4	3.4

The following table presents the average MCFs for other systems for the years 1990 and 2022.

Table 187: Average MCFs for other systems 1990 and 2022.

Animal Category	1990 [%]	2022 [%]
Dairy Cattle	6.2	4.6
Other Cattle	9.4	10.4
Swine	11.6	10.6

In submission 2010 deep litter systems were introduced to the Austrian MMS distribution (AMON et al. 2007). Based on new survey data (PÖLLINGER et al. 2018) a differentiation into deep litter < 1 month and deep litter > 1 month has been implemented into inventory submission 2019.

For deep litter systems < 1 month the default MCF value of 3% for the system *cattle and swine deep bedding < 1 month* was taken (2006 IPCC GL, Table 10.17).

In Austria manure from deep litter systems > 1 month is usually removed twice a year – in spring and in autumn. The bedding is continuously added, there is no mixing. Austrian measurements showed that CH₄ emissions from farmyard manure were always lower than CH₄ emissions from liquid manure. In the IPCC Guidelines the default MCF for deep litter systems equals the default MCF for liquid systems. Hence, for Austria the chosen MCF of 17% (IPCC 2006) is a conservative estimate.

The big share of deep litter in the other system category is responsible for the high MCF values of other cattle and swine. However, compared to the submissions before, in submission 2019 the average MCF of other systems decreased due to the split of the deep litter systems into deep litter < 1 month and deep litter > 1 month.

MCF used for yards

In yards aerobic processes are predominant, the dung dries after excretion. Thus, seen from the microbiological point of view, conditions for methane production from dung excreted on yards are unfavourable: CH₄ is only formed under anaerobic and wet conditions. The creation of methane in yards is best reflected in the 2006 IPCC MCF of 1%.

Maximum methane producing capacity (B_{0i})

The IPCC default values were used (Annex 10A.2, Tables 10A-4 through 10A-9, IPCC 2006 Guidelines).

5.3.2.1.1 Cattle (3.B.1.1 – CH₄ and 3.B.2.1 – N₂O)

Key Source: Yes (CH₄, N₂O)

Austrian specific values for cattle are calculated dependent on annual milk yields (dairy and suckling cows), growth, activity and maintenance information as well as corresponding feed intake data (gross energy intake, feed digestibility, ash content, see chapter 5.2.2.1 and Table 188).

In submission 2022 feed intake assumptions were updated within the framework of the new country specific study on animal feeding and nutrition (HÖRTENHUBER et al. 2022b, HÖRTENHUBER et al. 2023). Calculation of VS excretion rates follows equation 10.24 provided in (IPCC 2019)

$$VS = [GE * (1 - DE\%/100) + (UE * GE)] * [(1 - ASH)/18.45]$$

VS = volatile solid excretion per day on a dry-organic matter basis, kg VS day⁻¹

GE = gross energy intake, MJ day⁻¹

DE% = digestibility of the feed in percent (e.g. 60 percent)

(UE * GE) = urinary energy expressed as fraction of GE. The default value of 0.04GE has been taken.

ASH = ash content of manure calculated as a fraction of the dry matter feed intake

18.45 = conversion factor for dietary GE per kg of dry matter (MJ kg⁻¹).

Volatile solid (VS) excretion – dairy cattle

The following table provides the parameters used for determining the VS excretion of dairy cattle. VS excretion rates increased over the time series. Information on GE intake, feed digestibility and ash content are described in chapter 5.2.2.1.

Table 188: Feed intake and VS excretion of Austrian dairy cattle for the period 1990–2022

Year	GE intake [MJ day ⁻¹]	Digestibility of feed [%]	Ash content in dry matter [%]	VS excretion [kg VS day ⁻¹]
1990	253.80	66.48	8.83	4.71
1995	268.30	67.70	8.83	4.81
2000	279.55	68.58	8.83	4.89
2005	290.60	69.43	8.82	4.97
2010	296.82	69.89	8.82	5.00
2011	298.55	70.08	8.82	5.00
2012	301.97	70.37	8.81	5.02
2013	302.69	70.43	8.81	5.02
2014	303.96	70.55	8.81	5.03
2015	305.20	70.60	8.81	5.04
2016	308.25	70.87	8.81	5.05
2017	309.29	71.03	8.81	5.04
2018	312.61	71.38	8.81	5.04
2019	313.67	71.49	8.81	5.04
2020	315.52	71.65	8.81	5.04
2021	315.15	71.59	8.81	5.05
2022	314.76	71.60	8.81	5.04

Volatile solid (VS) excretion – suckling cows

In submission 2022 VS excretion rates of suckling cows have been updated according to (HÖRTENHUBER et al. 2022b, HÖRTENHUBER et. al. 2023). In the table below the feed intake parameters relevant for VS excretion are provided. Further information on GE intake, feed digestibility and ash content are included in chapter 5.2.2.1.

Table 189: Feed intake and VS excretion of Austrian suckling cows for the period 1990–2022.

Year	GE intake [MJ day ⁻¹]	Digestibility of feed [%]	Ash content in dry matter [%]	VS excretion [kg VS day ⁻¹]
1990	231.81	65.31	11.00	4.33
1995	236.61	65.57	11.00	4.39
2000	242.31	65.84	11.00	4.46
2005	247.64	66.05	11.00	4.53
2010	249.87	66.05	11.00	4.57
2011	250.20	66.05	11.00	4.58
2012	250.92	66.05	11.00	4.59
2013	251.18	66.05	11.00	4.60
2014	251.56	66.05	11.00	4.61
2015	252.20	66.05	11.00	4.62
2016	252.76	66.05	11.00	4.63
2017	252.63	66.05	11.00	4.62

Year	GE intake [MJ day ⁻¹]	Digestibility of feed [%]	Ash content in dry matter [%]	VS excretion [kg VS day ⁻¹]
2018	252.65	66.05	11.00	4.63
2019	252.64	66.05	11.00	4.63
2020	252.81	66.05	11.00	4.63
2021	252.88	66.05	11.00	4.63
2022	252.67	66.05	11.00	4.63

Volatile solid (VS) excretion – other non-dairy cattle

As for dairy and suckling cows Austrian specific values on VS excretion for all other non-dairy cattle categories were calculated in (HÖRTENHUBER et al. 2022b, HÖRTENHUBER et. al. 2023) by applying Equation 10.24 provided in (IPCC 2019).

Instead of calculations based on a constant gross energy intake as in previous submissions, dynamic VS excretion rates could be determined (see Table 190).

The data used for the calculation of VS excretion of the livestock categories *Non-Dairy Cattle* (GE intake, ash content, digestibility) is described in detail in (HÖRTENHUBER et al. 2022a). As indicated in chapter 5.2.2 (see Figure 29), the other cattle categories had to be further subdivided in order to calculate at the required level of detail.

Table 190: VS excretion of Austrian other cattle categories for the period 1990–2022.

Year	Breeding heifers 1-2 years [kg VS day ⁻¹]	Fattening heifers 1-2 years [kg VS day ⁻¹]	cattle <1 year [kg VS day ⁻¹]	cattle >2 year [kg VS day ⁻¹]
1990	3.32	2.73	0.88	3.21
1995	3.30	2.73	1.05	3.22
2000	3.27	2.73	1.05	3.22
2005	3.24	2.73	1.07	3.23
2010	3.25	2.76	1.11	3.21
2011	3.26	2.76	1.12	3.23
2012	3.27	2.77	1.12	3.24
2013	3.27	2.77	1.12	3.25
2014	3.28	2.78	1.13	3.26
2015	3.29	2.78	1.13	3.27
2016	3.30	2.79	1.14	3.28
2017	3.31	2.80	1.14	3.29
2018	3.32	2.80	1.15	3.30
2019	3.33	2.80	1.16	3.30
2020	3.34	2.81	1.16	3.31
2021	3.34	2.81	1.16	3.31
2022	3.34	2.80	1.15	3.32

5.3.2.1.2 Swine (3.B.1.3)

Key Source: No

Volatile solid (VS) excretion – swine

Since submission 2022 updated country-specific VS excretion rates determined on the basis of animal diets taken from (HÖRTENHUBER et al. 2022b, HÖRTENHUBER et. al. 2023) and calculated according to equation 10.24 provided in (IPCC 2019) are used. Information on energy intake, ash content and digestibility is described in (HÖRTENHUBER et al. 2022a). The following table presents the VS excretion rates for the swine categories:

Table 191: VS excretion from Austrian swine for the period 1990–2022

Year	Breeding sows [kg VS day ⁻¹]	Young & fattening pigs [kg VS day ⁻¹]	Young swine 8–32 kg [kg VS day ⁻¹]
1990	0.59	0.38	0.14
1995	0.60	0.38	0.14
2000	0.61	0.38	0.14
2005	0.62	0.39	0.15
2010	0.64	0.38	0.14
2011	0.64	0.38	0.14
2012	0.64	0.38	0.14
2013	0.65	0.37	0.14
2014	0.65	0.37	0.14
2015	0.66	0.37	0.13
2016	0.66	0.37	0.13
2017	0.66	0.37	0.13
2018	0.67	0.37	0.13
2019	0.67	0.37	0.13
2020	0.67	0.37	0.13
2021	0.67	0.37	0.13
2022	0.67	0.37	0.13

Piglets (< 8 kg) were not taken into account because the emission factors for breeding sows already take into account the emissions of suckling piglets up to 8 kg live weight.

5.3.2.1.3 Sheep (3.B.2) and Other livestock (3.B.4: Poultry, Horses, Goats, Deer)

Key Source: No

CH₄ emissions of sheep, poultry, horses, goats and deer are estimated with the Tier 2 approach (equation 10.23 of the 2006 IPCC GL).

For VS excretion, B₀ and MCF the 2006 IPCC default values were taken. Information on management systems is indicated in Table 179.

Table 192: IPCC default values used for CH₄ calculation of sheep and other livestock in Austria.

Livestock category	Volatile Solids (VS) excretion [kg animal ⁻¹ day ⁻¹]	CH ₄ producing potential – B ₀ [m ² CH ₄ kg ⁻¹ VS]
Sheep	0.40	0.19
Goats	0.30	0.18
Horses	2.13	0.30
Layers	0.02	0.39

Broilers	0.01	0.36
Turkeys	0.07	0.36
Other Poultry (ducks, geese,...)	0.02	0.36

Data source: IPCC 2006, Table 10A-9

The Austrian inventory does not distinguish between horses and mules and asses. Mules and asses are included in the horse category (3.B.4.2) and are only of very little importance in Austria (please refer to chapter 5.1.7). Thus, CH₄ emissions from the manure of horses were estimated with the default values of horses.

The deer category (3.B.4.4) includes red deer, sika deer and fallow deer. The contribution to the overall emissions is very small, so a simple conservative approach has been chosen: except for the MMS data, for which a country-specific distribution has been used, the default values of sheep were applied, because sheep is the most similar animal category to deer (which dominates this category).

5.3.2.1.4 Estimation of direct N₂O Emissions from manure management

Key Source: 3.B.1

Following the guidelines, all direct and indirect emissions of N₂O occurring before the manure is applied to soils (during the storage and treatment of manure or otherwise used for feed, fuel or construction purposes) are reported under manure management.

For the estimation of direct N₂O emissions from manure management systems Austria uses a Tier 2 approach. The IPCC methodology for estimating N₂O emissions from manure management entails multiplying the total amount of N excretion (from all animal species/categories) in each type of manure management system by an emission factor for that type of manure management system. Emissions are then summed over all manure management systems (see formulas below).

N excretion per animal waste management system:

$$Nex_{(S)} = \sum_{(T)} [N_{(T)} \times Nex_{(T)} \times MS_{(T,S)}]$$

$Nex_{(S)}$ = N excretion in manure management system S [kg yr⁻¹]

$N_{(T)}$ = number of animals of type T in the country

$Nex_{(T)}$ = N excretion of animals of type T in the country [kg N animal⁻¹ yr⁻¹]

$MS_{(T,S)}$ = fraction of $Nex_{(T)}$ that is managed in manure management system S for animals of type T in the country

T = type of animal category

Direct N₂O emission per animal waste management system:

$$N_2O_{(S)} = \sum [Nex_{(S)} \times EF_{3(S)}] \times (44/28)$$

$N_2O_{(S)}$ = direct N₂O emissions from manure management system S in the country [kg N₂O yr⁻¹]

$Nex_{(S)}$ = N excretion in manure management system S [kg yr⁻¹]

$EF_{3(S)}$ = N₂O-N emission factor for manure management system S [kg N₂O-N per kg of Nex in MS_(S)]

Manure Management System (MMS)

The manure management system distribution data applied to estimate N₂O emissions from *Manure Management* is the same as used for the estimation of CH₄ emissions from *Manure Management* (see Table 180).

N excretion

In previous years country specific N excretion values were based on (GRUBER & PÖTSCH 2006, PÖTSCH et al. 2005, STEINWIDDER & GUGGENBERGER 2003, UNTERARBEITSGRUPPE N-ADHOC 2004 and ZAR 2004) and Richtlinien Sachgerechter Düngung (BML 2022a). However, the feeding of cattle and swine has changed in the last two decades. Therefore, a new research project on country-specific animal feeding and nutrition ("MiNutE" study, HÖRTENHUBER et. al. 2022b, HÖRTENHUBER et. al. 2023) has been carried out by the University of Natural Resources and Life Sciences, Vienna. As a result, updated and representative values for energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) are available. New data have been included into the inventory of submission 2022.

Within the framework of this country specific study, the necessary information was compiled and derived from official statistical data, international and national technical literature, representative data from producer associations (e.g. ZAR, project "Efficient Cow" EGGER-DANNER et al. 2018), feed analyses and feed calculations of the project partner and the feed company Fixkraft (fixkraft.at, based on the feeding strategies of their customers). The results were supplemented and revised with information from experts, e.g. feeding advisors from the chambers of agriculture, working group advisors and additional data surveys on farms.

The extensive results of the "MiNutE" study made it possible to calculate national excretion values at a much more detailed level based on the latest available scientific literature (IPCC 2019).

Cattle

The annual N excretion rates were calculated with Equation 10.31A (IPCC 2019), which can be estimated as the difference between the total nitrogen taken in by the animal and the total nitrogen retained for growth and milk production.

$$N_{ex(T)} = (N_{intake(T)} - N_{retention(T)}) * 365$$

$N_{ex(T)}$ = annual N excretion rates, kg N animal⁻¹ yr⁻¹

$N_{intake(T)}$ = the daily N intake per head of animal of species/category T, kg N animal⁻¹ day⁻¹

$N_{retention(T)}$ = amount of daily N intake by head of animal of species / category T, that is retained by animal of species/category T, kg N animal⁻¹ day⁻¹,

365 = Number of days in a year

The same dietary assumptions have been used as for modelling methane emissions from CRF sector 3.A *Enteric Fermentation* (see chapter 5.2).

N intake rates are determined by applying equation 10.32 (IPCC 2019) based on the gross energy intake and crude protein in dry matter. The energy demand of cattle has been also calculated by applying the 2019 Refinement to the 2006 IPCC GL, taking into account body mass and weight gain performance, husbandry, milk yield, gestation and feeding parameters. Crude protein in dry matter was calculated using data from different national studies (EGGER-DANNER et al. 2016, STEINWIDDER

AND HÄUSLER 2004, STEINWIDDER AND GUGGENBERGER 2003, STEINWENDER 1992) and is detailed documented in (HÖRTENHUBER et al. 2022a).

N retention rates are calculated by applying equation 10.33 of the 2019 Refinement to the 2006 IPCC GL. For dairy and suckling cows the respective milk yields and protein in milk is taken into account. Milk yields are presented in Table 193. For dairy cows the milk yield is provided annually by Statistics Austria, published in (BML 2023b). For suckler cows an annual milk yield of 3 000 kg for 1990 and of 3 500 kg for the years from 2004 onwards was determined (HÄUSLER 2009). Data on the average fat content and protein content of milk from dairy cows for the years 1991-2022 were derived from information provided by AgrarMarkt Austria (AMA). Due to missing data for the year 1990, the value of 1991 was adopted. Similar to dairy cows, the AMA data on the average fat and protein content of delivered has been used as the measured milk fat content of cows of beef breeds does not differ significantly to those of dairy cows according to (SCHOLZ et al. 2001). For the other cattle categories the average daily weight gain and net energy for growth are the parameters needed. The average daily weight gain was determined on the basis of national studies, detailed described in (HÖRTENHUBER et al. 2022a). Net energy for growth has been calculated by applying equation 10.15 (IPCC 2019).

Table 193: Austria specific N excretion values of dairy and suckling cows for the period 1990–2022.

Year	Dairy cows		Suckling cows	
	Milk yield [kg yr ⁻¹]	Nitrogen excretion [kg/animal*yr]	Milk yield [kg yr ⁻¹]	Nitrogen excretion [kg/animal*yr]
1990	3 791	91.05	3 000	72.18
1995	4 619	92.44	3 179	72.85
2000	5 210	93.92	3 357	74.14
2005	5 783	97.00	3 500	75.46
2010	6 100	99.88	3 500	76.37
2011	6 227	100.57	3 500	76.44
2012	6 418	102.15	3 500	76.71
2013	6 460	102.38	3 500	76.76
2014	6 542	103.08	3 500	76.95
2015	6 579	103.65	3 500	77.20
2016	6 759	104.88	3 500	77.30
2017	6 865	105.13	3 500	77.25
2018	7 104	106.04	3 500	77.20
2019	7 179	106.27	3 500	77.15
2020	7 286	106.78	3 500	77.16
2021	7 249	106.69	3 500	77.18
2022	7 250	106.85	3 500	77.27

¹ From 1995 onwards data have been revised by Statistik Austria, which led to significant higher milk yield data of Austrian dairy cows.

Table 194: Austria specific N excretion values of other cattle for the period 1990–2022

Year	Nitrogen excretion [kg/animal*yr]			
	breeding heifers 1–2 years	fattening heifers & bulls & oxen 1–2 years	cattle <1 year	cattle >2 year
1990	60.67	58.53	30.53	63.75
1995	60.14	58.46	33.18	63.40
2000	59.61	58.14	33.74	63.10
2005	59.08	57.51	34.60	62.75
2010	59.24	57.93	36.35	62.46
2011	59.38	58.00	36.45	62.66
2012	59.52	58.17	36.41	62.90
2013	59.66	58.37	36.25	63.12
2014	59.79	58.48	36.20	63.34
2015	59.93	58.57	36.30	63.54
2016	60.07	58.62	36.37	63.75
2017	60.21	58.66	36.43	63.90
2018	60.39	58.63	36.48	64.02
2019	60.57	58.68	36.65	64.16
2020	60.75	58.83	36.74	64.33
2021	60.75	58.82	36.67	64.32
2022	60.75	58.70	35.80	64.55

Swine

Annual N excretion rates of the categories breeding pigs (sows and boars), piglets 8–32 kg, and fattening pigs were calculated using equation 10.31A provided in the 2019 Refinement to the IPCC 2006 GL.

N intake rates for swine are estimated with equation 10.32A taking into account dry matter intake per day during a specific growth stage and the crude protein in dry matter for growth stage.

Following the 2019 Refinement to the IPCC 2006 Guidelines, the N retention rates vary among different swine categories. So, for breeding sows equation 10.33A, for piglets equation 10.33B and for fattening pigs equation 10.33C have been applied.

Information on performance indicators (daily gain of weight, average slaughter weights, etc.), feed quantities (energy requirements, crude protein content per kg feed, information N-reduced feeding etc.) and components of feed rations is summarized in (HÖRTENHUBER et al. 2022a).

Table 195: Austria specific N excretion values of swine for the period 1990–2022

Year	Nitrogen excretion [kg/animal*yr]		
	breeding sows plus litter	fattening pigs	piglets 8–32 kg
1990	23.2	14.8	3.7
1995	22.9	14.6	3.7
2000	22.6	14.5	3.8
2005	22.3	14.3	3.8
2010	22.3	13.8	3.6
2011	22.3	13.7	3.6
2012	22.3	13.6	3.6

Year	Nitrogen excretion [kg/animal*yr]		
	breeding sows plus litter	fattening pigs	piglets 8–32 kg
2013	22.3	13.5	3.5
2014	22.3	13.4	3.5
2015	22.2	13.3	3.5
2016	22.2	13.2	3.5
2017	22.2	13.1	3.4
2018	22.2	13.0	3.4
2019	22.1	12.9	3.4
2020	22.1	12.9	3.4
2021	22.1	12.9	3.4
2022	22.1	12.9	3.4

Other livestock

Sheep and goats: life weight, daily gain of weight, degree of pregnancy or lactating, feeding rations.

Poultry: feeding ration, duration of keeping, nitrogen uptake, nitrogen efficiency.

Horses: feeding ration per horse category, weight of horses.

Table 196: 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

Livestock numbers per category can be found in Table 163, Table 164 and Table 165. Data on manure management system distribution is presented in Table 179 and Table 180.

Emission factors

N₂O emission factors of the 2006 IPCC Guidelines have been used for all MMS.

Emission factors applied in the Austrian inventory are listed in the following table.

Table 197: Emission factors for N₂O from manure management.

Animal Waste Management System	Emission factor [kg N ₂ O-N per kg N excreted]	Reference
Liquid/Slurry	~0.005*	IPCC 2006, Table 10.21
Solid Storage	0.005	IPCC 2006, Table 10.21
Pasture/Range/Paddock (cattle, poultry and pigs)	0.020	IPCC 2006, Table 11.1

Animal Waste Management System	Emission factor [kg N₂O-N per kg N excreted]	Reference
Pasture/Range/Paddock (sheep, goats, horses and deer)	0.010	IPCC 2006, Table 11.1
Composting	0.006	IPCC 2006, Table 10.21
Aerobic Treatment	0.005	IPCC 2006, Table 10.21
Anaerobic Digester	0.0	IPCC 2006, Table 10.21
Deep Litter	0.010	IPCC 2006, Table 10.21
Poultry manure (with/without litter)	0.001	IPCC 2006, Table 10.21

* The average N₂O emission factor of liquid slurry was calculated from the proportion of untreated slurry without natural crust (zero emissions following IPCC, 2006) and the proportion which is aerated, covered, or with natural crust (EF of 0.005 following IPCC, 2006).

Yard

In the IPCC Guidelines no emission factor for yard is available. It is assumed, that the storage of the yard manure equals the average manure management systems distribution in Austria (see Table 179 and Table 180). Thus, the implied N₂O emission factor of all systems (except pasture) has been used.

Scientific background for this approach:

N₂O emissions result from the interaction of manure N with organic carbon that is present in soils and in straw. This explains the higher IPCC N₂O EFs of pasture, solid systems or composting compared to liquid slurry EF or the EF of slurry from anaerobic digesters. The presence of organic carbon favours N₂O formation. Applying the N₂O EF of pasture or solid systems for N₂O emissions from yards would result in an overestimation of N₂O emissions, as there is neither soil-C nor straw-C in the yard.

Manure excreted in yards regularly (daily) enters the storage; urine is continuously discharged to the storage. Keeping the high uncertainties of N₂O emissions in mind, the weighted implied N₂O EFs of all systems (except pasture) per animal category are a conservative approach that tends to overestimate yard emissions, as these values include high shares of solid storage systems.

Table 198: N₂O emission factors used for the calculation of N₂O from yards 1990–2022.

Year	Dairy	Non-Dairy	Swine
	[kg N₂O-N per kg N excreted]		
1990	0.004	0.004	0.005
1995	0.004	0.004	0.004
2000	0.004	0.004	0.004
2005	0.004	0.004	0.004
2010	0.004	0.004	0.004
2011	0.004	0.004	0.004
2012	0.004	0.004	0.004
2013	0.004	0.004	0.005
2014	0.004	0.005	0.005
2015	0.004	0.005	0.005
2016	0.004	0.005	0.005
2017	0.005	0.005	0.005
2018	0.005	0.005	0.005

Year	Dairy	Non-Dairy	Swine
	[kg N ₂ O-N per kg N excreted]		
2019	0.005	0.005	0.005
2020	0.005	0.005	0.005
2021	0.005	0.005	0.005
2022	0.005	0.005	0.005

For the calculation of the losses of gaseous N species (NH₃-N, NO_x-N, N₂) the mass-flow procedure pursuant to EMEP/EEA methodologies (EEA 2023a) has been applied. A brief description of methodologies and emission factors applied in the Austrian NH₃ and NO_x inventory under the NEC Directive as well as the UNECE/LRTAP convention is provided in chapter 5.4.2.1.

5.3.2.1.5 Estimation of indirect N₂O emissions from manure management

Key Source: Yes (Tier 2)

Following the 2006 IPCC guidelines, indirect N₂O emissions from atmospheric deposition result from volatile nitrogen losses primarily occurring in the forms of ammonia and nitric oxide. Nitrogen losses begin at the point of excretion and continue through on-site management in storage and treatment systems. Further nitrogen can be lost through run-off and leaching into soils from the solid storage of manure at outdoor areas.

Indirect N₂O emissions through N-leaching and run-off from manure storage

Relevant information concerning Austria's animal housings and manure storage systems was derived from national publications, recommendations and regulations, i.e. from ÖKL (Österreichisches Kuratorium für Landtechnik und Landentwicklung), from the Austrian Institute of Construction Engineering (OIB) and on regional regulations of the federal states of Lower Austria (Niederösterreich) and Salzburg.

According to ÖKL-Merkblatt 24 (ÖKL 2011), a watertight construction of animal housings and manure storage systems is generally required. Water tightness has to be certificated for funding administrations. Furthermore, the tightness of the constructions is required in construction laws of the federal states and the Austrian Institute of Construction Engineering (OIB) (section 3.4.2 in OIB Guideline 3) (OIB 2011).

The OIB Guideline 3⁹⁰ is directly implemented in the laws of all federal states' in Austria except for Salzburg and Lower Austria. Lower Austria and Salzburg implemented comparable laws, which ensure the closeness of animal housing and storage constructions. A demand on tightness can also be derived from Austrian laws concerning groundwater protection (§ 30) and according to environmental protection regulations of the federal states (KREUZHUBER 2013).

Considering the legal background in Austria, leaching from sector manure management does not occur in Austria and is thus reported as "not occurring".

⁹⁰ <http://www.oib.or.at/>

Indirect N₂O emissions through volatilization losses from manure management

Following the 2006 IPCC GL, indirect N₂O emissions due to volatilization of N from manure management were calculated using Tier 2 methodology. Austria considers a detailed flow of nitrogen throughout the animal housing and manure management systems.

The indirect N₂O emissions from volatilization of N in forms of NH₃ and NO_x are estimated following equation 10.26 (IPCC 2006) multiplied with the default IPCC emission factor presented in the IPCC 2006 GL in Table 11.3, which is 0.01 kg N₂O-N (kg NH₃-N+NO_x-N volatilised).

$$N_{\text{volatilisation-MMS}} = \sum_S [\sum_T [(N_{(T)} * Nex_{(T)} * MS_{(T,S)} * (Frac_{\text{GasMS}}/100)_{(T,S)})] * EF$$

$N_{(T)}$ = number of head of livestock species/category T

$Nex_{(T)}$ = annual average N excretion per head of species/category T , expressed in kg N

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure system S

$Frac_{\text{GasMS}}$ = percent of managed manure nitrogen for livestock category T that volatilizes as NH₃ and NO_x in the manure management system S , %

The country specific value of $Frac_{\text{GasMS}}$ includes the following N losses calculated within the Austrian N-flow model:

- NH₃-N losses from housing, storage, yard
- NO_x-N losses from manure management

Table 199: NH₃-N and NO_x-N volatilisation losses of manure management systems 1990 to 2022.

Year	N losses from manure management systems	Frac _{GASMS}
	[t N/yr]	(N _{losses} /N _{ex})
1990	24 629	0.13
1995	24 924	0.13
2000	23 751	0.14
2005	23 748	0.14
2010	25 175	0.15
2011	25 014	0.15
2012	25 102	0.15
2013	25 205	0.15
2014	25 455	0.15
2015	25 732	0.15
2016	25 991	0.15
2017	26 418	0.16
2018	26 362	0.16
2019	26 342	0.16
2020	26 470	0.16
2021	26 724	0.16
2022	26 643	0.16

5.3.3 Category-specific QA/QC

In the categories 3.B.1 (cattle) and 3.B.3 (swine) the following source specific QA/QC procedures have been carried out:

- ✓ VS and N excretion data elaborated by national experts (Agricultural Research and Education Centre Raumberg-Gumpenstein, University of Natural Resources and Applied Life Sciences), derived from peer reviewed sources;
- ✓ Surveys on MMS conducted by scientific experts;
- ✓ Country specific MCF derived from peer reviewed studies;
- ✓ Differences to default values explained and documented;
- ✓ Rationale for selecting MCFs and EFs explained and documented;
- ✓ Audit of data supplier: milk yield data (Statistik Austria), livestock data;
- ✓ External review by Austrian agricultural experts (stakeholder meetings “inventory talks” 2010),
- ✓ Expanded QA and verification activities in 2012: in-depth review of the agriculture model.
- ✓ Expanded QA/QC of the software tool (calculation sheets) for new and revised sources (e.g. crop residues, energy crops performed in 2015)
- ✓ External review of the revised agricultural model according to the 2006 IPCC GL by Austrian agricultural experts: stakeholder meeting “inventory talks” 2014.
- ✓ External review of the revised agricultural model (AMON & HÖRTENHUBER 2019) according to the new data on the agricultural practice (PÖLLINGER et al. 2018) by Austrian agricultural experts: stakeholder meeting “inventory talks” 2018.
- ✓ External review of the updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) based on the research project on country-specific animal feeding and nutrition (“MiNutE” study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER et. al. 2023) by Austrian agricultural experts.
- ✓ Verification of the calculations for NH_3 emissions from animal husbandry with the *3.B Manure Management N flow tool* of the EEA.

Sector specific routine control procedures are provided in chapter 5.1.4.

5.3.4 Uncertainties

Uncertainties are presented in Table 159.

5.3.5 Recalculations

Update of activity data

Livestock data – cattle < 1 year

The livestock category cattle < 1 year comprises slaughtering calves < 1 year, other male calves and cattle < 1 year, and other female calves and cattle < 1 year according to the official statistics (Statistics Austria). The breakdown by type of use is determined by Statistics Austria using model calculations. Methodological improvements resulted in shifts between the cattle < 1 year sub-categories in

the years 2003-2021 and thus led to revised average values for gross energy intake, $N_{\text{excretion}}$ and $VS_{\text{excretion}}$ for cattle < 1 year.

Background data for feeding and nutrition of dairy and suckling cows

New figures for the protein and fat content of milk for the year 2021 became available (AMA 2023a). This update resulted in minor revisions of the values for gross energy intake, $N_{\text{excretion}}$ and $VS_{\text{excretion}}$ of dairy and suckling cows.

Biogas plants

New data on input materials for Austria's biogas plants became available from the compost and biogas association (Kompost- und Biogasverband). The update resulted in slightly revised CH_4 and N_2O emissions with an impact on the source categories *3.B Manure Management*, *3.D.a.2.a Animal manure applied to soils* and *3.D.a.2.c Other organic fertilizers applied to soils* for 2020 and 2021.

Methane and N_2O emissions have been revised for the years 2003–2021 (+0.3 kt CH_4 for 2021, +0.004 kt N_2O for 2021), because of updated activity and nutrition data (see above).

5.4 Agricultural soils (Category 3.D)

Key source: N_2O from 3.D.1 and 3.D.2

5.4.1 Source Category Description

N_2O emissions from the source categories *3.D.a direct soil emissions* and *3.D.b indirect soil emissions* are key categories.

In 2022 78.8% of total N_2O emissions from agriculture (72.8% of total Austrian N_2O emissions) originated from agricultural soils, the rest stemmed from manure management.

Emissions from this category (N_2O) contributed 2.4% (1 742.56 kt CO_2 equivalents) to Austria's total greenhouse gas emissions in the year 2022. This is 23.9% of all GHG emissions from the sector agriculture.

The trend of N_2O emissions from this category is decreasing: in 2021 emissions were 18.3% below 1990 levels.

Table 200 presents N_2O emissions of agricultural soils by sub-category as well as their trends and their share in total N_2O emissions.

Table 200: N₂O emissions from agricultural soils, 1990–2022.

Year	N ₂ O emissions [kt]													
	3.D Total	3.D.a Direct Soil Emissions	Inorganic N-Fertilisers	Organic N-Fertiliser	Animal manure applied to soils	Sewage sludge applied to soils	Other organic fertilizers applied to soils	Urine and dung deposited by grazing	Crop Residues	Mineralization	Organic Soils	3.D.b Indirect Soil Emissions	Athm. Deposition	Nitrogen Leaching and run-off
1990	8.05	6.70	2.20	2.60	2.58	0.02	0.00	0.56	1.18	0.00	0.17	1.35	0.63	0.71
1995	7.46	6.21	2.00	2.49	2.45	0.03	0.02	0.46	1.08	0.00	0.17	1.25	0.58	0.66
2000	7.10	5.93	1.89	2.34	2.27	0.03	0.03	0.37	1.15	0.00	0.17	1.17	0.54	0.64
2005	6.63	5.54	1.58	2.25	2.17	0.02	0.06	0.29	1.26	0.00	0.17	1.09	0.49	0.60
2010	6.43	5.35	1.39	2.27	2.17	0.03	0.08	0.30	1.21	0.00	0.17	1.08	0.51	0.57
2011	6.85	5.72	1.63	2.25	2.14	0.03	0.08	0.30	1.36	0.00	0.17	1.13	0.51	0.62
2012	6.72	5.60	1.69	2.24	2.13	0.03	0.09	0.30	1.20	0.00	0.17	1.12	0.52	0.60
2013	6.64	5.53	1.65	2.23	2.12	0.02	0.09	0.30	1.17	0.00	0.17	1.11	0.52	0.59
2014	6.99	5.83	1.76	2.23	2.12	0.02	0.09	0.31	1.36	0.00	0.17	1.16	0.53	0.63
2015	6.97	5.81	1.90	2.24	2.12	0.03	0.09	0.31	1.19	0.01	0.17	1.17	0.54	0.63
2016	7.28	6.07	1.99	2.25	2.13	0.03	0.09	0.31	1.35	0.01	0.17	1.21	0.55	0.66
2017	6.99	5.82	1.89	2.26	2.13	0.03	0.09	0.31	1.19	0.01	0.17	1.18	0.55	0.63
2018	6.83	5.68	1.81	2.22	2.10	0.03	0.09	0.31	1.16	0.01	0.17	1.15	0.53	0.61
2019	6.70	5.59	1.66	2.19	2.08	0.03	0.09	0.31	1.26	0.01	0.17	1.12	0.51	0.60
2020	6.76	5.64	1.68	2.18	2.06	0.03	0.09	0.30	1.30	0.01	0.17	1.12	0.51	0.61
2021	6.79	5.67	1.75	2.18	2.07	0.03	0.08	0.30	1.26	0.01	0.17	1.12	0.51	0.61
2022	6.58	5.49	1.59	2.17	2.05	0.03	0.08	0.29	1.24	0.03	0.17	1.09	0.49	0.59
Share 2022	100.0%	83.5%	24.2%	33.0%	31.2%	0.5%	1.2%	4.4%	18.9%	0.5%	2.5%	16.5%	7.5%	9.0%
1990–2022	-18.3%	-18.1%	-27.6%	-16.6%	-20.3%	59.1%	4358%	-47.6%	5.5%	617.0%	0.0%	-19.4%	-22.0%	-17.1%

5.4.2 Methodological Issues

Austria uses IPCC Tier 1 and country specific methodologies for the calculation of N₂O emissions from agricultural soils. In response to recommendations of the ERT (ARR 2013, para 51 and 52) additional descriptions of the Austrian N-flow model have been included since NIR 2014 (see Annex 3.2).

Table 201: N₂O emission factors for agricultural soils.

Category	Emission Factor [kg N ₂ O-N/kg N]	Source
3.D.1 Direct N₂O Emissions from Managed Soils		
1. Inorganic N fertilizers		
2. Organic N fertilizers		
a. Animal manure applied to soils		
b. Sewage sludge applied to soils	0.01	IPCC 2006 (Table 11.1)
c. Other organic fertilizers applied to soils (energy crops from biogas plants, compost)		
3. Urine and dung deposited by grazing animals (cattle, pigs, poultry)	0.02	IPCC 2006 (Table 11.1)

Category	Emission Factor [kg N ₂ O-N/kg N]	Source
3. Urine and dung deposited by grazing animals (other animals)	0.01	IPCC 2006 (Table 11.1)
4. Crop residues	0.01	IPCC 2006 (Table 11.1)
5. Mineralization/immobilization associated with C-losses	0.01	IPCC 2006 (Table 11.1)
6. Cultivation of organic soils	8.2 [kg N ₂ O-N/ha]	IPCC 2013 Wetland Supplement (Table 2.5)
3.D.b Indirect N₂O Emissions from managed soils		
1. Atmospheric deposition	0.01	IPCC 2006 GL (Table 11.3)
2. Nitrogen leaching (and run-off)	0.0075	IPCC 2006 GL (Table 11.3)

Activity Data

Data for necessary input parameters (activity data) were taken from the following sources:

Table 202: Data sources for nitrogen input to agricultural soils.

Category	Activity Data Sources
3.D.a Direct soil emissions	
Inorganic N fertilizers (mineral fertilizers)	Total mineral fertilizer consumption (including urea): National data provided by Agrarmarkt Austria (AMA) and published annually in the official national reports "Grüne Berichte" (BML 2023b) ¹⁾ .
Animal manure applied to soils	Calculations within source category 3.B
Sewage sludge applied to soils	Water Quality Report 2000 (PHILIPPITSCH et al. 2001), Report on sewage sludge (UMWELTBUNDESAMT 1997), Austrian report on water pollution control (BMLFUW 2002), Data deliveries from Austria's federal provinces (UMWELTBUNDESAMT 2011a, 2013, 2014a, 2015, 2016a, 2017, 2018, 2019a, 2020, 2021, 2022, 2023d)
Other organic fertilizers applied to soils	Energy crops from biogas plants: Ökostromberichte 2006-2021 (E-Control 2006-2021), EAG-Monitoringbericht 2022 (E-Control 2022), HKN-database (E-Control 2023b); raw material balances for 2007, 2009, 2011, 2014, 2015, 2016, 2017 & 2018 (E-CONTROL 2008, 2011, 2013, 2017, 2018, 2019, 2020, 2021 & 2022); KOMPOST- UND BIOGASVERBAND ÖSTERREICH (2023) Compost application: AD elaborated from treated amounts in composting plants (chapter waste, Table 291) and application paths worked out by (UMWELTBUNDESAMT 2015)
Urine and dung deposited by grazing animals	Calculations within source category 3.B
Crop residues	Harvest amounts of agricultural crops (BML 2023b)
Mineralization/immobilization associated with C-losses	C losses reported in sub category 4.B.1.3 'Perennial converted to annual' (see chapter LULUCF)
Cultivation of organic soils	Organic soils area is estimated on the basis of soil inventory data
3.D.b Indirect soil emissions	
Atmospheric deposition	Amount of manure left for spreading calculated within source category 3.B. Mineral fertilizer data obtained from (BML 2023b) ¹⁾
Nitrogen leaching (and run-off)	see above (synthetic fertilizers, animal waste, sewage sludge)

¹⁾ Agrarmarkt Austria Marketing (<https://www.ama.at>) is Austria's entity preparing the national mineral fertilizer statistics annually published in (BML 2023b) (www.gruenerbericht.at and www.agraroeconomik.at)

Mineral fertilizer application

Austria's official national mineral fertilizer statistics (total amounts, including urea) is compiled by Agrarmarkt Austria, AMA, and annually published by the Austrian Federal Ministry of Agriculture, Forestry, Regions and Water Management in its official reports (BML 2023b).

The S & A report 2004 noticed high inter-annual variations in N₂O emissions of sector 3.D.1.a *Inorganic N-fertilizers*. These variations are caused by the effect of storage: Sales data are changing very rapidly due to changing market prices. Additionally, the fertilizer tax intensified this effect at the beginning of the 1990ies. However, not the whole amount purchased is applied in the year of purchase. Considering this effect, Austria uses the arithmetic average of each two years as activity data. For reasons of transparency, the time series of fertilizer sales data, presented in Table 203, includes the year 1989 as starting point as Austria uses the average mean of sold fertilizers of the years 1989 and 1990 as activity data for 1990.

In the in-country review 2007 it was recommended to consider revising the time series by determining actual fertilizer use in accordance with the IPCC good practice guidance. However, investigations showed that data on the actual fertilizer use are not available in Austria. Therefore it has been decided to continue to use the official fertilizer sales data as input data for the emission inventory. The UNFCCC centralized review 2008 considered the use of fertilizer sales data as an appropriate alternative (ARR 2008, para 50). Austria's approach is fully in line with the 2006 IPCC Guidelines, *Chapter 11.2.1.3 – Choice of activity data*, which states that annual fertiliser consumption data may be collected from official country statistics, often recorded as fertiliser sales and/or as domestic production and imports. In 2016 the UNFCCC centralized review confirmed the Austrian approach (ARR 2016, para A.6).

Time series for fertilizer consumption is presented in Table 203. For detailed information on different types of mineral fertilizers used in Austria, please refer to "Austria's Informative Inventory Report 2024 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants" (UMWELTBUNDESAMT 2024b).

Table 203: Mineral fertilizer N consumption in Austria 1990–2022 and arithmetic average of each two years.

Year	Annual Nutrient Sales Data [t N/yr]	Weighted Nutrient Consumption [t N/yr]
1989	140 916	
1990	139 042	139 979
1995	128 000	127 368
2000	121 600	120 550
2005	99 700	100 250
2010	90 629	88 465
2011	116 751	103 690
2012	97 721	107 236
2013	112 005	104 863
2014	111 615	111 810
2015	130 252	120 934
2016	122 623	126 438
2017	117 704	120 163
2018	113 136	115 420
2019	98 234	105 685

Year	Annual Nutrient Sales Data [t N/yr]	Weighted Nutrient Consumption [t N/yr]
2020	115 676	106 955
2021	106 483	111 080
2022	96 253	101 368

Data source: AMA data (Agrarmarkt Austria, www.ama.at) published in the "Green Reports" of the Federal Ministry of Agriculture, Forestry, Regions and Water Management (BML, <https://www.bml.gv.at/>): <https://gruenerbericht.at/cm4/>

Legume cropping areas

The yearly numbers of the legume cropping areas were taken from official statistics (BML 2023b) and (STATISTIK AUSTRIA 1990–2023).

Table 204: Cropped area legume production and others, 1990–2022.

Year	Areas [ha]					Meadows ploughed every four years**	Cover crops***
	peas	soja beans	horse/field beans	clover hey, lucerne, ...	Other forage renewed annually*		
1990	40 619	9 271	13 131	57 875	3 650	39 233	3 000
1995	19 133	13 669	6 886	71 024	4 928	40 586	73 379
2000	41 114	15 537	2 952	74 266	4 087	56 794	437 276
2005	36 037	21 429	3 549	88 974	9 185	76 501	475 938
2010	13 562	34 378	4 344	106 080	16 525	59 169	300 969
2011	11 715	38 123	6 028	104 800	17 162	58 534	303 121
2012	10 704	37 126	6 852	104 808	18 046	56 794	301 810
2013	7 248	42 027	6 194	101 861	17 326	60 087	285 509
2014	6 863	43 832	7 862	102 369	18 203	59 899	269 812
2015	7 274	56 895	10 780	100 364	18 592	57 503	276 689
2016	7 733	49 791	10 823	96 672	18 266	52 117	275 547
2017	6 721	64 467	10 296	94 209	17 477	50 029	268 515
2018	6 917	67 624	7 645	96 098	20 445	52 431	278 946
2019	5 333	69 207	5 713	101 671	22 785	53 098	269 682
2020	5 616	68 424	5 492	104 449	24 559	50 440	261 238
2021	5 652	76 430	6 188	100 351	22 390	50 602	250 557
2022	5 880	93 142	5 538	94 726	21 508	48 194	259 637

* value for 1991 is interpolated as no data is available

** (BML 2023b), 1991–1994 and 1996 (STATISTIK AUSTRIA 1990–2014)

*** greening variants A+B+C+D until 2014. From 2015 onwards a new funding period started (BML 2023b). Only small amounts before 1995.

Harvest Data

Harvest data and data of the cultivated area were taken from (BML 2023b) and the datapool of (BUNDESANSTALT FÜR AGRARWIRTSCHAFT UND BERGBAUERNFRAGEN 2023) and are presented in Table 205: and Table 206.

Table 205: Harvest Data I, 1990–2022.

Year	Harvest [1 000 t]									
	corn	wheat	rye	barley	oats	maize (corn)	Other* cereals	potato	sugar beet	fodder beet
1990	5 290	1 404	396	1 521	244	1 620	104	794	2 494	171
1995	4 452	1 301	314	1 065	162	1 474	136	724	2 886	85
2000	4 490	1 313	183	855	118	1 852	171	695	2 634	47
2005	4 880	1 453	164	880	128	2 021	234	763	3 084	17
2010	4 776	1 518	161	778	98	1 956	265	672	3 132	11
2011	5 669	1 782	202	859	110	2 453	263	816	3 456	12
2012	4 839	1 275	205	662	93	2 351	252	665	3 114	10
2013	4 545	1 598	235	734	87	1 639	252	604	3 466	8
2014	5 658	1 804	233	846	106	2 334	335	751	4 244	11
2015	4 784	1 726	171	840	96	1 638	312	536	2 853	7
2016	5 642	1 970	188	860	95	2 180	349	767	3 534	8
2017	4 813	1 437	129	782	77	2 076	313	653	2 994	8
2018	4 747	1 371	177	695	75	2 130	299	698	2 150	6
2019	5 363	1 605	201	833	78	2 299	348	751	1 965	5
2020	5 595	1 660	219	870	84	2 412	350	886	2 092	6
2021	5 226	1 529	152	738	89	2 435	284	770	3 017	5
2022	5 118	1 685	168	758	84	2 114	308	686	2 586	5

* mixed grain, triticale

Table 206: Harvest Data II, 1990–2022.

Year	Harvest [1 000 t]								
	silos- green maize	clover- hey	rape	Sun- flower	soja bean	horse- /fodder bean	peas	vegeta- bles	oil pumpkin
1990	4 289	457	102	57	18	41	145	273	3
1995	3 996	549	268	61	31	17	60	302	5
2000	3 531	493	125	55	33	7	97	361	6
2005	3 600	705	104	81	61	10	90	384	8
2010	3 557	682	171	66	95	11	31	457	15
2011	4 006	631	180	74	109	18	36	557	16
2012	4 003	588	149	53	104	16	15	471	13
2013	4 199	547	197	51	83	14	18	464	10
2014	4 072	630	198	58	118	21	17	555	11
2015	3 807	484	112	38	136	25	19	442	19
2016	4 172	636	142	60	153	28	19	473	30
2017	3 697	514	117	51	193	23	15	452	15
2018	3 777	488	121	60	184	16	17	427	15
2019	3 954	519	107	64	215	13	13	460	16
2020	4 277	607	100	56	203	14	13	483	23
2021	4 006	564	86	74	235	16	13	501	26
2022	3 882	521	91	56	246	14	14	497	28

Table 207: Cultivation Area I, 1990–2022.

Year	Area [ha]								
	wheat	rye	barley	oats	maize (corn)	Other* cereals	potato	sugar beet	fodder beet
1990	278 226	93 041	292 424	61 956	198 073	24 717	31 760	49 758	3 845
1995	255 910	76 826	229 099	40 778	173 352	31 705	27 036	51 643	1 759
2000	293 806	52 473	223 762	32 981	187 802	37 224	23 737	42 836	1 036
2005	288 960	42 847	191 740	30 218	189 637	48 108	22 186	44 690	296
2010	302 852	45 699	168 891	26 576	201 137	56 997	21 973	44 841	193
2011	304 334	45 943	153 286	25 029	217 100	53 613	22 851	46 580	179
2012	308 179	48 525	150 576	24 815	219 702	51 392	21 782	49 263	170
2013	297 286	56 108	142 574	23 165	201 917	52 221	21 128	50 849	168
2014	304 645	48 241	145 825	23 297	216 316	58 347	21 384	50 604	169
2015	302 965	39 563	151 769	23 501	188 728	59 934	20 368	45 436	134
2016	315 088	37 312	140 425	22 512	195 252	60 360	21 221	43 497	133
2017	295 029	34 476	138 903	23 245	209 476	60 872	22 991	42 684	131
2018	292 654	40 725	139 270	21 452	209 903	61 700	23 755	31 246	116
2019	277 291	43 679	137 242	20 596	220 690	64 190	23 969	27 878	107
2020	277 912	42 735	134 801	20 135	212 596	60 274	24 260	26 319	100
2021	277 447	32 869	123 624	24 360	218 198	54 102	22 562	37 852	89
2022	292 863	34 432	122 547	20 278	215 335	55 377	21 441	33 826	84

* mixed grain, triticale

Table 208: Cultivation Area II, 1990–2022.

Year	Area [ha]								
	silo- green maize	clover- hey	rape	Sun- flower	soja bean	horse- /fodder bean	peas	vegeta- bles	oil pumpkin
1990	107 134	54 225	40 844	23 336	9 271	13 131	40 619	8 390	9 000
1995	90 682	66 096	89 246	28 550	13 669	6 886	19 133	8 482	8 957
2000	73 960	70 179	51 762	22 336	15 537	2 952	41 114	8 173	10 376
2005	76 987	79 789	35 251	30 179	21 429	3 549	36 037	8 042	16 271
2010	81 239	89 555	53 803	25 411	34 378	4 344	13 562	9 112	26 464
2011	81 444	87 638	53 636	26 049	38 123	6 028	11 715	10 024	26 119
2012	82 375	86 762	55 821	23 362	37 126	6 852	10 704	8 800	22 741
2013	110 818	84 535	58 557	21 808	42 027	6 194	7 248	9 523	17 884
2014	83 464	84 166	52 816	20 540	43 832	7 862	6 863	9 710	22 382
2015	91 989	81 772	37 529	19 061	56 895	10 780	7 274	9 455	31 816
2016	84 643	78 406	39 662	18 189	49 791	10 823	7 733	10 143	38 928
2017	82 188	76 732	40 502	22 018	64 467	10 296	6 721	10 282	22 397
2018	83 349	75 653	40 504	21 504	67 624	7 645	6 917	10 152	23 241
2019	85 684	78 886	35 966	21 245	69 207	5 713	5 333	10 463	25 220
2020	86 792	79 889	31 827	23 828	68 424	5 492	5 616	10 259	35 438
2021	84 557	77 960	28 273	24 678	76 430	6 188	5 652	10 247	39 131
2022	82 227	73 218	28 385	24 291	93 142	5 538	5 880	9 858	37 310

Sewage sludge application on fields

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 209: Amount of sewage sludge (dry matter) produced in Austria, 1990–2022.

Year	Total [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied sewage sludge N [t N]
1990	161 936	31 507	19.5	1 232
1995	390 500	42 400	10.9	1 654
2000	392 909	43 220	11.0	1 686
2005	290 110	35 541	12.3	1 386
2010	262 805	44 354	16.9	1 730
2011	265 962	43 796	16.5	1 708
2012	266 949	41 487	15.5	1 618
2013	238 273	38 231	16.0	1 491
2014	239 044	39 626	16.6	1 545
2015	234 880	46 861	20.0	1 828
2016	237 938	48 313	20.3	1 884
2017	236 180	47 549	20.1	1 854
2018	234 481	48 170	20.5	1 879
2019	233 499	49 676	21.3	1 937
2020	228 009	48 357	21.2	1 886
2021	193 623	47 909	24.7	1 868
2022	196 448	50 229	25.6	1 959

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 2002), and submissions from Austria's federal provinces to the Umweltbundesamt (UMWELTBUNDESAMT 2011a, 2013, 2014a, 2015, 2016a, 2017, 2018, 2019a, 2020, 2021, 2022, 2023d).

Application of compost on fields

Total amounts of compost (composting plants and home composting) were taken from Table 291 (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 210: Amount of compost (dry matter) produced in Austria, 1990–2022.

Year	Total amount of compost [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied compost N [t N]
1990	83 561	4 303	5.1	60
1995	230 215	49 597	21.5	694
2000	293 394	62 568	21.3	876
2005	337 811	81 236	24.0	1 137
2010	366 861	93 140	25.4	1 304

Year	Total amount of compost [t dm]	agriculturally applied [t dm]	agriculturally applied [%]	Applied compost N [t N]
2011	383 990	100 612	26.2	1 409
2012	408 881	111 488	27.3	1 561
2013	395 643	105 092	26.6	1 471
2014	406 344	109 334	26.9	1 531
2015	403 880	107 489	26.6	1 505
2016	427 051	116 967	27.4	1 638
2017	428 747	117 254	27.3	1 642
2018	426 617	116 502	27.3	1 631
2019	440 388	121 782	27.7	1 705
2020	445 348	123 677	27.8	1 731
2021	458 589	129 337	28.2	1 811
2022	453 852	126 333	27.8	1 769

5.4.2.1 Direct soil emissions (3.D.a)

Key Source: Yes (N₂O)

Direct soil emissions are the most important sub-category of *3.D Agricultural Soils*. 83% (5.49 kt in 2022) of N₂O emissions from agricultural soils arise from this sub-category (see Table 200).

N₂O emissions from the following sources were estimated:

- Inorganic N fertilizers (mineral fertilizers and urea)
- Organic N fertilizers

Animal manure applied to soils,

Sewage sludge applied to soils

Other organic fertilizers applied to soils

- Urine and dung deposited by grazing animals
- Incorporation of *crop residues* after harvest
- Mineralization/immobilization associated with loss/gain of soil organic matter
- Cultivation of organic soils (i.e. histosols)

Following IPCC 2006, N₂O is calculated from overall N additions to soils without subtraction of the amounts that volatilize as NH₃-N and NO_x-N during and after application as it had to be done according to the 1996 IPCC GL.

Direct N₂O emissions from manure applied to soils were calculated using a country specific methodology based on the N-flow approach. N₂O emissions from all other sources were calculated using the 2006 IPCC Tier 1 methodology. Calculation methods are described in the following subchapters. The conversion from N₂O-N to N₂O emissions is performed by multiplication with (44/28).

5.4.2.1.1 Nitrogen input through application of inorganic (mineral) N fertilizers

The method applied for calculation of direct N₂O emissions is IPCC Tier 1 (IPCC 2006, Equation 11.1).

$$N_2O-N_{N\text{ inputs}} = F_{SN} * EF_1$$

$N_2O-N_{N\text{ inputs}}$ = annual direct N₂O-N emissions produced from managed soil, kg N₂O-N yr⁻¹

F_{SN} = annual amount of synthetic fertilizer N (mineral and urea) applied to soils, kg N yr⁻¹ – (see Table 203)

EF_1 = emission factor for N₂O emissions from N inputs, kg N₂O-N (kg N input)⁻¹ (IPCC 2006, table 11.1)

5.4.2.1.2 N input from organic N fertilizers to cropland and grassland

Organic N fertilizers (F_{ON}) include the following N-inputs to soils (IPCC 2006, equation 11.3):

$$F_{ON} = F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$$

- Nitrogen input through the application of animal manure to soils, excluding grazing (F_{AM})
- Nitrogen input through the application of sewage sludge to soils (F_{SEW})
- Nitrogen input through the application of compost to soils (F_{COMP})
- Nitrogen inputs through other organic amendments (F_{OOA}) used as fertiliser (in Austria energy crops from biogas plants applied to soils).

Nitrogen input from animal manure applied to soils

A country specific methodology based on the N-flow approach was used. According to the IPCC method, nitrogen from manure that is used as a biofuel should be subtracted, but this is irrelevant for Austria because in Austria manure is not used as a biofuel at all.

Nitrogen left for spreading

After storage, manure is applied to agricultural soils. Manure application is connected with NH₃-N, NO_x-N, N₂O-N and N₂ losses that depend on the amount of manure N. With regard to a comprehensive treatment of the nitrogen budget, Austria established a link between the ammonia and nitrous oxide emissions inventory. This procedure enables the use of country specific data, which is more accurate than the use of the default values for $Frac_{GasMS}$ provided in the 2006 IPCC GL, table 10.23.

From total N excretion by Austrian livestock, the following losses were subtracted:

- N excreted during grazing,
- NH₃-N losses from the housings and yards,
- NH₃-N losses from manure storages,
- NH₃-N losses from biogas plants,
- NO_x-N losses from manure management,
- N₂O-N losses from manure management,
- N₂ losses from manure storages.

The remaining N is applied to agricultural soils.

Table 211: Animal manure left for spreading on agricultural soils per livestock category 1990–2022 (I).

Year	Nitrogen left for spreading [t N per year]					
	IPCC Livestock Categories					
	total	dairy cattle	suckling cows	all other cattle	breeding sows & litter	young & fattening pigs
1990	164 035	64 656	2 627	55 468	6 930	26 554
1995	155 870	52 220	11 654	52 049	6 697	24 789
2000	144 743	47 484	13 972	47 446	5 463	22 520
2005	137 963	42 956	14 910	45 211	5 000	21 680
2010	138 084	43 952	14 037	46 001	4 500	20 500
2011	136 248	43 794	13 773	45 018	4 361	19 984
2012	135 280	44 116	13 283	44 431	4 189	19 718
2013	134 803	44 717	12 579	44 733	4 040	19 039
2014	135 003	45 694	12 177	44 676	3 917	18 661
2015	135 016	45 615	11 844	45 047	3 915	18 407
2016	135 301	46 639	11 338	44 641	3 857	18 279
2017	135 688	47 037	10 764	44 566	3 901	18 365
2018	133 795	46 426	10 376	43 983	3 716	18 121
2019	132 218	45 658	10 085	43 397	3 748	18 087
2020	131 389	45 846	9 781	42 519	3 696	18 256
2021	131 555	45 858	9 487	42 983	3 645	18 183
2022	130 761	47 923	8 072	42 706	3 392	17 291

Table 212: Animal manure left for spreading on agricultural soils per livestock category 1990–2022 (II).

Year	Nitrogen left for spreading [t N per year]					
	IPCC Livestock Categories					
	total	poultry	sheep	goats	horses/solipeds	deer
1990	164 035	4 667	1 699	287	1 085	63
1995	155 870	4 376	2 002	417	1 598	68
2000	144 743	3 672	1 860	431	1 829	67
2005	137 963	3 884	1 786	423	2 041	73
2010	138 084	4 154	1 965	551	2 344	80
2011	136 248	4 300	1 980	556	2 404	77
2012	135 280	4 443	1 999	562	2 465	74
2013	134 803	4 586	1 960	554	2 525	71
2014	135 003	4 764	1 914	543	2 586	70
2015	135 016	4 944	1 939	589	2 646	70
2016	135 301	5 122	2 074	636	2 646	69
2017	135 688	5 219	2 201	700	2 867	68
2018	133 795	5 310	2 228	703	2 867	67
2019	132 218	5 393	2 208	711	2 867	66
2020	131 389	5 489	2 159	713	2 867	65
2021	131 555	5 489	2 206	773	2 867	65
2022	130 761	5 488	2 197	761	2 867	65

A more detailed description of the methods applied for the calculation of NH_3 and NO_x emissions is given in the report “Austria’s Informative Report 2024 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants” (UMWELTBUNDESAMT 2024b)⁹¹. Following a recommendation of the in-country review 2007, more information on the calculation of volatilization ratios has been included to the NIR (see below).

NH_3 emissions from cattle and swine are estimated using a country specific methodology following the N-flow approach. NH_3 emissions from sheep, goats, horses, poultry and deer are estimated using the EMEP/EEA Tier 2 methodology (EEA 2023a).

NH_3 emissions from housing (cattle and swine)

Table 213 provides the NH_3 -N emission factors used in the calculation of NH_3 emissions from animal housing (DÖHLER ET AL. 2001). For cattle they differentiate between loose housing and tied housing systems, which is relevant for Austria.

Table 213: Emission factors for NH_3 emissions from animal housing.

Manure management system	kg NH_3 -N (kg N excreted) ⁻¹
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
Young & Fattening pigs, liquid slurry system	0.150
Young & 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

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.

NH_3 emissions from manure storage

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.

Cattle and swine

Table 214 provides NH_3 emission factors for the storage of cattle and swine manures (EIDGENÖSSISCHE FORSCHUNGSANSTALT 1997).

⁹¹ <https://www.ceip.at/status-of-reporting-and-review-results/2024-submission>

Table 214: NH_3 emission factors for manure storage.

Manure storage system	kg $\text{NH}_3\text{-N}$ (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

TAN content in excreta

The detailed method makes use of the total NH_3 nitrogen (TAN) when calculating emissions. TAN content for Austrian cattle and swine manure is given in SCHECHTNER 1991.

Table 215: TAN content for Austrian cattle and swine manure (SCHECHTNER 1991).

Manure	TAN content for Austria [%]	Manure	TAN content for Austria [%]
cattle – solid storage system	15.0	pig – solid storage system	15.0
cattle – liquid slurry system	50.0	pig – liquid slurry system	65.0

Austria's ammonia inventory additionally uses specific abatement factors to emission factors for a range of manure treatment options taken from the Swiss ammonia inventory model 'DYNAMO' (MENZI et al. 2003, REIDY et al. 2007, REIDY & MENZI 2005). These abatement factors are fully consistent with the abatement factors provided in the UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions (UNECE 2015). For further information please refer to "Austria's Informative Inventory Report 2024" (UMWELTBUNDESAMT 2024b).

Sheep, goats, horses, poultry and deer

The EMEP/EEA Tier 2 methodology was applied. Tier 2 uses a mass flow approach based on the concept of a flow of TAN through the manure management system (EEA 2023a). Table 216 presents the default EMEP/EEA Tier 2 $\text{NH}_3\text{-N}$ emission factors and associated parameters used in the calculations for Austria's non-key livestock categories (EEA 2023a, Table 3-9). Information on MMS is provided in Table 179; country specific N excretion values are presented in Table 216.

Table 216: Default Tier 2 $\text{NH}_3\text{-N}$ EF and associated parameters for the Tier 2 methodology.

NFR	Livestock category	proportion of TAN	EF housing	EF storage	EF spreading
3.B.2	Sheep	0.50	0.22	0.32	0.90
3.B.4.d	Goats	0.50	0.22	0.28	0.90
3.B.4.e	Horses (mules, asses)	0.60	0.22	0.35	0.90
3.B.4.g.i	Laying hens	0.70	0.20	0.08	0.45
3.B.4.g.ii	Broilers	0.70	0.21	0.30	0.38
3.B.4.g.iii	Turkeys	0.70	0.35	0.24	0.54
3.B.4.g.iv	Other poultry	0.70	0.38 ^(*)	0.21 ^(*)	0.50 ^(*)
3.B.4.h	Other animals ^(**)	0.50	0.22	0.32	0.90

^(*) EF = weighted mean of ducks & geese for 2022

^(**) In Austria 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.

In submission 2019 for layers and broilers the management system “manure belt with covered storage” was implemented into Austria’s ammonia inventory (AMON & HÖRTENHUBER 2019) using specific abatement factors from the *UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions* (UNECE 2015).

NO_x emissions from manure management

NO_x-N-losses from manure management were calculated according to the Tier 2 methodology as outlined in the EMEP/EEA Emission Inventory Guidebook 2023 (EEA 2023a). The calculations make use of the mass-flow approach based on the concept of a flow of TAN through the manure management system.

Emission factors for slurry and solid NO are taken from the EMEP/EEA GB 2023 chapter 3.B, Table 3-10.

For cattle and swine national TAN contents were taken from (SCHECHTNER 1991, see Table 215). Default TAN values according to the EMEP/EEA GB 2023 Table 3-9, are applied for sheep, goats, horses, poultry and deer. Detailed information is included in “Austria’s Informative Inventory Report 2024” (UMWELTBUNDESAMT 2024b).

N₂ emissions from manure management

In submission 2019 for the first time N₂ losses have been considered in Austria’s N flow model (AMON & HÖRTENHUBER 2019). For both, slurry and litter-based manures, the default N₂ emission factors from Table 3-10 (EEA 2023a) were used. For further information, please refer to “Austria’s Informative Inventory Report 2024” (UMWELTBUNDESAMT 2024b).

NH₃-N and NO_x-N volatilisation losses associated with manure application

Volatilisation losses following the application of organic N fertilizers on soils are basis for the estimation of indirect N₂O emissions from atmospheric deposition. NH₃-N and NO_x-N emission factors used in Austria’s Air Emission Inventory are briefly described in chapter indirect N₂O emissions from soils/ deposition (5.4.2.2).

Nitrogen input through sewage sludge application

N₂O emissions

The method applied for the calculation of N₂O emissions is IPCC Tier 1 with a default emission factor of 1.0% N₂O-N per kg N input to agricultural soils.

In Austria fertilisation by sewage sludge is very small. In 2022 N₂O emissions from sewage sludge contributed only 0.5% of N₂O emissions from category 3.D Agricultural Soils.

N content data 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 to the following formula:

$$F_{\text{Sslu}} = \text{Sslu}_N * \text{Sslu}_{\text{agric}}$$

F_{Sslu} = Annual nitrogen input to soils by agriculturally applied sewage sludge [t N]

Sslu_N = Nitrogen content in dry matter [%] – 3.9%

$\text{Sslu}_{\text{agric}}$ = Annual amount of sewage sludge agriculturally applied [t/t] (see Table 209)

The annual agricultural consumption of sewage sludge is presented in Table 209.

Other organic fertilizers applied to soils (energy crops from biogas plants and compost)

This sub-category includes the N inputs from energy crops applied to soils as fertilizer after the digestion process in biogas plants and the N inputs from the application of compost to agriculture soils.

Activity data

Energy crops

The calculation of N from anaerobically digested energy crops (digestates) was done on the basis of raw material and energy balances reported by E-Control (E-CONTROL 2008, 2011, 2013, 2017, 2018, 2019, 2020, 2021 & 2022) as well as (KOMPOST- UND BIOGASVERBAND ÖSTERREICH 2023). N content of digested energy crops was derived from specific literature (RESCH et al. 2006; LANDESBETRIEB LANDWIRTSCHAFT HESSEN 2013; SÜD-TREBER GMBH 2021). Amounts of digested manure N are calculated in sector manure management.

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).

Table 217: N from biogas slurry and compost 1990–2022.

Year	Digestates (livestock manures) [kg N year ⁻¹]	Digestates (veg. part) [kg N year ⁻¹]	N from compost [kg N year ⁻¹]
1990	43 081	55 953	60 236
1995	316 882	425 239	694 352
2000	988 928	1 342 861	875 945
2005	1 901 150	2 585 007	1 137 307
2010	4 500 717	3 542 337	1 303 964
2011	2 712 475	3 967 113	1 408 564
2012	2 813 841	3 982 333	1 560 827

Year	Digestates (livestock manures) [kg N year ⁻¹]	Digestates (veg. part) [kg N year ⁻¹]	N from compost [kg N year ⁻¹]
2013	2 906 643	3 997 529	1 471 292
2014	3 004 643	4 012 634	1 530 673
2015	3 011 112	4 124 919	1 504 839
2016	3 609 104	4 291 965	1 637 533
2017	3 395 759	4 330 692	1 641 556
2018	3 619 066	4 071 751	1 631 028
2019	3 105 022	3 747 936	1 704 948
2020	3 952 113	3 704 492	1 731 477
2021	4 391 852	3 464 602	1 810 716
2022	3 587 746	3 410 620	1 768 664

Methodology

IPCC Tier 1 methodology and the default emission factor of 1.0% N₂O-N per kg N input to agricultural soils were used.

5.4.2.1.3 Urine and dung deposited by grazing animals

Key Source: No

Following the IPCC Guidelines, N₂O emissions resulting from nitrogen input through excretions of grazing animals (directly dropped onto the soil) are calculated under *Manure Management* but reported under *Agricultural Soils*.

$$N_2O-N_{PRP} = F_{PRP} * EF_{3PRP}$$

N_2O-N_{PRP} = annual direct N₂O-N emissions from urine and dung inputs to grazed land, kg N₂O-N yr⁻¹.

F_{PRP} = annual amount of urine and dung nitrogen deposited on soils during grazing [t N] – see Table 218

EF_{3PRP} = default emission factors for N₂O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals [t N₂O-N/t N], – 0.02 for cattle and swine and 0.01 for sheep, goats, horses and other animals (IPCC GUIDELINES 2006 – table 11.1).

Table 218: Nitrogen excreted during grazing on pasture, range and paddock (N_{exPRP}) 1990–2022.

Year	N excretion grazing [t]
1990	18 864
1995	16 135
2000	13 219
2005	10 638
2010	11 284
2011	11 310
2012	11 329
2013	11 307
2014	11 369
2015	11 479
2016	11 635
2017	11 790
2018	11 674
2019	11 505

Year	N excretion grazing [t]
2020	11 369
2021	11 384
2022	11 055

5.4.2.1.4 Nitrogen input from incorporation of crop residues

Austria uses the IPCC 2006 Tier 1 methodology for emission calculation.

Additionally to the residues from harvest crops (including legume crops) the following N amounts returned to soils are included:

- N from meadows ("seeded pastures") ploughed every four years
- N from other forage crops on arable land renewed annually
- N from cover crops

According the IPCC 2006 GL biological nitrogen fixation has been removed as a direct source of N₂O due to the lack of evidence of significant emissions arising from the fixation process itself.

N from meadows ploughed every four years („Wechselwiesen“)

Specific seeded pastures have to be ploughed every few years and followed by another crop to formally remain the status "arable land". Following Austrian experts these kind of meadows are ploughed (and covered by another crop) every four years (AMON & HÖRTENHUBER 2014; UMWELTBUNDESAMT 2014c). Activity data on seeded pastures („Wechselwiesen“) were taken from the Green Reports (BML 2023b). The average N content of residues was derived on the basis of the assumption that 25% of plants are legume forages and 75% are non-legume forages (AMON & HÖRTENHUBER 2014; UMWELTBUNDESAMT 2014c). Average dry matter net yield per hectare (7 000 kg dm for common management) was taken from BUCHGRABER & GINDL (2004).

N from other forage crops on arable land renewed annually

Activity data on other forage crop area renewed annually was taken from the Green Reports (BML 2023b).

The average N content of residues was derived on the basis of the assumption that 25% of plants are legume forages and 75% are non-legume forages (AMON & HÖRTENHUBER 2014; UMWELTBUNDESAMT 2014c). Average dry matter net yield per hectare (7 000 kg dm for common management) was taken from BUCHGRABER & GINDL (2004).

N from crop residues of cover crops

N input amount (20 kg N/ha) from mineralising residues of cover crops was obtained from the „Richtlinien für die sachgerechte Düngung“ (Austrian fertilizer recommendations) (BML 2022a). Activity data (areas with cover crops) were taken from Austria's Green Reports (BML 2023b).

Methodology

Austria applies the 2006 IPCC Tier 1 methodology, equation 11.7A. For emission calculation the default emission factor of 1.0% N₂O-N per kg N input to agricultural soils is used.

Applied parameters are presented in Table 219.

Table 219: Input factors used for estimation of N added to soils from crop residues (IPCC 2006, Table 11.2).

	Slope	Intercept	N content of above-ground residues (N _{AG})	Ratio of below- ground residues to above-ground biomass (R _{BG-BIO})	N content of below-ground residues (N _{BG})	dry matter fraction of harvested product*	Frac _{Renew}
Wheat**	1.09	0.88	0.006	0.22	0.009	0.86	1.0
Rye	1.09	0.88	0.005	0.22	0.011	0.86	1.0
Barley	0.98	0.59	0.007	0.22	0.014	0.86	1.0
Oats	0.91	0.89	0.007	0.25	0.008	0.86	1.0
Other cereals***	1.09	0.88	0.006	0.22	0.009	0.86	1.0
Maize (corn)	1.03	0.61	0.006	0.22	0.007	0.86	1.0
Potato	0.1	1.06	0.019	0.20	0.014	0.22	1.0
Sugarbeet	0.1	1.06	0.019	0.20	0.014	0.22	1.0
Fodderbeet	0.1	1.06	0.019	0.2	0.014	0.20	1.0
Maize (silo)	1.03	0.61	0.006	0.22	0.007	0.32	1.0
Clover-hay	0.29	0	0.027	0.40	0.019	0.86	0.48
Rape	1.13	0.85	0.008	0.19	0.008	0.91	1.0
Sunflower	1.13	0.85	0.008	0.19	0.008	0.91	1.0
Sojabean	0.93	1.35	0.008	0.19	0.008	0.88	1.0
Fodderbean	1.13	0.85	0.008	0.19	0.008	0.88	1.0
Peas	1.13	0.85	0.008	0.19	0.008	0.86	1.0
Vegetables	1.07	1.54	0.016	0.20	0.014	0.20	1.0
Oil pumpkin	1.07	1.54	0.016	0.20	0.014	0.92	1.0
Other forages	0.30	0	0.018	0.505	0.0145	1.00	1.0
Meadows ploughed every four years	0.30	0	0.018	0.505	0.0145	1.00	0.25

* Country specific values are taken from (Umweltbundesamt 1998) and (STATISTIK AUSTRIA 2015) for grains, maize, potato, sugar beet, silo maize, rape, sunflower, soja bean, fodder bean, peas and oil pumpkin.

**IPCC defaults for "grains" chosen, as IPCC default values for wheat are not appropriate for Austria.

***Mixed grain, mainly triticale. IPCC defaults for "grains" chosen.

Frac_{Renew}: For most of the crops the total area is renewed annually (Frac_{Renew} = 1).

In the case of clover hay a Frac_{Renew} of 0.48 is used. This factor has been determined by analysing INVEKOS data for the period 2007 to 2013 based on the mean cultivation time without ploughing. Within this investigation for individual parcels with cultures of clover, clover-grass, and lucerne (alfalfa) the development over time was observed. Data analyses resulted in a cultivation time of 2.1 years (weighted mean).

Meadows are ploughed every four years resulting in a Frac_{Renew} factor of 0.25 (see above).

Activity data

Harvest data were taken from (BML 2023b) and the datapool of (BUNDESANSTALT FÜR AGRARWIRTSCHAFT UND BERGBAUERNFRAGEN 2023) and are presented in Table 205: and Table 206. Legume cropping areas were available from official statistics (BML 2023b) and (STATISTIK AUSTRIA 1990–2023) and can be found in Table 204.

5.4.2.1.5 Mineralization/immobilization associated with loss/gain of soil organic matter

In Austria N₂O emissions from this source category are occurring only in a very small scale.

Methodology

N₂O emissions from mineralisation due to management changes on 'cropland remaining cropland' are calculated using equation 11.8 from the 2006 IPCC guidelines and the IPCC default emission factor of 0.01 kg N₂O-N/kg N. For the C:N ratio the default value of 10 has been used.

Activity data

The annual losses of soil carbon (tons of C) are taken as reported under *4.B.1 Cropland remaining cropland* (see chapter 6.3.4.1). In the following table, all subdivisions of cropland remaining cropland that are losing soil carbon and hence contributing to the emissions under category *3.D.a.5*, are indicated as recommended in the UNFCCC Review 2023 (ARR 2023).

Table 220: Soil carbon losses in 4.B.1 Cropland remaining cropland 1990–2022

year s	4.B.1.1 Annual cropland remaining annual cropland	4.B.1.2 Perennial cropland remaining perennial cropland	4.B.1.3 Perennial cropland to annual cropland	4.B.1.4 Annual cropland to per- ennial cropland	Total C losses
[kt C]					
1990	0.00	0.00	-2.63	4.36	-2.63
1995	8.83	1.45	-2.62	4.32	-2.62
2000	53.72	1.15	-2.59	4.28	-2.59
2005	78.66	7.28	-2.57	4.24	-2.57
2010	77.03	6.83	-3.08	4.08	-3.08
2011	75.94	6.85	-3.07	3.98	-3.07
2012	75.16	6.80	-3.06	3.87	-3.06
2013	73.81	6.58	-3.04	3.76	-3.04
2014	71.33	5.94	-3.05	3.77	-3.05
2015	58.23	3.76	-3.24	3.90	-3.24
2016	49.76	4.32	-3.33	4.02	-3.33
2017	40.96	4.74	-3.33	4.15	-3.33
2018	32.01	4.76	-3.34	4.13	-3.34
2019	24.07	4.75	-3.39	4.08	-3.39
2020	13.90	4.76	-3.46	4.00	-3.46
2021	-3.49	-0.86	-3.53	3.93	-7.89
2022	-14.27	-1.01	-3.61	3.84	-18.89

5.4.2.1.6 Cultivation of organic soils (i.e. histosols)

According to Austria's soil inventories organic soils are not occurring in cropland in Austria. They can be found only in the grassland category.

Methodology

The emissions from organic soils were estimated according to the IPCC (2013) Wetlands Supplement which provides updated default emission factors for drained organic soils. The IPCC default emission factor for temperate nutrient rich deeply drained grassland of 8.2 kg N₂O-N/ha (Table 2.5 of IPCC 2013 Wetland Supplement) has been applied.

The associated N₂O emissions are reported in sector Agriculture under CRF source category *3.D.6 Cultivation of organic soils (i.e. histosols)* in line with the IPCC Reporting Guidelines.

Activity data

The area of organic grassland soils was estimated with data of the soil inventories of the Federal Provinces of Austria which are compiled in the Austrian Soil Information System – BORIS – (<http://www.borisdaten.at>). The carbon content from the upper soil horizon (weighted mean for 0–30 cm) was calculated out of 200 grassland sites. Sites with more than 17% C_{org} (NESTROY et al. 2000) were selected as “organic soils” and their area was extrapolated to the complete Austrian grassland area.

The estimation resulted in a total area of 12 954 ha organic grassland soils which was applied for the whole time series. Emission calculation with the default emission factor for drained grassland soils resulted in constant emissions from drained organic grassland soils across the time series.

5.4.2.2 Indirect soil emissions (3.D.b)

Key Source: Yes (N₂O)

According to the IPCC definition, indirect N₂O emissions are caused by atmospheric deposition of nitrogen onto soils and by nitrogen leaching and runoff from soils.

Indirect N₂O emissions through atmospheric nitrogen deposition

A country specific methodology was used. Detailed calculations of volatilisation losses follow the N-flow approach and result in country specific values of Frac_{GASF} and Frac_{GASM}.

Emissions were calculated following equation 11.9 provided in the IPCC 2006 GL

$$N_2O_{(ATD)}-N = [(F_{SN} * Frac_{GASF}) + ((F_{ON} + F_{PRP}) * Frac_{GASM})] * EF_4$$

$N_2O_{(ATD)}-N$ = annual amount of N₂O-N produced from atmospheric deposition of N volatilised from managed soils, kg N₂O-N

F_{SN} = annual amount of synthetic fertilizer N applied to soils [t N] (see Table 203)

$Frac_{GASF}$ = Fraction of synthetic fertilizer N that volatilises as NH₃ and NO_x, kg N volatilised (kg of N applied)⁻¹

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr⁻¹

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr⁻¹

$Frac_{GASM}$ = Fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilises as NH₃ and NO_x, kg N volatilised (kg of N applied or deposited)⁻¹

EF_4 = emission factor for N₂O emissions from N volatilisation and re-deposition on soils and water surfaces, kg N₂O-N (kg NH₃-N + NO_x-N volatilised) (2006 IPCC GUIDELINES, Table 11.3)

Country specific volatilisation fraction of synthetic N fertilizers (Frac_{GASF}) includes:

- NH₃-N and NO_x-N losses from urea and non-urea N fertilizers

Country specific volatilisation fraction of organic N fertilizers and N deposited by grazing animals (Frac_{GASM}) includes:

- NH₃-N and NO_x-N losses from animal manure applied to agricultural soils
- NH₃-N and NO_x-N losses from dung and urine deposited by grazing animals
- NH₃-N and NO_x-N losses from sewage sludge applied to agricultural soils
- NH₃-N and NO_x-N losses from biogas digestates applied to agricultural soils
- NH₃-N and NO_x-N losses from compost applied to agricultural soils

Table 221: $\text{NH}_3\text{-N}$ and $\text{NO}_x\text{-N}$ volatilisation losses from synthetic fertilizers and organic N fertilizers (including grazing) 1990 to 2022.

Year	N losses mineral fertilizer (incl. urea)	Frac _{GASF}	N losses from applied organic N fertilizer materials and grazing	Frac _{GASM}
	[t N/yr]	(N _{losses} /N _{FERT})	[t N/yr]	(N _{losses} /N _{FON+FPRP})
1990	10 761	0.08	29 628	0.16
1995	9 483	0.07	27 701	0.16
2000	8 970	0.07	25 108	0.16
2005	8 022	0.08	23 444	0.15
2010	7 759	0.09	24 520	0.16
2011	8 343	0.08	24 364	0.16
2012	8 680	0.08	24 361	0.16
2013	8 513	0.08	24 446	0.16
2014	9 048	0.08	24 663	0.16
2015	9 495	0.08	24 873	0.16
2016	9 992	0.08	25 124	0.16
2017	9 617	0.08	25 405	0.16
2018	8 955	0.08	25 031	0.16
2019	8 038	0.08	24 664	0.16
2020	7 980	0.07	24 467	0.16
2021	8 141	0.07	24 298	0.16
2022	7 534	0.07	23 965	0.16

Following a recommendation of the in-country review 2007, additional background information on the calculation of volatilization ratios has been included to the NIR (see below).

A detailed description of the method applied for NH_3 and NO_x is given in the report 'Austria's Informative Inventory Report 2024 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants' (UMWELTBUNDESAMT 2024b).

$\text{NH}_3\text{-N}$ and $\text{NO}_x\text{-N}$ volatilization losses from mineral fertilizer application

With regard to a comprehensive treatment of the nitrogen budget, Austria established a link between the ammonia and nitrous oxide emissions inventory. This procedure enables the use of country specific data, which is more accurate than the use of the default value for Frac_{GASF}.

NH_3 and NO_x emissions from sector 3 *Agriculture* are estimated according to the EMEP/EEA 2023 Guidebook (EEA 2023a).

NH_3 emissions from synthetic fertilizers are estimated using a country specific methodology which requires detailed information on urea fertilizer application. The EMEP/EEA GB 2023 provides specific NH_3 emission factors for different types of synthetic fertilizers and for normal and high pH soils (EEA 2023a, table 3-2). A 'normal' pH is a pH of 7.0 or below, a 'high' pH is a pH of more than 7.0 (usually calcareous soils) as defined in (EEA 2023a). 65% of Austria's soils are classified as normal and 35% as high based on Austrian Soil Information System – BORIS – (<http://www.borisdaten.at>).

For more detailed information, please refer to 'Austria's Informative Inventory Report 2024 – Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive

(EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants' (UMWELTBUNDESAMT 2024b).

For the calculation of NO_x-N losses the Tier 1 methodology according to the EMEP/EEA GB 2023 is applied. Emissions of NO_x are calculated as a fixed percentage of total fertilizer nitrogen applied to soil. For all mineral fertilizer types the default emission factor of 4% is used (0.04 kg NO per kg applied fertilizer-N).

NH₃-N volatilization losses occurring during manure application

NH₃ emission factors for spreading of slurry and farmyard manure (expressed as share of TAN) following (REIDY et al. 2007) have been applied:

Table 222: Emission factors for NH₃ emissions from animal waste application.

Application technique	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

Austria's ammonia inventory considers various techniques used for manure application in Austria (AMON & HÖRTENHUBER 2019). Specific abatement factors were obtained from the *UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions* (UNECE 2015). For more information please refer to Austria's Informative Inventory Report 2024 (UMWELTBUNDESAMT 2024b).

NO_x-N emissions from animal manure applied to soils

The Tier 1 methodology according to the EMEP/EEA GB 2023, chapter 3.D, is applied. The default emission factor of 0.04 kg NO per kg of organic fertilizer-N spread on agricultural soils is used, which has been taken from table 3-1 (EEA 2023a).

NH₃-N and NO_x-N volatilization losses from sewage sludge application

For the calculation of NH₃-N losses the EMEP/EEA default emission factor for sewage sludge of 0.13 kg NH₃/kg fertilizer N was applied (EEA 2023a).

NO_x emissions were estimated according to the EMEP/EEA GB 2023 (EEA 2023a, Annex 2.3) using the default Tier 1 EF of NO for sewage sludge (0.04 kg NO₂/kg sewage sludge N).

NH₃-N and NO_x-N volatilization losses from biogas slurry application (energy crops)

For the calculation of NH₃-N losses from energy crops applied to soils as fertilizer after the digestion process (biogas slurry), the EMEP/EEA Tier 1 approach and the default emission factor for other organic wastes of 0.08 kg NH₃ per kg N applied was applied (EEA 2023a, Table 3-1).

NO_x-N losses were estimated with the EMEP/EEA Tier 1 approach and the default emission factor for other organic wastes of 0.04 kg NO per kg waste N applied (EEA 2023a, Table 3-1).

NH₃-N and NO_x-N volatilization losses from compost application

NH₃-N losses from compost applied to soils as fertilizer were calculated with the EMEP/EEA Tier 1 approach and the default emission factor for other organic wastes of 0.08 kg NH₃ per kg N applied (EEA 2023a, Table 3-1).

NO_x-N losses were estimated with the EMEP/EEA Tier 1 approach and the default emission factor for other organic wastes of 0.04 kg NO per kg N applied (EEA 2023a, Table 3-1).

Indirect N₂O emissions from nitrogen leaching and run-off

A country-specific methodology based on the N-flow approach and country specific losses by leaching and runoff was used.

Results of a country specific study (EDER et al. 2015) determine a value of 15.154% for the fraction of leaching losses from nitrogen additions to Austria's managed soils. The peer reviewed study used 22 lysimeters, covering a wide range of soils, climatic conditions and management practices in Austria, to evaluate nitrogen losses through leaching and to calculate an Austria-specific value of F_{LEACH} .

The emission calculation follows the following formula (equation 11.10, IPCC 2006 GL):

$$E\text{-N}_2\text{O}_{\text{LL}} = (F_{\text{SN}} + F_{\text{ON}} + F_{\text{PRP}} + F_{\text{CR}} + F_{\text{SOM}}) * \text{Frac}_{\text{LEACH}} * EF_5$$

$E\text{-N}_2\text{O}_{\text{LL}}$ = N₂O emissions from leaching losses, expressed as N₂O-N [t N]

F_{SN} = Annual amount of nitrogen in synthetic fertilizers (mineral and urea) applied on soils [kg N] (see Table 203)

F_{ON} = Annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils [kg N]

F_{PRP} = Annual amount of urine and dung N produced by grazing animals and directly dropped on agricultural soils during grazing [kg N]

F_{CR} = amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually [kg N]

F_{SOM} = Annual amount of N mineralised in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management [kg N] → not occurring in Austria [NO]

$\text{Frac}_{\text{LEACH}}$ = Fraction of all N added to/mineralised in managed soils that is lost through leaching and run off (country specific value of 0.15154 following EDER et al. 2015)

EF_5 = Emission factor for N₂O from N leaching and runoff, kg, N₂O-N (0.0075 [kg/kg] following 2006 IPCC GL, Table 11.3)

5.4.3 Category-specific QA/QC

In the categories 3.D the following source specific QA/QC procedures have been carried out:

- ✓ NH₃-N, NO_x-N and N₂ losses calculated in compliance to the obligations under EU NEC Directive and UNECE/LRTAP Convention;
- ✓ Methods and emission factors reviewed by the EAGER⁹² network;
- ✓ Plausibility of CRF N-fractions checked;
- ✓ Differences to IPCC default values explained and documented;
- ✓ External review by Austrian agricultural experts (stakeholder meeting "inventory talks" 2010);

⁹² European Agricultural Gaseous Emissions Inventory Researchers Network (EAGER)

- ✓ Expanded QA and verification activities in 2012: in-depth review of the agriculture model.
- ✓ Expanded QA/QC of the software tool (calculation sheets) for new and revised sources (e.g. crop residues, energy crops performed in 2015)
- ✓ External review of the revised agriculture inventory according to the 2006 IPCC GL by Austrian agricultural experts: stakeholder meeting “inventory talks” 2014
- ✓ External review of the revised agricultural model (AMON & HÖRTENHUBER 2019) according to the new data on agricultural practice (PÖLLINGER et al. 2018) by Austrian agricultural experts: stakeholder meeting “inventory talks” 2018.
- ✓ External review of the updated and representative values for nitrogen and energy intake, excretion of nitrogen (N_{ex}) and volatile solids (VS_{ex}) based on the research project on country-specific animal feeding and nutrition (“MiNutE” study, HÖRTENHUBER et. al. 2022b; HÖRTENHUBER) by Austrian agricultural experts.
- ✓ Verification of the calculations for NH_3 emissions from animal husbandry with the *3.B Manure Management N flow tool* of the EEA.

Sector specific routine control procedures are provided in chapter 5.1.4.

5.4.4 Uncertainties

Uncertainties are presented in Table 159.

5.4.5 Recalculations

Update of activity data

Please refer to chapter 5.3.5.

3.D.a.2.a Animal Manure Applied to Soils

Updates and improvements as described in chapter 5.3.5 resulted in revised emissions from animal manure application for the years 2003–2021 (+0.01 kt N_2O for 2021).

3.D.a.2.c Other organic fertilisers

As a result of updated activity data on input materials for biogas plants, N_2O emissions have been revised for the years 2020 and 2021 (-0.003 kt N_2O for 2021).

3.D.a.3 Urine and dung deposited by Grazing Animals

Livestock related updates as already described in chapter 5.3.5, led to recalculated N_2O emissions for the years 2003–2021 (+0.002 kt N_2O for 2021).

3.D.a.5 Mineral Soils (N_2O)

Revisions of activity data (perennial cropland remaining perennial cropland, perennial cropland converted to annual cropland, annual cropland remaining annual cropland; for more information see chapter 6 on LULUCF) resulted in slightly revised N_2O emissions for the entire time series (-0.00001 kt N_2O for 2021).

Improvements of methodologies and emission factors

3.D Agricultural Soils (N₂O)

3.D.b Agricultural Soils (indirect soil emissions – N₂O)

Atmospheric deposition: the main reasons for revised emissions are the application of updated Tier 2 NH₃ EF for mineral fertilisers and the update of the NH₃ EF for grazed sheep and deer according to the EMEP/EEA GB 2023 in the ammonia inventory as well as the adjusted activity data (N_{excretion} values for cattle and biogas). As a result, the indirect N₂O emissions from atmospheric deposition have been revised upwards for the entire time series (+0.04 kt N₂O for 2021).

N leaching and run-off: reasons for the minor recalculations are the revised amounts of animal manure applied to soils (+0.001 kt N₂O for 2021).

The whole time series of recalculations is included in Annex 8 to the NIR.

5.5 Field burning of agricultural residues (Category 3.F)

Key source: no

5.5.1 Source Category Description

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.

In the years 2021 and 2022 no emissions occurred in this category ("not occurring"). CH₄ and N₂O emissions for the years from 1990 to 2022 are presented in Table 223.

Table 223: Emissions from field burning (3.F) 1990–2022.

Year	CH ₄ [kt]	N ₂ O [kt]
1990	0.03	0.001
1995	0.03	0.001
2000	0.03	0.001
2005	0.03	0.001
2010	0.02	0.001
2011	0.01	0.000
2012	0.01	0.000
2013	0.01	0.000
2014	0.01	0.000
2015	0.01	0.000
2016	0.01	0.000

Year	CH ₄ [kt]	N ₂ O [kt]
2017	0.00	0.000
2018	0.00	0.000
2019	0.00	0.000
2020	0.00	0.000
2021	NO	NO
2022	NO	NO
Trend 1990–2022	–100%	–100%
Share in Agriculture 2022	0%	0%

5.5.2 Methodological Issues

5.5.2.1 Cereals (3.F.1)

Following a recommendation of the Centralized Review 2003 the IPCC method with default emission factors was applied. In response to questions raised during the UNFCCC centralized review 2010, the estimate has been improved by providing a breakdown of the emissions on a crop by crop basis.

In submission 2016 the calculation has been updated according to the 2006 IPCC GL, equation 2.27. Default emission factors were applied, taken from (IPCC 2006, Table 2.5); default combustion factors from the 2006 IPCC GL, Table 2.6, were used. Dry matter fractions were taken from (STATISTIK AUSTRIA 2015). IPCC default residue/crop product ratios as used in source category *3.D.a.4 crop residues* (see also chapter on N from crop residues 0) were applied. Parameters are presented in the following table:

Table 224: Input parameters used to estimate emissions from field burning of cereals.

	Combustion factor [%]	Dry matter fraction [t/t]	Residue/Crop product (ExF) [t/t]
Wheat	0.90	0.86	1.27
Barley	0.90	0.86	1.09
Oats	0.90	0.86	1.16
Rye	0.90	0.86	1.30
Other cereals*	0.90	0.86	1.28

* mixed grain, triticales

According to the Austrian Chamber of Agriculture (AUSTRIAN CHAMBER OF AGRICULTURE 2022), no field burning occurred in Austria in 2021 and 2022 ("NO"). In the last years the areas burnt were decreasing steadily, in the year 2020 only 5 ha were burnt. 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 resulted in a value of 2 630 ha.

5.5.3 Category-specific QA/QC

Sector specific routine control procedures are provided in chapter 5.1.4.

5.5.4 Recalculations

No recalculations have been carried out.

5.6 Liming (Category 3.G)

Key Source: No

5.6.1 Source Category Description

The application of lime to agricultural soils is a source of CO₂ emissions. It is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. Adding carbonates to soils in the form of lime (e.g. calcic limestone (CaCO₃), or dolomite (CaMg(CO₃)₂) leads to CO₂ emissions as the carbonate limes dissolve and release bicarbonate (2HCO₃⁻), which evolves into CO₂ and water (H₂O) (IPCC 2006).

Table 225: CO₂ emissions from Liming (3.G) 1990–2022.

Year	Limestone [kt]	Dolomite [kt]
1990	36.79	8.87
1995	28.75	6.93
2000	33.69	8.91
2005	44.25	9.38
2010	57.27	11.34
2011	63.61	13.54
2012	65.68	15.16
2013	60.48	14.85
2014	61.02	14.12
2015	68.20	15.23
2016	68.22	15.57
2017	69.62	16.40
2018	78.03	18.48
2019	80.78	18.62
2020	80.56	18.38
2021	80.75	18.35
2022	80.84	18.36
Share in 3.G 2022	81.5%	18.5%
Trend 1990–2022	119.7%	107.0%
Trend 2021–2022	0.1%	0.1%

5.6.2 Methodological Issues

In response to a question raised during the ESD review 2019 regarding the reporting of 'NO' for emissions from dolomite application, Austria carried out an investigation on that issue. As a result, Austria improved its calculations and reports CO₂ emissions from the use of dolomite from submission 2020 onwards.

Activity data

Since submission 2020 new activity data on the amounts of both, limestone and dolomite, have become available. New data are based on specific information from Austria's biggest trading company and on sales data. In previous submissions application amounts of limestone were estimated on the basis of annual area data (ha) and assumptions on limestone application.

Table 226: Application of limestone and dolomite in Austria (arithmetic average of each two years)

Year	Liming [tons year ⁻¹]		
	Limestone	Dolomite	Total
1990	83 623	18 612	102 235
1995	65 330	14 540	79 871
2000	76 560	18 701	95 261
2005	100 557	19 673	120 230
2010	130 155	23 795	153 950
2011	144 578	28 398	172 975
2012	149 268	31 808	181 075
2013	137 463	31 163	168 625
2014	138 679	29 631	168 310
2015	155 005	31 945	186 950
2016	155 053	32 673	187 725
2017	158 235	34 415	192 650
2018	177 336	38 760	216 095
2019	183 581	39 065	222 645
2020	183 085	38 565	221 651
2021	183 532	38 504	222 036
2022	183 716	38 524	222 240

Total application amounts for Austria provided in Table 226 are derived from annual sales data of Austria's biggest trade company for carbonate liming materials (www.bodenkalk.at) and expert judgement on domestic production and market (Wolfgang Gfrerer, Bodenkalk company). Provided annual amounts of calcic limestone and dolomite are considered to be representative for Austria.

Not the whole amount purchased is applied in the year of purchase. Considering this effect, Austria uses the arithmetic average of each two years as activity data. This approach has been chosen in consistency with the approach used in the estimation of N₂O emissions from mineral fertiliser application (see chapter 5.4.2).

Methodology

The Tier 1 methodology following equation 11.12 (IPCC 2006) for calculating the CO₂ emissions has been applied.

$$\text{CO}_2\text{-C Emission} = (M_{\text{Limestone}} \cdot \text{EF}_{\text{Limestone}}) + (M_{\text{Dolomite}} \cdot \text{EF}_{\text{Dolomite}})$$

$\text{CO}_2\text{-C Emission}$ = annual C emissions from lime application, tonnes C yr⁻¹

M = annual amount of calcic limestone (CaCO_3) and dolomite ($\text{CaMg}(\text{CO}_3)_2$), tonnes yr⁻¹

EF = emission factor, tonne of C (tonne of limestone)⁻¹.

Emission Factors

The IPCC default emission factors for limestone (0.12) and dolomite (0.13) have been applied.

5.6.3 Category-specific QA/QC

Sector specific routine control procedures are provided in chapter 5.1.4.

5.6.4 Recalculations

No recalculations have been carried out.

5.6.5 Planned Improvements

No improvements are planned.

5.7 Urea Application (Category 3.H)

Key Source: No

5.7.1 Source category description

CO_2 is lost by adding urea to soils during fertilisation. Urea ($\text{CO}(\text{NH}_2)_2$) is converted into ammonium (NH_4^+), hydroxyl ion (OH^-), and bicarbonate (HCO_3^-), in the presence of water and urease enzymes. The formed bicarbonate evolves into CO_2 and water, similar to the soil reaction during addition of lime (IPCC 2006 GL).

Table 227: Emissions from Urea Application (3.H) 1990–2022.

Year	CO ₂ emissions [kt]
1990	9.60
1995	19.79
2000	19.36
2005	21.89
2010	28.85
2011	27.47

Year	CO ₂ emissions [kt]
2012	30.63
2013	30.28
2014	34.04
2015	34.90
2016	39.26
2017	38.30
2018	32.03
2019	26.77
2020	24.54
2021	23.12
2022	25.54
Trend 1990–2022	166.2%
Share in Agriculture 2022	17.1%

5.7.2 Methodological Issues

For the CO₂-C emissions from urea usage, the IPCC 2006 Tier 1 methodology is applied using equation 11.13. The amount of urea used is multiplied with an emission factor. The default emission factor of 0.20 for urea, which is equivalent to the carbon content of urea on an atomic weight basis (20% for CO(NH₂)₂), is applied.

$$\text{CO}_2\text{-C Emission} = M \cdot EF$$

CO₂-C Emission = annual C emissions from urea application, tonnes C yr⁻¹

M = annual amount of urea fertilisation, tonnes urea yr⁻¹

EF = emission factor, tonne of C (tonne of urea)⁻¹

Activity Data

The activity data taken for the amount of urea used in agriculture are the same as used for the calculation of N containing emissions (see Table 203). It comprises non-stabilized and stabilized urea quantities.

Table 228: Urea used in agriculture

Year	Weighted Urea Consumption [t N/yr]	Urea used in agriculture [t UREA/yr]
1990	6 107	13 085
1995	12 592	26 983
2000	12 320	26 400
2005	13 932	29 855
2010	18 357	39 335
2011	17 481	37 460
2012	19 489	41 763
2013	19 266	41 285
2014	21 662	46 418
2015	22 212	47 597
2016	24 983	53 535

Year	Weighted Urea Consumption [t N/yr]	Urea used in agriculture [t UREA/yr]
2017	24 375	52 232
2018	20 380	43 671
2019	17 035	36 503
2020	15 616	33 462
2021	14 712	31 526
2022	16 255	34 833

RWA: Raiffeisen Ware Austria, sales company

5.7.3 Category-specific QA/QC

Sector specific routine control procedures are provided in chapter 5.1.4.

5.7.4 Recalculations

No recalculations have been carried out.

5.7.5 Planned Improvements

No improvements are planned.

5.8 Other carbon-containing fertilizers (Category 3.I)

Key Source: No

5.8.1 Source category description

CAN (calcium ammonium nitrate) fertilizers include limestone or dolomite and therefore emit CO₂ when applied to soils.

Table 229: Emissions from Other carbon-containing fertilizers (3.I) 1990–2022.

Year	CO ₂ emissions [kt]
1990	30.66
1995	28.76
2000	27.37
2005	20.03
2010	14.89
2011	21.37
2012	22.20

Year	CO ₂ emissions [kt]
2013	21.60
2014	23.59
2015	27.15
2016	28.55
2017	26.38
2018	26.30
2019	24.61
2020	25.47
2021	27.06
2022	24.43
Trend 1990–2022	-20.3%
Share in Agriculture 2022	16.4%

5.8.2 Methodological Issues

Activity Data

CAN fertilizer data is fully consistent with AD amounts used in source category 3.D.1.1 Inorganic N fertilizers and corresponds to the fertiliser type specific AD used in the Tier 2 calculations within Austria's ammonia inventory under the LRTAP Convention and NEC Directive (UMWELTBUNDESAMT 2024b). In consistency with the calculations under source category 3.D.1.1 the arithmetic average of each two years was used as activity data.

Methodology

CAN traded in Austria contains 27% nitrogen. From this share the composition can be derived considering the molar weights of the two components (Ammoniumnitrate NH_4NO_3 and limestone or dolomite). This results in a share of 23 weight% of limestone (or dolomite, respectively).

Table 230: Amounts of calcium ammonium nitrate in Austria 1990–2022

Year	Calcium ammonium nitrate (CAN) [t N]	Calcium ammonium nitrate (CAN) [t]	Limestone (or dolomite) contained in CAN [t]
1990	79 024	292 680	66 898
1995	74 114	274 495	62 742
2000	70 547	261 286	59 723
2005	51 614	191 164	43 695
2010	38 384	142 162	32 494
2011	55 080	204 001	46 629
2012	57 214	211 904	48 435
2013	55 660	206 148	47 120
2014	60 808	225 213	51 477
2015	69 977	259 174	59 240
2016	73 583	272 528	62 292
2017	67 977	251 768	57 547
2018	67 774	251 015	57 375
2019	63 431	234 930	53 698

Year	Calcium ammonium nitrate (CAN)	Calcium ammonium nitrate (CAN)	Limestone (or dolomite) contained in CAN
	[t N]	[t]	[t]
2020	65 632	243 081	55 561
2021	69 745	258 317	59 044
2022	62 955	233 168	53 296

Finally, the Tier 1 methodology following equation 11.12 (IPCC 2006) for calculating the CO₂ emissions from lime application has been applied.

$$\text{CO}_2\text{-C Emission} = (M_{\text{Limestone}} \cdot EF_{\text{Limestone}}) + (M_{\text{Dolomite}} \cdot EF_{\text{Dolomite}})$$

CO₂-C Emission = annual C emissions from lime application, tonnes C yr⁻¹

M = annual amount of calcic limestone (CaCO₃) and dolomite (CaMg(CO₃)₂), tonnes yr⁻¹

EF = emission factor, tonne of C (tonne of limestone)⁻¹.

According to information of producers and importers both lime and dolomite containing CAN is applied in Austria. Therefore, the arithmetic average of limestone and dolomite has been applied. This approach was accepted by the TERT (EEA 2020).

In the submission 2022, Austria checked its import statistics in order to validate its assumptions on limestone and dolomite contents. The investigations confirmed the current approach using the arithmetic mean of limestone and dolomite.

5.8.3 Category-specific QA/QC

Sector specific routine control procedures are provided in chapter 5.1.4.

5.8.4 Recalculations

No recalculations have been carried out.

5.8.5 Planned Improvements

No improvements are planned.

6 LULUCF (CRF SECTOR 4)

6.1 Sector Overview

This chapter describes the GHG emissions and removals arising from land use, land-use change and forestry (LULUCF). Table 231 presents total sector emissions and removals, as well as the category contributions to the sectors CO₂ balance.

Table 231: Emissions and removals (+/-) from Sector 4 LULUCF by category and gas - kt CO₂, CH₄ and N₂O.

Year	Carbon dioxide emissions/removals [kt CO ₂]								[kt CH ₄]	[kt N ₂ O]
	4 Total	A Forest land	B Crop land	C Grass land	D Wet lands 1)	E Settle ments ¹⁾	F Other land ¹⁾	G Harvested Wood Products	Total CH ₄	Total N ₂ O (direct and indirect)
1990	-11 852	-11 077	184	697	48	917	502	-3 122	0.97	0.54
1995	-19 506	-18 864	140	480	34	861	413	-2 569	0.95	0.55
2000	-14 116	-13 927	-17	488	40	783	406	-1 889	0.96	0.50
2005	-18 259	-16 766	-118	740	52	941	353	-3 461	0.95	0.50
2010	-19 604	-19 094	-121	545	86	937	495	-2 452	0.96	0.52
2011	-15 199	-14 424	-125	541	90	912	494	-2 687	0.96	0.52
2012	-5 607	-5 458	-133	538	87	921	493	-2 055	0.96	0.52
2013	-6 074	-6 851	-117	538	118	885	492	-1 138	0.96	0.51
2014	-7 446	-7 982	-89	535	88	882	491	-1 372	0.96	0.50
2015	-6 395	-7 057	-25	529	75	843	494	-1 254	0.97	0.50
2016	-6 828	-7 647	30	503	94	833	497	-1 137	0.95	0.50
2017	-3 090	-3 346	82	482	73	838	500	-1 719	0.96	0.50
2018	5 063	5 054	108	465	73	828	503	-1 969	0.96	0.50
2019	2 279	1 750	138	460	73	812	507	-1 462	0.96	0.49
2020	-6 000	-7 895	188	454	73	792	510	-122	0.96	0.49
2021	-11 231	-11 406	279	445	70	758	514	-1 889	0.97	0.48
2022	-4 629	-4 612	317	444	70	746	517	-2 110	0.98	0.48
1990-2022	-61%	-58%	73%	-36%	47%	-19%	3%	-32%	1%	-11%

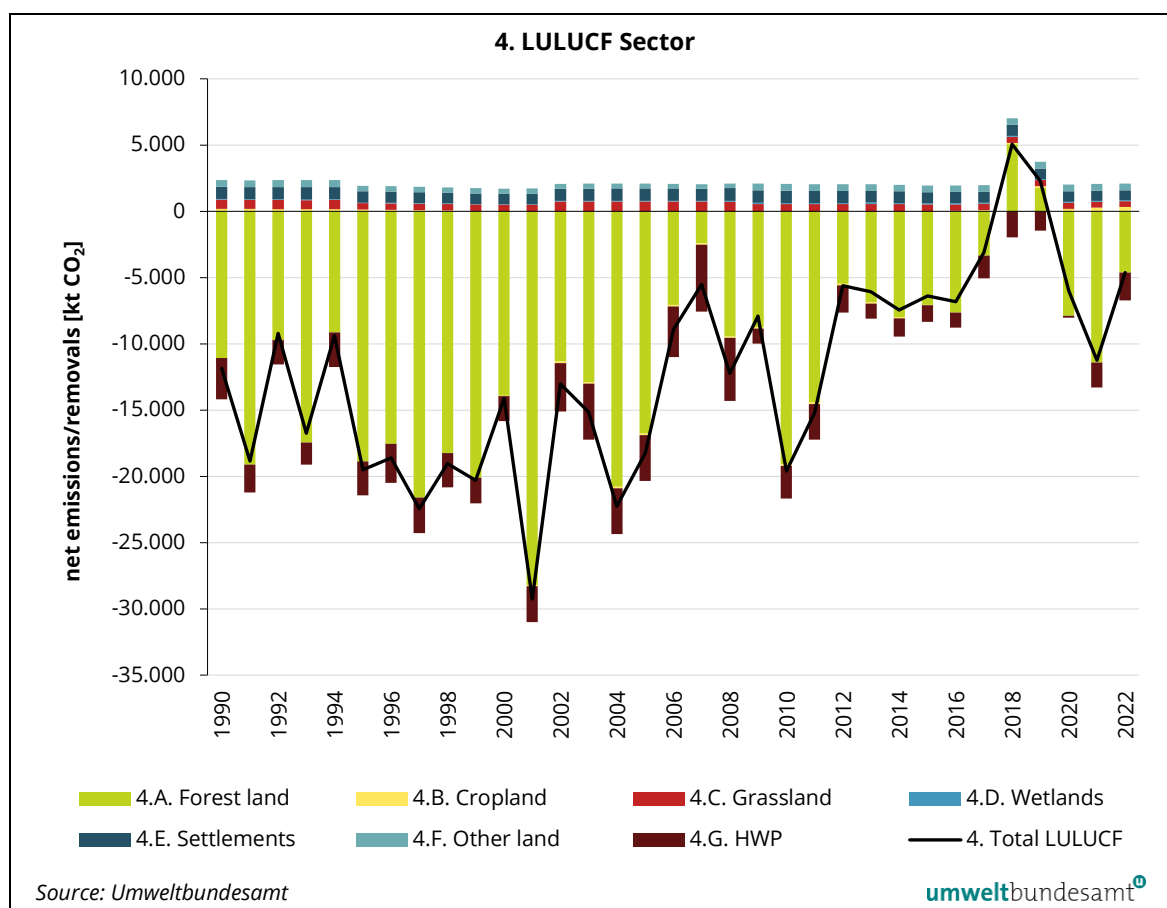
¹⁾ Only land use conversions are reported

Table 231 and Figure 30 show that land use, land-use change and forestry is generally a net sink in Austria. For the years after 2002 a significant increase in biomass drain from Forest land caused a decrease in the net sink of the biomass pool of the subcategory "Forest land remaining forest land (4.A.1) with subsequent impacts on the annual total GHG balance of the LULUCF sector.

The most important category is Forest land, in particular its subcategory Forest land remaining forest land which is generally a net sink for CO₂. Forest land essentially dictates the level and trend in LULUCF total emissions/removals. For example, the net LULUCF emissions in 2018 and 2019 were driven by the respective net emissions from this category. Harvested wood products represent the second most important category, contributing consistent, and at times substantial, removals of CO₂. Between 2000 and 2015, the cropland category constituted a net sink of CO₂ and total GHGs

(in CO₂ equivalent); however, since 2016 this category has been estimated as a small yet increasing net source of emissions. The other subcategories are consistent sources of GHG emissions.

Figure 30: Carbon dioxide emissions and removals (+/-) from Sector 4 LULUCF and its respective categories [kt CO₂]



6.1.1 Emission Trends

In 2022, net CO₂ removals from the sector LULUCF amounted to 4 629 kt CO₂, while CH₄ (0.98 kt CH₄) and N₂O (0.48 kt N₂O) emissions together amounted to 155 kt in CO₂ equivalent. Therefore, the net GHG balance of the sector in 2022 amounted to -4 474 kt in CO₂ equivalent, which corresponds to a net sink that offset 6.1 % of national total GHG emissions (without LULUCF) in 2022.

The most important category is Forest land (4.A) with net removals of 4 594 kt CO₂ equivalent in 2022 (including indirect emissions). Harvested Wood Products (HWP, 4.G) is the second largest sink category and contributed removals of 2 110 kt CO₂ equivalent. Total net emissions arising from the other categories amounted to 2 230 kt CO₂ equivalent in 2022 (including indirect emissions).

The net carbon stock changes in forest biomass (subcategory 4.A.1) demonstrate considerable interannual variation and thus have a major impact on the overall results in sector 4. Figures for annual growth and for annual harvest of forest biomass differ significantly year by year due to annual variations in influencing factors like weather conditions, timber demand and prices, as well as occurrence of windthrow and other disturbance events (e.g. low increment in 2003, 2013, 2015, 2018

and 2019; very high harvest rates in 2007 and 2008). The dynamics in forest biomass gains and losses explain high annual variations, as well as the overall declining sink strength of the Forest land category and the LULUCF sector. In addition to the aforementioned year-to-year variations, it should also be noted that annual increment has generally decreased over the time series, while harvest rates on the other hand have been increasing. Finally, changes in forest soil carbon stocks (particularly in subcategory 4.A.1) also vary substantially between years due to dynamics in weather (and harvest residues) that affect inputs to the soil C pool, as well as rates of soil decomposition. Indeed variations in the forest soil C pool have a substantial influence on the LULUCF sector as a whole. For example, low increments and relatively high harvest rates in 2018 and 2019 coincided with substantial net C losses from the forest soil pool, leading to substantial net CO₂ emissions from the Forest land category and the LULUCF sector.

6.1.2 Key Categories

The overall key category analysis is presented in Chapter 1.5.

6.1.3 Methodology

The methodologies for estimating emissions/removals from LULUCF are described in detail in the subchapters 6.1 to 6.8. However, due to the NFI as the source of data for LUC to and from forests, the methodology for calculating emissions/removals due to land use changes from Forest land (which are subcategories of 4.B – 4.F) are included in the methodological description of emissions/removals due to Land converted to forest land. The next two subchapters nonetheless give a sector overview on the methods used for estimating the LULUCF emissions/removals.

6.1.3.1 Activity data

Austria applies the default transition period of 20 years for areas undergoing land conversion. As such, annual land transition matrices, starting 20 years before the base year 1990, need to be compiled. For this 2024 submission, methods for land representation have been substantially improved. The NFI, an approach 3 method of repeated in situ sampling of Forest land areas (as well as land-use changes to- and from Forest land) at georeferenced plots distributed over a 4 x 4 km grid over the country, remains a fundamental and unchanged input into the national land use monitoring system. However, for the years since 2016, the monitoring of Cropland, Grassland, Wetlands and Settlements, as well land-use changes not involving Forest land, is now largely based on 5 x 5 m resolution land-use maps of Austria. These maps, so far produced for the years 2016, 2020 and 2022 are compiled in a geographic information system that integrates spatially-explicit, national data layers on land use and land cover from various sources (see further down). Statistical time series on land use, which for recent years (and partly for the whole time series) are based on many of the spatially-explicit national land-use layers, are used for extrapolating non-forest land use and land-use change back to 1970. According to Chapter 3 of Volume 4 of the 2006 IPCC Guidelines, the Austrian system for land representation thus constitutes a spatially-explicit approach 3 method for land representation that uses statistical time series on land use (derived themselves from maps and geospatial databases (approach 3), as well as surveys (approach 1)) to extrapolate and ensure consistency in the annual land transition matrices over the whole time series.

The design of the system for land representation and the hierarchical treatment of the various data sources and methods was developed to ensure:

- Consistency with respect to the Austrian area (use of subcategory “Other land”)
- Consistency in the category and subcategory areas within and across years

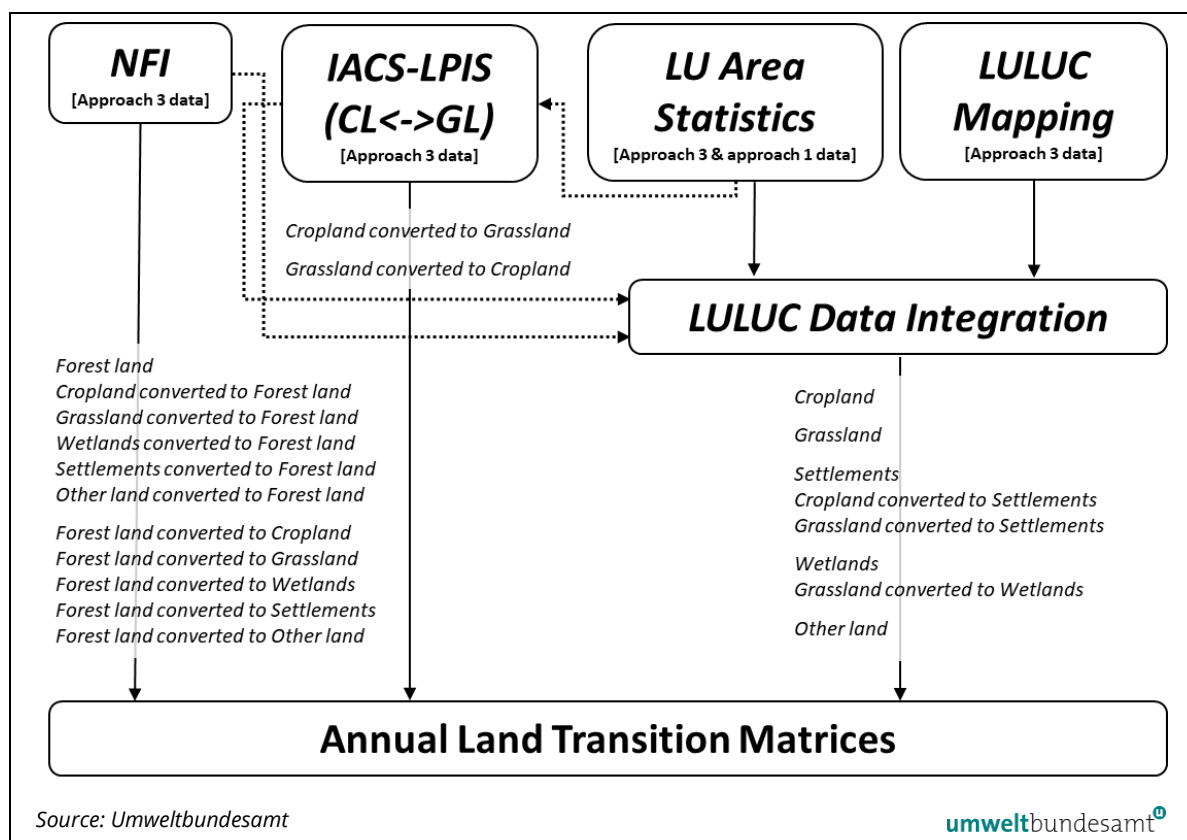
Furthermore, the new system for land representation continues to apply the following expert judgements and assumptions that certain land use changes are considered not occurring in Austria:

- Wetlands, Settlements or Other land converted to Cropland or Grassland – the total area of Cropland and Grassland is decreasing, whereas the areas of Settlement and Wetland increase over the time period (see Table 232). Furthermore, from an economical and practical point of view any re-conversion of Settlements and Wetlands to Cropland or Grassland are considered as very unlikely. Other land is not suited for Cropland and Grassland use.
- Cropland or Settlements converted to Wetlands – it is assumed that LUC to water bodies occur close to existing water bodies, which are mainly from Grassland
- Wetlands converted to Settlements

Analysis of the 2016, 2020 and 2022 high-resolution land use maps do not provide compelling evidence to contradict these assumptions. However, the validity of these expert judgements will be continuously evaluated as updated, spatially-explicit national datasets become available for subsequent years.

The following paragraphs describe in brief the main elements of the national system for quantifying annual land use and land-use change areas in Austria and the sources of spatial and statistical data that feed into them. Furthermore, Figure 31 illustrates graphically how the elements are linked.

Figure 31: Austrian system for land representation



- NFI: National Forest Inventory for Forest land and conversions to- and from Forest land.** The area of Forest land, as well as the land-use change areas from- and to Forest land, are based on data from the National Forest Inventory (NFI). The Austrian NFI uses a geographically fixed grid system to classify land-use and land-use change at specific, permanent plot locations over time. For each mean year of an NFI cycle, data on the total forest area are provided, with annual area data between two consecutive NFI cycles calculated by linear interpolation. The land-use changes from and to forests are based on area measurements of such activities at the NFI grid points. The sum of observed areas of each afforestation and deforestation category are divided by the years between respective inventory cycles to derive annual estimates of land-use changes to and from Forest land. For gap-filling of annual areas since 2019 (mid-point of the last NFI cycle), the rates of afforestation and deforestation derived from the last two NFI cycles (2007/09 and 2016/21) are assumed to have remained constant. Based on these assumed conversion values, the total Forest land area from 2019 is extrapolated to the end of the time series. The Forest land category subchapter provides further details on the NFI and the processing of the area data on total Forest land and forest conversions (see 6.2.2). The derived annual time series of total Forest land and all categories of land conversion to- and from Forest land are included directly and unchanged in the annual land transition matrices; however, the data also feed into the *LULUC Data Integration* element to ensure area consistency in the land transition matrix between categories and years.
- IACS-LPIS (CL<->GL): IACS-LPIS analysis for land conversions between Cropland and Grassland.** The geographically specific Integrated Administrative Control System/Land Parcel Information System is used for this analysis (IACS-LPIS, see also 6.3.2). Short-term and

oscillating conversions between the Cropland and Grassland categories can occur in agricultural management; however, such conversions can have important implications for LULUCF estimates. Therefore, for these conversions a specific method and analysis of spatially-explicit data on Cropland and Grassland land parcels from IACS-LPIS is applied to filter such short-term ($\leq$ five years) oscillating conversions. The IPCC inventory approach to LULUCF calculates the carbon stock changes caused by land-use change over a conversion period, for which the default length is 20 years. Consequently, areas undergoing an annual land-use change are assigned to the respective land conversion category for the conversion period, so that they can be multiplied by the correct, national/regional carbon stock change factors and/or emission factors. However, short-term oscillating changes between land use categories on the same land parcels would lead to such land areas being included in two land conversion categories multiple times over the conversion period. The IPCC Guidelines recommend to keep such short-term oscillating land areas in the main category. A method was thus developed and refined over previous submissions to filter short-term conversions between Cropland and Grassland areas based on land parcel data from Integrated Administration and Control System (IACS), that is responsible for administering agricultural subsidies. Based on a sample of land parcels for the years 2002-2015, as well as high-resolution sampling of the annual IACS GIS layers available since 2016, the method removes oscillating land conversions at the land parcel level. Subsequently, long-term Cropland conversions to Grassland and Grassland conversions to Cropland are derived from the corrected sample and expressed as percentages of total Cropland area. These percentages are then multiplied by the annual areas of Cropland (from the *LU Area Statistics* element) to derive national level estimates of Cropland conversions to Grassland and Grassland conversions to Cropland. The Cropland category subchapter provides further details on this specific element (see 6.3.2). The derived annual time series of Cropland conversions to Grassland and Grassland conversions to Cropland are included directly and unchanged into the annual land transition matrices; however, the data also feed into the *LULUC Data Integration* element to ensure area consistency in the land transition matrix between categories and years.

- **LU Area Statistics: Pre-processing of land use area statistics derived from maps, geo-spatial databases and surveys.** In this element area statistics (derived from national maps, spatial databases and surveys) on total Cropland, Grassland, Wetland, Settlement and Other land are pre-processed before feeding into other elements of the system (*IACS-LPIS (CL<->GI)*; *LULUC Data Integration*).
- Data for the total cropland area are available from Statistik Austria based on FSS (Farm Structure Surveys) (ÖSTAT, 1991, 1994, 1998, STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013, 2014, 2018, 2022a) and IACS (Integrated Administration and Control System) data (STATISTIK AUSTRIA 1990–2022). The Cropland category subchapter provides details on how statistics from these two data sources are processed to derive complete time series of yearly total Cropland area (as well as total annual and perennial cropland areas) starting from 1970 (see 6.3.2).
- Based on the Austrian farm structure surveys, Statistik Austria also provides data for the total Grassland area. For the years between these surveys, Grassland area data were derived by linear interpolation. However, as part of continuous inventory QA/QC, a consistency issue in these Grassland statistics has been identified, whereby grasslands that are not owned by farmers, but nonetheless retain their status as managed grasslands, are not included in these total area statistics. The Grassland category subchapter provides

further details (see 6.4.2). Consequently, these statistics are no longer the basis for estimating Grassland areas. They do however feed into the *LULUC Data Integration* element for the purpose of comparison and continued analysis.

- The Real Estate Database, compiled using spatial data from in situ mapping by regional authorities, provides statistics on the land use subcategories belonging to Wetlands. Due to data discontinuities, data were interpolated between 1971–1981, 1981–1995 and 1995–2005. Since 2005 annual data are reported. Changes in the derived total Wetland area over time are due to changes in the area of water bodies. Bogs/fens are protected areas in most Austrian provinces and are thus considered as areas which have not been subject to change since 1990. Further details on these area statistics are provided in the Wetland category subchapter (see 6.5.2). The derived time series feeds into the *LULUC Data Integration* element for the purpose of extrapolating the Wetland areas derived from the *LULUC Mapping* element back to 1970.
- The Real Estate Database, compiled using spatial data from in situ mapping by regional authorities, also provides statistics on land use subcategories belonging to Settlements. Further details on these area statistics are provided in the Settlement category subchapter (see 6.6.2). As for Wetlands, the derived time series feeds into the *LULUC Data Integration* element for the purpose of extrapolating the Settlement areas derived from the *LULUC Mapping* element back to 1970.
- Finally, the Real Estate Database, compiled using spatial data from in situ mapping by regional authorities, also provides statistics on land use subcategories belonging to Other land. Further details on these area statistics are provided in the Other land category subchapter (see 6.7.2). In accordance with the 2006 IPCC GL, Other land is understood to be the difference between the sum of areas of all LU categories except “Other Land” and the official total area of Austria. This calculation helps to avoid double counting or area omissions. Nonetheless, the statistics on Other land feed into the *LULUC Data Integration* element for the purpose of comparison and continued analysis.
- ***LULUC Mapping: Spatially-explicit mapping of land use and land-use change for the years 2016 onwards.*** This represents a new element that was developed in preparation for this 2024 submission. For the years 2016, 2020 and 2022, 5 x 5 m resolution land-use maps for Austria were produced using a range of national spatial datasets, in particular:
 - The national Forest Layer (*BFW Waldkarte*) that was produced by the same federal agency responsible for the NFI (Bundesforschungszentrum für Wald, BFW) based on interpretation of orthophotos from the years 2013 to 2018 (BFW, 2023).
 - The 2016, 2020 and 2022 vector layers of IACS-LPIS that map the areas of Cropland and Grassland which are subsidised (AMA, 2016; AMA, 2020; AMA 2022).
 - The 2022 LISA light layer (BEV, 2023b), a dataset of land cover based on orthophoto interpretation that is produced and made available by BEV. This layer provides for a better estimate of Other land subcategories.
 - The 2016, 2020 and 2022 vector layers of the Digital Cadastral Map (Digitale Katastralmappe; DKM) that is produced and made available by the Austrian Federal Office of Metrology and Surveying (Bundesamt für Eich- und Vermessungswesen, BEV). This dataset maps land use categories belonging to Wetlands, Settlements, and Other land, as well as classes that belong to Forest land, Cropland and Grassland (BEV, 2023c).
 - The 2022 Water Body Layer (*Digitales Landschaftsmodell – Gewässer*), a dataset mapping water bodies that is produced and made available by BEV (BEV, 2023d).

- A pre-final version of the updated Austrian Bog Catalogue (*Österreichischer Moorschutzkatalogue*) that maps Austrian bogs, fens and peatlands and is compiled by the Environment Agency Austria (Umweltbundesamt, 2023e).

The above main layers, as well as other data layers (e.g. a custom-made agriculture layer to capture Croplands and Grasslands outside of the IACS-LPIS database), are incorporated into a geographic information system, with respective land-use and land cover classifications translated to the national LULUCF land use definitions. Overlap between layers in the same year are addressed by a hierarchical ranking of the different sources. For the years 2016, 2020 and 2022, respective 5 x 5 m resolution land use maps are produced based predominantly on the datasets that span all three years (e.g. DKM, IACS-LPIS). Furthermore, a best-estimate 2022 status map (also 5 x 5 m) is produced that incorporates in addition to DKM, IACS-LPIS, etc. the datasets that are only available and representative of 2022 and better map the Wetland subcategories (e.g. Water Body Layer, Austrian Bog Catalogue). All four maps are merged at the pixel-level and combined to generate a tabular output providing the respective total areas of all possible pixel combinations of land use between the four maps. This tabular output flows into the *LULUC Data Integration* element, together with the outputs from the other aforementioned elements.
- LULUC Data Integration*: Integration module to calculate non-forest land use and non-forest land-use change areas and to ensure consistency in final annual land transition matrices. As described above, the time series outputs of the *NFI* and *IACS-LPIS (CL<->GL)* elements feed directly and unchanged into the annual land transition matrices. However, they also flow into this integration element, together with the *LU Area Statistics* and *LULUC Mapping* outputs, to compile the time series of the remaining land use and land-use change areas. This is done in the following steps:

 - The 2022 total areas for Grassland, Wetlands and Settlements are first determined from the best-estimate 2022 status layer of the LULUC Mapping element. Furthermore, the areas of all land-use change combinations between the other 2016, 2020 and 2022 layers is quantified to produce annual time series of all land-use change categories for the years 2017-2022. These land-use changes, which represent **interim** estimates, are used to extrapolate the 2022 total areas of Wetlands and Settlements back to 2016.
 - The annual total Wetland and Settlement areas are further extrapolated back to 1970 using the respective statistical time series derived from the maps of the Real Estate Database. This is done by separately normalising the entire Wetland and Settlement area time series by the respective 2016 values to create time series of proportional area changes (relative to 2016 total areas). Multiplying these 1970-2015 time series of relative changes by the 2016 total areas derived from the spatial datasets allows for the final time series of annual total Wetland and Settlement area for 1970 onwards to be compiled.
 - After compiling the final time series of total Wetland and Settlement area for 1970 onwards, the changes in area over time have to be balanced by respective land-use changes to and from these categories. In an initial step, the changes to and from Forest land (output of the *NFI* element) are accounted for, resulting in a residual net change that needs to be balanced between conversions to and from the other categories. This is done for Wetlands and Settlements as follows:
 - For Wetlands, the remaining net change (a net increase over time) is assumed to be explained completely by Grassland conversions to Wetlands, allowing for the annual areas of this conversion category to be quantified as such. The above assumption was verified

by the net conversion of Grassland to Wetland derived from analysis of the 2016, 2020 and 2022 GIS layers.

- For Settlements, the remaining net change (a net increase over time) is assumed to be explained completely by conversions of agricultural land (Cropland and Grassland) to Settlements. The above assumption was verified by the net conversion of Cropland plus Grassland to Settlements derived from analysis of the 2016, 2020 and 2022 GIS layers. The relative split between conversions from Cropland and conversions from Grassland are then calculated based on the net change in the total Cropland area over time and potential area available for conversion to Settlements. The annual Cropland area derived from the *LU Area Statistics* element is taken to derive the net annual change in Cropland area over time. After taking into account conversions to and from Forest land (*NFI* element) and conversions to and from Grassland (*IACS-LPIS (CL<->GL)* element), a residual net change in Cropland remains (a net decrease) that is quantified as Cropland conversion to Settlements. Where the residual net change in Cropland area provides a larger annual area than that required to explain the residual net increase in Settlement area, small individual adjustments of the Cropland area time series were made (corrections of <|0.03 %| Cropland area for years 2014, 2017 and 2019). Finally, after quantifying and accounting for Cropland conversions to Settlement, the remaining residual net change in Settlement area is quantified as Grassland conversion to Settlement.
- The final steps in the *LULUC Data Integration* element are to determine the total annual areas of Grassland and Other land. For Grassland, the basis for the calculation is the total Grassland area derived from the best-estimate 2022 status layer from the *LULUC Mapping* element. With all annual Grassland conversions estimated from 1970 onwards (to and from Forest land, *NFI*; to and from Cropland, *IACS-LPIS (CL<->GL)*; conversions to Wetlands and to Settlements, *LULUC Data Integration*), the 2022 total Grassland area is extrapolated for all years back to 1970. Finally, now that the annual areas of Forest land, Cropland, Grassland, Wetlands and Settlements are calculated, Other land is quantified as the difference between the total area of the Austrian territory and the total estimated area of the five land use categories above. Note that if the above five land use category areas were summed together with the Other land areas according to the Real Estate Database, the resulting sum of annual areas of all land use categories would be 0.8% lower- to 0.1% higher than the total territorial area of Austria. From these small differences, it is assumed that the Austrian system for land representation gives an accurate picture of how the total Austrian area is distributed between the land use categories over time.

Table 232 presents land use data and data for land use changes for the years 1990 and 2022 for the total area of Austria as used for the calculations.

Table 232: Land use and LUC data for Austria for the years 1990 and 2022.

Area in ha	1990	2022	Diff 1990–2022
4.A Forest land – total area	3 892 518	4 021 843	129 325
1 Forest land remaining forest land – total area	3 632 699	3 892 687	259 988
1.1.a Forest land remaining forest land (forest in yield): coniferous	2 431 959	2 445 653	13 693
1.1.b Forest land remaining forest land (forest in yield): deciduous	737 406	1 005 734	268 329
1.1.c Forest land remaining forest land: forest not in yield	463 333	441 300	-22 034

Area in ha	1990	2022	Diff 1990–2022
2. Land converted to forest land	259 819	129 156	-130 663
2.1 Cropland converted to forest land	30 962	11 824	-19 138
2.2 Grassland converted to forest land	144 197	58 270	-85 927
2.3 Wetland converted to forest land	12 534	8 622	-3 912
2.4 Settlement converted to forest land	17 122	8 737	-8 385
2.5 Other Land converted to forest land	55 004	41 703	-13301
4.B Cropland – total area	1 500 824	1 391 342	-109 482
1. Cropland remaining cropland	1 465 600	1 329 685	-135 916
1.a Annual remaining annual	1 362 924	1 251 806	-111 118
1.b Perennial remaining perennial	82 705	56 575	-26 129
1.c Perennial converted to annual	7 529	10 323	2 795
1.d Annual converted to perennial	12 443	10 980	-1 463
2. Land converted to cropland	35 224	61 657	26 433
2.1 Forest Land converted to cropland	4 125	2,657	-1468
2.2 Grassland converted to cropland	31 099	59,000	27902
2.2.a Grassland converted to annual cropland	30 563	57 633	27070
2.2.b Grassland converted to perennial cropland	535	1 367	832
2.3 Wetland Land converted to cropland	NO	NO	NO
2.4 Settlement converted to cropland	NO	NO	NO
2.5 Other Land converted to cropland	NO	NO	NO
4.C Grassland – total area	1 812 380	1 611 421	-200 959
1. Grassland remaining grassland	1 755 264	1 510 530	-244 735
2. Land converted to grassland	57 116	100 892	43 776
2.1 Forest land converted to grassland	32 467	34 825	2 358
2.2 Cropland converted to grassland	24 648	66 067	41 418
2.2.a annual cropland converted to grassland	24 399	64 832	40 433
2.2.b perennial cropland converted to grassland	250	1 235	985
2.3 Wetland land converted to grassland	NO	NO	NO
2.4 Settlement converted to grassland	NO	NO	NO
2.5 Other land converted to grassland	NO	NO	NO
4.D Wetlands – total area	133 981	154 617	20 636
1. Wetlands remaining wetlands	124 464	132 691	8 227
2. Land converted to wetlands	9 517	21 926	12 409
2.1 Forest land converted to wetlands	1 706	3 834	2 128
2.2 Cropland converted to wetlands	NO	NO	NO
2.3 Grassland converted to wetlands	7 811	18 092	10 281
2.4 Settlement converted to wetlands	NO	NO	NO
2.5 Other land converted to wetlands	NO	NO	NO

Area in ha	1990	2022	Diff 1990–2022
4. E Settlements – total area	359 158	556 376	197 219
1. Settlements remaining settlements	216 868	427 571	210 703
2. Land converted to settlements	142 289	128 805	-13 484
2.1 Forest land converted to settlements	9 792	11 313	1 521
2.2 Cropland converted to settlements	49 307	62 296	12 990
2.3 Grassland converted to settlements	83 191	55 196	-27 995
2.4 Wetlands converted to settlements	NO	NO	NO
2.5 Other land converted to settlements	NO	NO	NO
4. F Other land – total area	688 140	651 400	-36 739
1. Other land remaining other land	670 005	632 353	-37 652
2. Land converted to other land	18 134	19 047	913
2.1 Forest land converted to other land	18 134	19 047	913
2.2 Cropland converted to other land	NO	NO	NO
2.3 Grassland converted to other land	NO	NO	NO
2.4 Wetlands converted to other land	NO	NO	NO
2.5 Settlement converted to other land	NO	NO	NO
Total area	8 387 000	8 387 000	

6.1.3.2 Definition of C-pools

As recommended by the ERT during the ICR 2013 a detailed description of the C-pools as used in the GHG-reporting of Austria is given in the table below.

Table 233: Definitions of C-pools.

Pools		Description
Living biomass	Above ground biomass	Forest land: All living biomass (DBH > 5cm) above the soil including stem, stump, branches, seeds, bark and foliage (foliage only of evergreen trees). At ARD sites and LUC from and to forests all forest biomass (shrubs, forest under-story) with a DBH > 0 cm to 5 cm is also taken under consideration. Other subcategories: All living biomass is taken under consideration
	Below ground biomass	All living biomass of live roots with a diameter > 2 mm.
Dead organic matter	Dead wood	All non-living woody biomass not contained in the litter or soil, standing on the ground, without dead roots, as they are already considered as part of the litter or soil.
	Litter	All non-living biomass lying dead in various states of decomposition above the mineral or organic soil.

Pools	Description
Soils Soil organic matter	All organic matter in mineral and organic soils (including peat) to a soil depth of 50 cm (forests, LUC from and to forests) or to a soil depth of 30 cm (all other land uses and LUC). For that purpose, soil carbon stocks of consistent soil depth are used for the estimates of the respective LUC category (e.g. a cropland soil carbon stock for soil depth of 50 cm for LUC from and to forests and a cropland soil carbon stock for soil depth of 30 cm for all other LUCs). As part of the planned improvements, the inventory team is currently working on implementing the use of soil carbon stocks for 50 cm soil depth for the estimates of stock changes across all land-use change categories.

6.1.3.3 Emission factors

The calculations of the emissions follow the methods described in the 2006 IPCC GL, with an almost complete use of higher tier methods and carbon stock change-/emission factors derived from national data. Austria is consistently closing gaps in national input data for relevant subcategories with surveys and studies. The most important national statistics and data sources for the used emission factors are the Austrian national forest inventory, agricultural statistics, studies on cropland and grassland biomass, as well as studies on the cropland soil organic carbon content and the results of the country-wide soil surveys. Furthermore, specific national studies are available to come up with carbon stock change-/emission factors for the categories “settlements” and “other land”.

6.1.4 Quality Assurance and Quality Control (QA/QC)

The calculations of the data for category 4 are embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 1.2.3).

Important elements of QA/QC:

- ✓ 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 ...)
- ✓ Correct transformation/transcription into CRF
- ✓ Where possible data is checked with data from other sources
- ✓ order of magnitude checks ...
- ✓ Are all references clearly made?
- ✓ Are all assumptions documented?

Specific elements of QA/QC for LULUCF:

The input data estimates and results are checked as follows. The results of these checks are described in the QA/QC documentation:

1) Bottom-up check

1.1) Input data

1.1.1) Check for the plausibility of the activity data and their trend

Step 1: Documentation of the most important reasons for changes and non-changes of activity data

Step 2: Check and documentation if these changes or non-changes of activity data fit to trends of underlying conditions

Step 3: If step 1 and 2 do not allow any explanation further check of the used data sources and their estimates (see 1.2) and/or communication with the data providers

1.1.2) Check for plausibility of the emission factors as well as the related input data and their trends

Step 1: Documentation of the most important reasons for changes and non-changes of emission factors

Step 2: Check and documentation if these changes or non-changes of emission factors fit to trends of underlying conditions

Step 3: If step 1 and 2 do not allow any explanation further check of the used data sources and their estimates (see 1.2) and/or communication with the data providers

1.1.3) Check of input data for completeness

1.2) Estimations

1.2.1) Check of the correctness of all equations in the estimate files

1.2.2) Check of the correctness of all interim results

1.3) Check of the plausibility of the results and their trends related to point 1.1 and documentation of the plausibility of changes and non-changes on basis of point 1.1

1.4) Check of the correctness of all data and results transfer

2) Top-down check

2.1) Check the consistency between sum of land use areas and the total official area for Austria.

2.2) Comparison of the used activity data with those from other statistics. Documentation of the results of these comparisons and documentation of the reasons for the choice of statistics when data deviate more than 5% compared to other statistics

2.3) Comparison of the used emission factors and underlying input data with those of other data sources (e.g. from literature results in NIRs of other comparable regions and IPCC default values). Documentation of the results of these comparisons. Further check according to points 1.1 and 1.2 as well as check on the suitability of the used input data in case of implausible differences. Documentation of this further check.

6.1.5 Uncertainty Assessment

The uncertainty in the LULUCF GHG balance is estimated by using the @Risk-Software, which runs Monte-Carlo-simulations of spreadsheet GHG emission calculations. For that purpose, the uncertainties of all activity data, emission factors and input parameters for emission factors were defined. For each subcategory a bottom-up analysis of the uncertainties of the estimated emission/removal figures for the subcategory was carried out. All pools and gases were included in this analysis. Correlations between the parameters were taken into consideration during the simulations. To calculate uncertainties the emission calculation procedures were repeated with 10 000 to 100 000 iteration steps, with uncertainty expressed as the 95% confidence interval (standard deviation of the multiple simulation outputs multiplied by 2), which is in line with IPCC 2006 GL. This procedure was applied to each LULUCF subcategory and for the total LULUCF sector emissions/removals.

The average uncertainty of the total LULUCF sector emissions/removals across the years is $\pm 5\,148\text{ kt CO}_2$. This represents on average $\pm 48\%$ of the total LULUCF emissions/removals.

The biomass and soil carbon stock changes of 4.A.1 have in most years the highest impact on the total emissions/removals of the LULUCF sector. As a consequence, the uncertainty of these emissions/removals (around 40% for the forest biomass pool and 57 % for the forest soil pool) also have a significant impact on the uncertainty of the total emissions/removals of the LULUCF sector.

All other subcategories contribute to a clearly smaller extent to the results and, hence, uncertainty of the LULUCF totals, despite their partly very high relative uncertainties (in %) in their respective total emissions/removals.

Regarding the high uncertainty of the LULUCF sector it is important to understand that the LULUCF sector is the only one where the total emissions/removals of the sector are the result of both additions and subtractions (biomass gains minus biomass losses and net emissions minus net removals from the subcategories and their respective pools). This is – following the rules of error propagation – one of the main reasons why the relative uncertainties of LULUCF are higher than in other sectors. Furthermore, the relative uncertainty depends significantly on the level of the net emission/removal – the closer the net result is to zero the higher is the relative uncertainty. So, even the use of country specific and sophisticated methods may result in typically high relative LULUCF uncertainty figures. Another issue is the use of higher tiers in LULUCF which does not necessarily reduce the uncertainty of the figures. For instance, a Tier 1 approach assumes the soil C stock does not change, and thus associated uncertainties in estimating soil C stock changes are also not considered. So, despite the large potential errors of not including this important C stock, the calculated uncertainties would be lower.

6.1.6 Recalculations

The GHG balance of the LULUCF sector has been revised since the last submission in 2023. Due to methodological improvements affecting all categories apart from *Other land* and *Harvested Wood Products*, the 1990-2021 time series of annual total GHG emissions/removals from LULUCF vary from the previous submission by -674 to +526 kt CO₂e per year. Methodological changes and impacts on emissions/removals at the category level are detailed below.

The whole time series of recalculations is included in Annex 8 to the NIR.

4.A Forest land

The soil carbon stocks of land-use changes from/to settlement were updated on basis of an updated sealing ratio, which caused minor changes for the land-use change subcategory *Settlement to Forest land* for the whole time series in the range of -4.0 and 3.5 kt CO₂e per year compared to the last submission in 2023. The *Forest land* results for the years 2020 to 2022 are extrapolated using the results of the last NFI 2016/21 and relative harvest indices based on the harvest statistics for these years. By introduction of a new reported year, the derived relative harvest indices for the years since 2020 and the biomass losses due to harvest have changed accordingly. Therefore, the *Forest land* results for the years 2020 and 2021 of this submission differ from those of the 2023 submission by -941 kt CO₂e (2020) and -1 031 kt CO₂e (2021).

4.B Cropland

The approach for calculating long-term land-use changes and conversions between Cropland and Grassland applies a stability threshold to determine if an annual conversion is long- or short-term. Additional years in the time series therefore lead to a revised and improved identification of short-term and long-term conversions in recent years, which propagate over the entire time series. These area improvements caused upward revisions of the annual net emissions for the whole time series of the *Cropland* category that range from 14 to 25 kt CO₂e per year compared to the last submission in 2023.

4.C Grassland

The previous approach for estimating mineral soil carbon stock changes in Grassland remaining grassland was revoked, due to conflicting soil carbon observations from national, long-term observations of grassland sites that were synthesised as part of a comprehensive national study. As of this 2024 submission, an interim assumption that mineral soil carbon stocks in this subcategory are in equilibrium (Tier 1 – no change in management) is applied. In addition, wildfires at Grassland (and Cropland included in the Grassland figures) were estimated for the first time for submission 2024. Finally, the approach for calculating long-term land-use changes and conversions between Cropland and Grassland applies a stability threshold to determine if an annual conversion is long- or short-term. Additional years in the time series therefore lead to a revised and improved identification of short-term and long-term conversions in recent years, which propagate over the entire time series. These improvements caused upward revisions of the annual net emissions for the whole time series of the *Grassland* category. The annual emissions are in the range of 11 to 13 kt CO₂e per year higher compared to the last submission in 2023.

4.D Wetlands

Activity data for the biomass burning subcategory has been revised due to the availability of a new data source. Also respective CO₂ emissions are, from this submission onwards, reported as NA because loss of biomass due to burning is assumed to be in equilibrium with gains in reed growth, which are also reported with a notation key (NE), as the IPCC 2006 Guidelines do not provide methodologies for estimating biomass carbon stock changes in Wetlands remaining wetlands that are not managed for peat extraction.

Finally, the improvements in Austrian system for land representation have led to revised areas of Grassland converted to wetlands. Due to the above improvements, the annual emissions of the *Wetlands* category are in the range of -10.4 to 0.51 kt CO₂e per year different compared to the last submission in 2023.

4.E Settlements

The land use and land-use change assessment for the *Settlements* category was revised as part of the improvements made to the Austrian system for land representation. The spatially explicit data of the previously used Real Estate Databases are now incorporated with additional, national sources of spatially explicit data, to derive improved and consistent estimates of settlement areas and conversions to settlement over the whole time series. Furthermore, the results of a new comprehensive study on biomass stocks and growth rates of settlement trees and shrubs were included in the inventory for this 2024 submission. Cadastral data on urban trees of several Austrian cities together with a new nationwide assessment of the (crown) cover of trees, shrubs, low vegetation and sealing in settlement using new GIS data were used to improve estimates of the biomass and soil carbon stock changes in *Settlements*. These improvements led to upward revisions of the annual net emissions for the whole time series of the *Settlement* category that were between 275 and 498 kt CO₂e per year higher than the last submission in 2023.

4.F Other land

There was no revision of the Other land GHG emissions and removals since the 2023 submission. Substantial improvements in the Austrian system for land representation have led to revisions in the total Other land area; however, these improvements have not affected conversions from Forest land to Other land – the only subcategory causing carbon stock changes and GHG emissions in Other land.

4.G HWPs

There were no recalculations despite the update with the most recent JFSQ statistics.

6.1.7 Completeness

Table 234 gives an overview of the new IPCC categories included in this chapter and the corresponding sub-divisions for which the calculations are made. It also provides information on the status of emission estimates of all subcategories. A “✓” indicates that emissions/removals from this subcategory have been estimated; for LULUCF CO₂ emissions/removals are estimated.

Table 234: IPCC categories according to the IPCC 2006 Guidelines.

IPCC categories ⁹³ / Sub division for calculation	Description	Status for CO ₂	Other GHG
4 A	Forest land	✓	
4.A.1	Forest land remaining forest land	✓	
<i>Coniferous</i>	<i>Increase, decrease, net change in biomass carbon stock</i>	✓	
<i>Deciduous</i>	<i>Increase, decrease, net change in biomass carbon stock</i>	✓	
<i>Forest not in yield</i>	<i>Net change in biomass carbon stock</i>	✓	
	<i>Net carbon stock change in dead organic matter</i>	✓	
	<i>Net carbon stock change in soils</i>	✓ ¹⁾	
4.A.2	Land converted to forest land	✓	
4.A.2.1	Cropland converted to forest land	✓	
	<i>Carbon stock change in biomass</i>	✓	

⁹³ IPCC categories – applied according to the 2006 IPCC 2006 Guidelines for National Greenhouse Gas Inventories

IPCC categories ⁹³ / Sub division for calculation	Description	Status for CO ₂	Other GHG
	<i>Net carbon stock change in dead organic matter</i>	✓	
	<i>Carbon stock change in soils</i>	✓	
4.A.2.2	Grassland converted to forest land	✓	
	<i>Carbon stock change in biomass</i>	✓	
	<i>Net carbon stock change in dead organic matter</i>	✓	
	<i>Carbon stock change in soils</i>	✓	✓ N ₂ O
4.A.2.3	Wetlands converted to forest land	✓	
	<i>Carbon stock change in biomass</i>	✓	
	<i>Net carbon stock change in dead organic matter</i>	✓	
	<i>Carbon stock change in soils</i>	✓	
4.A.2.4	Settlements converted to forest land	✓	
	<i>Carbon stock change in biomass</i>	✓	
	<i>Net carbon stock change in dead organic matter</i>	✓	
	<i>Carbon stock change in soils</i>	✓	
4.A.2.5	Other land converted to forest land	✓	
	<i>Carbon stock change in biomass</i>	✓	
	<i>Net carbon stock change in dead organic matter</i>	✓	
	<i>Carbon stock change in soils</i>	✓	
4.B	Cropland	✓	
4.B.1	Cropland remaining cropland	✓	
<i>Annual remaining annual</i>	<i>Carbon stock change in living biomass</i>	✓	
<i>Annual remaining annual</i>	<i>Carbon stock change in soils</i>	✓	
<i>Perennial remaining perennial</i>	<i>Carbon stock change in living biomass</i>	✓	
<i>Perennial remaining perennial</i>	<i>Carbon stock change in soils</i>	✓	
<i>Annual converted to perennial</i>	<i>Carbon stock change in living biomass</i>	✓	
<i>Annual converted to perennial</i>	<i>Carbon stock change in soils</i>	✓	
<i>Perennial converted to annual</i>	<i>Carbon stock change in living biomass</i>	✓	
<i>Perennial converted to annual</i>	<i>Carbon stock change in soils</i>	✓	
4.B.2	Land converted to cropland	✓	
4.B.2.1	Forest land converted to cropland	✓	
	<i>Carbon stock change in biomass</i>	✓	
	<i>Net carbon stock change in dead organic matter</i>	✓	
	<i>Carbon stock change in soils</i>	✓	✓ N ₂ O
4.B.2.2	Grassland converted to cropland	✓	
	<i>Carbon stock change in living biomass</i>	✓	
	<i>Carbon stock change in soils</i>	✓	✓ N ₂ O
4.B.2.3	Wetland converted to cropland	NO	
4.B.2.4	Settlements converted to cropland	NO	
4.B.2.5	Other land converted to cropland	NO	
4.C	Grassland	✓	
4.C.1	Grassland remaining grassland	✓	
	<i>Carbon stock change in soils</i>	✓	✓ CH ₄
4.C.2	Land converted to grassland	✓	
4.C.2.1	Forest land converted to grassland	✓	
	<i>Carbon stock change in biomass</i>	✓	
	<i>Net carbon stock change in dead organic matter</i>	✓	
	<i>Carbon stock change in soils</i>	✓	

IPCC categories ⁹³ / Sub division for calculation	Description	Status for CO ₂	Other GHG
4.C.2.2	Cropland converted to grassland	✓	
	<i>Carbon stock change in living biomass</i>	✓	
	<i>Carbon stock change in soil</i>	✓	
4.C.2.3	Wetland converted to grassland	NO	
4.C.2.4	Settlements converted to grassland	NO	
4.C.2.5	Other land converted to grassland	NO	
4.D	Wetlands	✓	
4.D.1	Wetlands remaining wetlands	NE/NO	
4.D.2.1	Forest land converted to wetlands	✓	
	<i>Carbon stock change in living biomass</i>	✓	
	<i>Net carbon stock change in dead organic matter</i>	✓	
	<i>Carbon stock change in soil</i>	✓	
4.D.2.2	Cropland converted to wetlands	NO	
4.D.2.3	Grassland converted to wetlands	✓	
	<i>Carbon stock change in living biomass</i>	✓	
	<i>Carbon stock change in soil</i>	✓	
4.D.2.4	Settlements converted to wetlands	NO	
4.D.2.5	Other land converted to wetlands	NO	
4.E	Settlements		
4.E.1	Settlements remaining settlements	NE	
4.E.2.1	Forest land converted to settlements	✓	
	<i>Carbon stock change in living biomass</i>	✓	
	<i>Net carbon stock change in dead organic matter</i>	✓	
	<i>Carbon stock change in soil</i>	✓	✓ N ₂ O
4.E.2.2	Cropland converted to settlements	✓	
	<i>Carbon stock change in living biomass</i>	✓	
	<i>Carbon stock change in soil</i>	✓	✓ N ₂ O
4.E.2.3	Grassland converted to settlements	✓	
	<i>Carbon stock change in living biomass</i>	✓	
	<i>Carbon stock change in soil</i>	✓	✓ N ₂ O
4.E.2.4	Wetlands converted to settlements	NO	
4.E.2.5	Other land converted to settlements	NO	
4.F	Other Land		
4.F.1	Other land remaining other land	NE	
4.F.2.1	Forest land converted to other land	✓	
	<i>Carbon stock change in living biomass</i>	✓	
	<i>Net carbon stock change in dead organic matter</i>	✓	
	<i>Carbon stock change in soil</i>	✓	✓ N ₂ O
4.F.2.2	Cropland converted to other land	NO	
4.F.2.3	Grassland converted to other land	NO	
4.F.2.4	Wetlands converted to other land	NO	
4.F.2.5	Settlements converted to other land	NO	
4.G	Harvested wood products		
4.G.1	Solid wood	✓	
4.G.1.1	Sawn wood	✓	
4.G.1.2	Wood panels	✓	
4.G.2	Paper and paper board	✓	

IPCC categories ⁹³ / Sub division for calculation	Description	Status for CO ₂	Other GHG
4(I)	Direct nitrous oxides emissions from nitrogen inputs to managed soil	NO	
4(II)	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	NA	✓ CH ₄
4(III)	Direct nitrous oxide emissions from nitrogen mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils	NA	✓ N ₂ O
4(III)A.2.1	Grassland converted to forest land	NA	✓ N ₂ O
4(III)B.2.1	Forest land converted to cropland	NA	✓ N ₂ O
4(III)B.2.2	Grassland converted to cropland	NA	✓ N ₂ O
4(III)E.2.1	Forest land converted to settlement	NA	✓ N ₂ O
4(III)E.2.2	Cropland converted to settlement	NA	✓ N ₂ O
4(III)E.2.3	Grassland converted to settlement	NA	✓ N ₂ O
4(III)F.2.1	Forest land converted to other land	NA	✓ N ₂ O
4(IV)	Indirect nitrous oxide emissions from managed soils	NO	✓ N ₂ O
4(V) 4 A 1 BiomassBurn_contr.	Biomass burning; controlled: Forest land remaining forest land	NO	NO
4(V) 4 A 1 BiomassBurn_wildfires	Biomass burning; Wildfires: Forest land remaining forest land	IE ²⁾	✓ N ₂ O ✓ CH ₄
4(V) 4 B 1 BiomassBurn_wildfires	Biomass burning; Wildfires: Cropland remaining cropland	NA	IE ³⁾ ✓ N ₂ O ✓ CH ₄
4(V) 4 C 1 BiomassBurn_wildfires	Biomass burning; Wildfires: Grassland remaining grassland	NA	✓ N ₂ O ✓ CH ₄
4(V) 4 D 1 BiomassBurn_wildfires	4.D.1 Biomass Burning: Wildfires: Wetlands remaining wetlands	NA	✓ N ₂ O ✓ CH ₄
4(G)	C stock changes in Harvested Wood Products	✓	

¹⁾ CO₂ emissions/removals from changes in soil carbon stock of 4.A.1. are estimated for coniferous and deciduous forests. For forest not in yield, the soil carbon pool is assumed to be in equilibrium (notation key NA).

²⁾ CO₂ emissions caused by wildfires (CRF Table 4(V)) are included in the category 4.A.1. Data on the area affected by wildfires are available for the years 1990 to 2021.

³⁾ Included in grassland remaining grassland category

6.1.8 Planned improvements

In the course of the inventory improvement process for LULUCF the used input parameters and applied methods are continuously re-evaluated. A number of potential future improvements have been identified, which will be considered for inclusion in future inventory submissions. These include:

- A current national study will improve the estimates of the area of drained organic soils and their land-uses by integrating various geographic data sources. Furthermore, possible soil emission factors for these areas are evaluated and synthesised.
- Work is ongoing to implement a more consistent treatment soil carbon stock changes using 0-50 cm depth stocks across all land-use change categories. Furthermore, a more resolved approach using specific subnational soil carbon stocks and regional land-use changes between Cropland, Grassland and Settlement is being investigated.

- Two projects, which started at the end of 2023, are still ongoing and are expected to deliver results that will improve LULUCF methods in two specific areas:
- Improved quantification of the total grassland area with additional spatially-explicit datasets.
- Quantification of non-agricultural woody biomass on croplands and grasslands (e.g. single trees/tree groups, hedgerows etc) and development of respective carbon stock change factors.

All these improvements will be finalised until submission 2025.

6.2 Forest land (Category 4.A)

6.2.1 Category description

In Austria, a total of 4.02 million ha (47.9%) is classified as Forest land (BfW 2022a). Since the first national forest inventory (NFI 1961–1970) there has been a steady increase in the total standing forest C stock in Austria. The sustaining of Austrian forests in the past has helped to maintain an important carbon stock in the Austrian landscape and avoid net CO₂ emissions to the atmosphere from the sector LULUCF. In 1990, the Austrian forests represented a carbon stock of 339 ± 42 Mt carbon from biomass and 463 ± 185 Mt carbon from soil, i.e. humus layer plus mineral soil to 50 cm depth. This total carbon stock is equivalent to approximately 40 times the total Austrian greenhouse gas emissions (in CO₂ equivalent) in the year 1990 (UMWELTBUNDESAMT 2000). Recently the Forest land category became, for the first time since reporting began, a net GHG source in single years, namely in 2018 and 2019. The net source values in these years are explained by a combination of high harvest rates due to natural disturbances, low increments due to weather conditions and net C losses from the soil pool.

Emission/Removal trends of forest land

In Austria, the area of Forest land has been constantly increasing since 1990 (Figure 34). However, Land converted to forest land subcategories show a decreasing trend with the exception of Other land to forest land which is stagnating (Figure 35).

The annual net CO₂ results under sector 4.A of the reported period 1990–2022 range from removals of -28 196 kt CO₂ to emissions of 5 054 kt CO₂ (mean: -11 618 kt CO₂). The most important subcategory is Forest land remaining forest land (4.A.1); however, land use changes to forests (4.A.2) and from forests (4.B.2 to 4.F.2) also contribute significantly to the net CO₂ balance of the LULUCF sector.

Between 1990 and 2022, the net carbon balance of the Forest land category fluctuated from a carbon sink sequestering 39% of the total CO₂ equivalent GHG emissions without LULUCF, to a source contributing an additional 7% to national total GHG emissions in the year 2018.

For the reported period 1990 to 2022, the total annual net CO₂ emissions and removals from Forest land remaining forest land range between -25 937 and 6 566 kt CO₂. Net removals from land-use changes to forest range from about 1 420 kt CO₂ to 3 283 kt CO₂. The total annual emissions from land-use changes from forests (deforestation) vary between 990 and 1 424 kt CO₂.

Figure 32: CO₂ removals/emissions (+/-) from IPCC Category 4.A Forest Land by forest land remaining forest land and land use change to forest land over 20 years from 1990–2022 [kt CO₂]

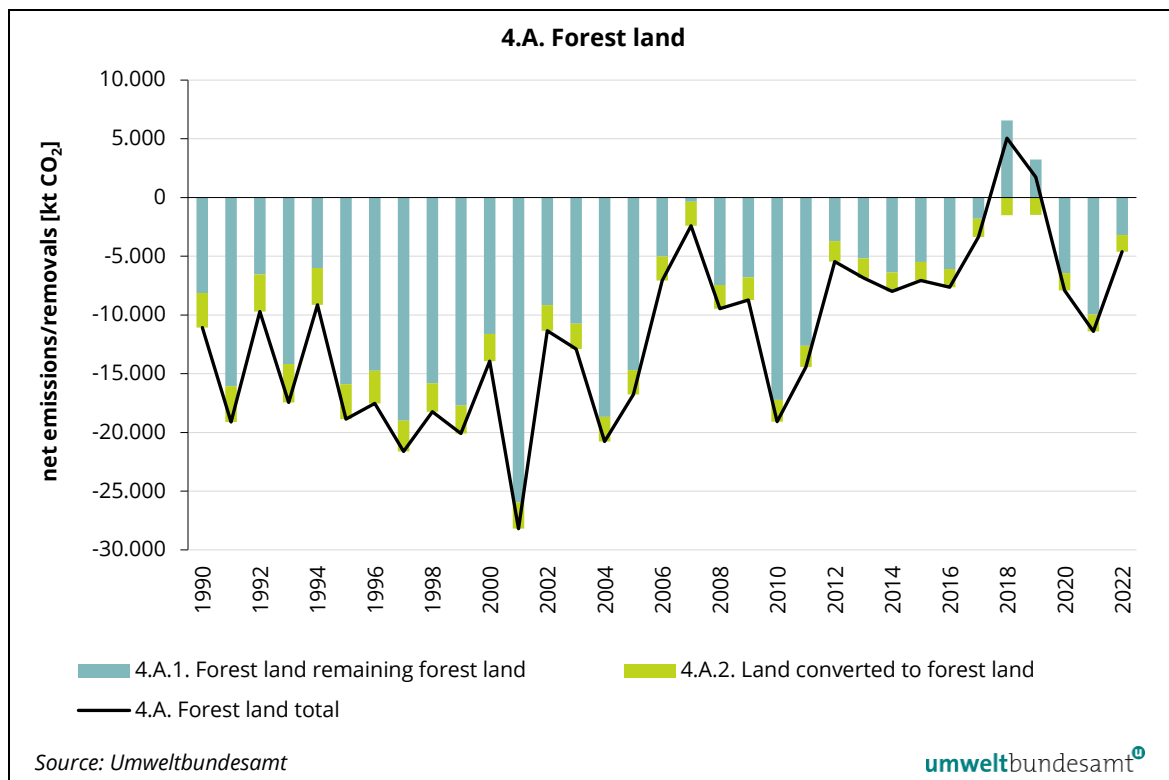


Figure 33: CO₂ removals/emissions (+/-) from IPCC Category 4.A Forest Land by carbon pools from 1990–2022 [kt CO₂]

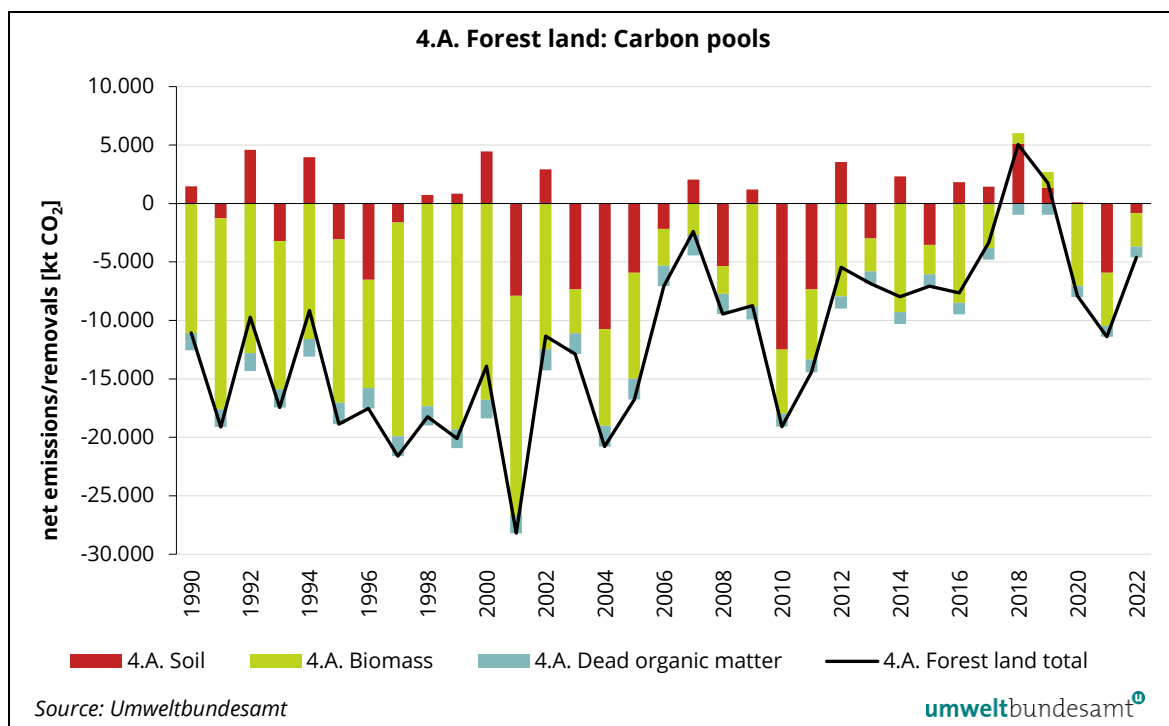


Figure 34: Trend of total forest land and forest land remaining forest land.

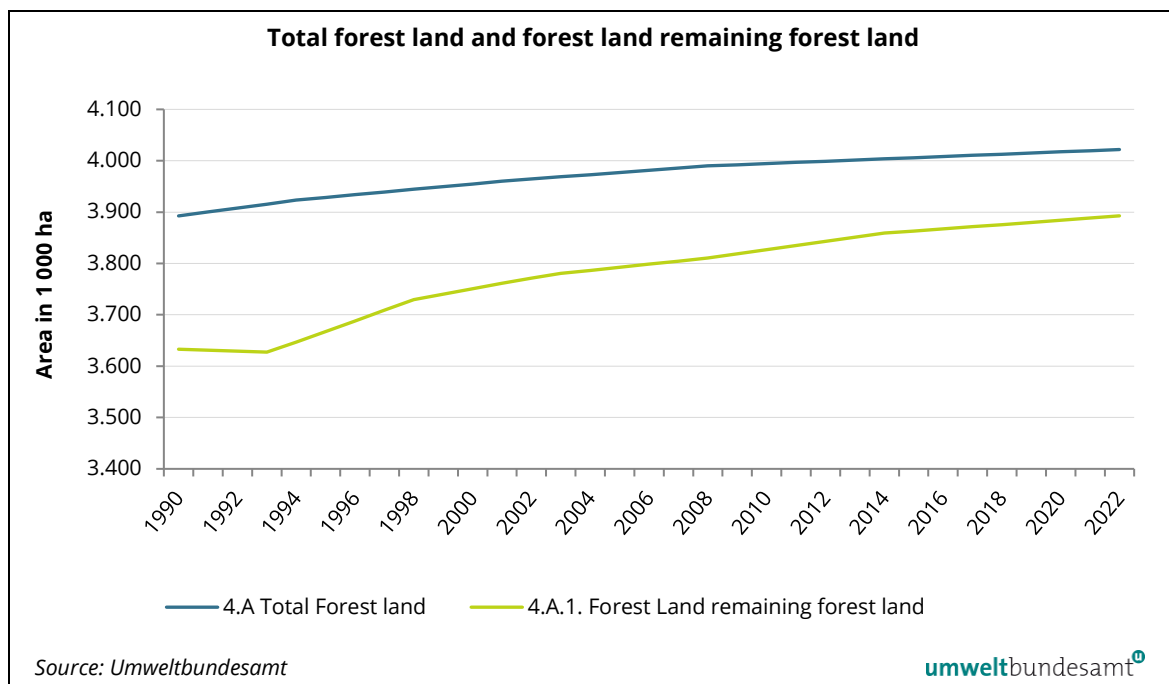
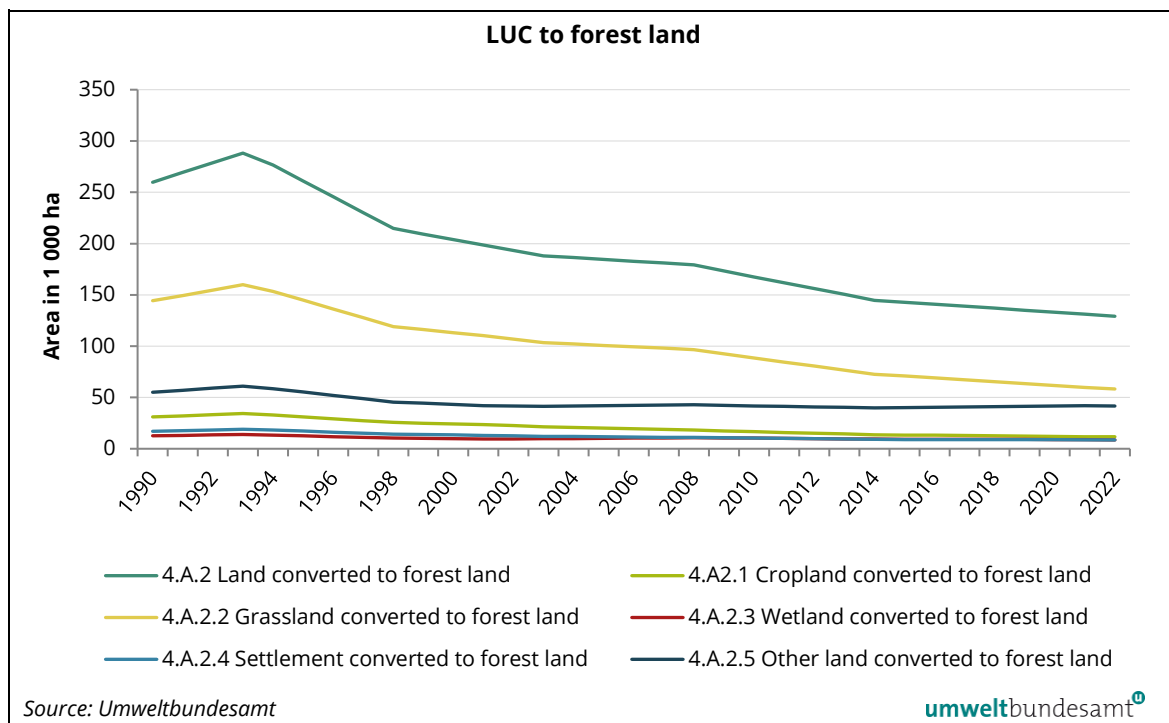


Figure 35: Trend of LUC to forest land (below) covering a conversion period of 20 years from 1990 to 2022 in 1 000 ha (Total forest land includes also forest out of yield).



The net carbon stock changes of the category 4.A vary considerably between single years. The reason for this variation is that the figures for annual growth and for annual harvest differ significantly year by year due to variations in factors influencing growth and harvest like weather conditions,

timber demand and prices and/or wind throws and other natural disturbances. This leads to high yearly variations in these gross gains and losses and net changes in stocks. For example, large annual increases in the soil C pool combined with low harvest rates and high increment resulted in a strong sink of CO₂ in 2001. In contrast, very high harvest rates due to natural disturbances in e.g. 2007, 2018 and 2019 combined with net emissions out of the forest soil pool and low increment rates (in case of 2018 and 2019) due to the weather conditions lead to a weaker sink or even net emissions out of the Forest land category (e.g. 2018 and 2019). It should be noted that the above dynamics in the Forest land category (and the LULUCF sector as a whole), are driven mainly by the respective carbon stock changes in the subcategory 4.A.1 Forest land remaining forest land.

The variation within the net removals time trend for 4.A.2 Land converted to forest land is mainly due to the change of LUC areas and the composition of the previous land use types across the time series.

Table 235: Total areas and land-use change areas of forest land (1990–2022) in kha – transition period of 20 years for LUC lands.

	4.A Total Forest land	4.A.1. Forest Land remaining forest land	4.A.2 Land converted to forest land	4.A.2.1 Cropland converted to forest land	4.A.2.2 Grassland converted to forest land	4.A.2.3 Wetland converted to forest land	4.A.2.4 Settlement converted to forest land	4.A.2.5 Other land converted to forest land
1990	3 893	3 633	260	31	144	13	17	55
1995	3 928	3 667	261	31	145	13	17	55
2000	3 955	3 751	204	24	113	10	13	43
2005	3 977	3 793	185	20	101	10	12	42
2010	3 994	3 827	168	17	88	10	10	42
2011	3 997	3 835	162	16	85	10	10	41
2012	3 999	3 843	156	15	81	10	10	41
2013	4 001	3 851	150	14	77	10	9	40
2014	4 004	3 859	145	14	73	9	9	40
2015	4 006	3 863	143	13	71	9	9	40
2016	4 008	3 867	141	13	69	9	9	40
2017	4 010	3 872	139	13	67	9	9	41
2018	4 013	3 876	137	13	65	9	9	41
2019	4 015	3 880	135	12	63	9	9	41
2020	4 017	3 884	133	12	62	9	9	42
2021	4 020	3 888	131	12	60	9	9	42
2022	4 022	3 893	129	12	58	9	9	42

Table 236: CO₂ removals/emissions (+/-) from IPCC Category 4.A Forest Land from 1990–2022 kt CO₂ and CO₂ equiv.).

	4.A Total Forest land_CO ₂	4.A.1. Forest land remaining Forest land_CO ₂	4.A.2. Land converted to Forest land_CO ₂	4.A.2.1 Cropland converted to Forest land_CO ₂	4.A.2.2 Grassland converted to Forest land_CO ₂	4.A.2.3 Wetlands converted to Forest land_CO ₂	4.A.2.4 Settlements converted to Forest land_CO ₂	4.A.2.5 Other Land converted to Forest land_CO ₂	4(III)A2_N ₂ O emissions due to C losses in managed soils_N ₂ O in CO ₂ eq	4(IV)A2_N ₂ O emissions from N leaching and runoff_N ₂ O in CO ₂ eq	4(V)A1_Biomass burning wildfires_CO ₂	4(V)A1_Biomass burning wildfires_CH ₄ in CO ₂ eq	4(V)A1_Biomass burning wildfire_N ₂ O in CO ₂ eq
1990	-11 077	-8 122	-2 955	-412	-985	-88	-323	-1 146	27	3.050	IE	0.521	0.273
1995	-18 864	-15 891	-2 973	-414	-992	-89	-325	-1 153	27	3.065	IE	0.083	0.044
2000	-13 927	-11 608	-2 319	-323	-773	-69	-254	-900	21	2.394	IE	0.109	0.057
2005	-16 766	-14 683	-2 083	-267	-672	-72	-218	-855	20	2.329	IE	0.081	0.042
2010	-19 094	-17 223	-1 871	-218	-570	-73	-190	-820	20	2.252	IE	0.128	0.067
2011	-14 424	-12 620	-1 804	-207	-542	-72	-184	-800	19	2.185	IE	0.115	0.060
2012	-5 458	-3 720	-1 738	-196	-513	-71	-178	-780	19	2.118	IE	0.143	0.075
2013	-6 851	-5 180	-1 671	-185	-484	-69	-172	-760	18	2.052	IE	0.236	0.123
2014	-7 982	-6 378	-1 604	-174	-456	-68	-166	-741	17	1.985	IE	0.146	0.077
2015	-7 057	-5 476	-1 581	-169	-442	-68	-165	-738	17	1.963	IE	0.361	0.189
2016	-7 647	-6 089	-1 558	-164	-427	-68	-164	-734	17	1.941	IE	0.050	0.026
2017	-3 346	-1 810	-1 535	-160	-413	-68	-163	-731	17	1.919	IE	0.094	0.049
2018	5 054	6 566	-1 512	-155	-399	-68	-161	-728	17	1.896	IE	0.180	0.094
2019	1 750	3 239	-1 489	-150	-385	-68	-160	-725	16	1.874	IE	0.107	0.056
2020	-7 895	-6 430	-1 465	-145	-370	-68	-159	-722	16	1.852	IE	0.172	0.090
2021	-11 406	-9 965	-1 441	-141	-356	-68	-158	-719	16	1.830	IE	0.477	0.250
2022	-4 612	-3 192	-1 420	-142	-348	-66	-160	-705	16	1.765	IE	0.704	0.368

6.2.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The information on forest area is based on data of the Austrian National Forest Inventory (BFW 2022a; GSCHWANTNER et al. 2010, SCHIELER et al. 1995; WINKLER 1997). The NFI was carried out in the periods 1961–70, 1971–80, 1981–85, 1986–90, 1992–96, 2000–02, 2007–09 and 2016–21 covering the total forest area.

The NFI uses a permanent 4 x 4 km grid across all of Austria with four permanent sample plots of 300 m² size at each grid point. The NFI provides representative and systematically measured data for the total Austrian forest area and for all Austrian areas of LUCs from and to forests. This includes the areas of the complete category 4.A and the areas of the subcategories 4.B.2.1, 4.C.2.1, 4.D.2.1, 4.E.2.1 and 4.F.2.1. The NFI grid covers the whole area of Austria and provides measured data on the total Austrian forest area with a statistical error of ±1.2% (see BFW 2022a). Each grid point is terrestrially inspected during each NFI assessment for a potential afforestation/reforestation.

Due to its representativeness and coverage, the NFI data allow an unbiased reporting of the complete Austrian forest area and its change by LUCs from and to forests. As such the NFI constitutes a fundamental element of the Austrian system for land representation (see 6.1.3.1). The following

subsections describe in detail how annual time series of the total Forest land area, as well as land-use conversion to and from Forest land, are derived from the NFI data. The derived data feed directly into the annual land transition matrices and into the subsequent calculation of respective subcategory calculations of GHG emissions and removals.

6.2.2.1 Methods used to derive annual data of FL remaining FL on the basis of the existing NFI datasets

The NFIs provide for each NFI period data on the area of productive forests and non-productive forests (forests not in yield) – those sum up to the total forest area in Austria and represent averages for the NFI assessment period.

By linear interpolation (area according to NFI is located in the mean year of NFI measurement period) annual figures for these areas are estimated. Furthermore, the NFIs provide information on the ratio of area covered by coniferous and deciduous trees.

The calculation of the annual data for **FL remaining FL** is then based on the following data (all based on NFI assessments), steps and considerations:

1. Total annual area of productive forests (forests in yield) is reduced by the area of LUC to productive FL over the previous 20 years (as sum of 20 years LUC transition period). For 1990: 3 169 kha. This is the sum of the figures of 1.1.a and 1.1.b in Table 232.
2. The result of step 1 is then split according to the area-distribution of coniferous and deciduous trees. e.g. for 1990: coniferous 2 432 kha + deciduous 737 kha = 3 169 kha (see Table 232 and CRF table).
3. LUC to forests not in yield also takes place and is assessed by the NFIs and after 20 years of transition period those areas are considered as FL remaining FL. Analogous to step 1, the total annual area of forests not in yield is reduced by the total area of LUC to forests not in yield. For 1990: 463 kha (see 1.1.c in Table 232).
4. Total forest land remaining forest land in CRF table is the sum of step 1 and 3 (For 1990 3 633 kha).

The result of step 4 and the total 20 year LUC to forest land sum up to the total forest area according to NFI (e.g. in 1990: 3 633 kha + 260 kha = 3 893 kha).

The NFI 2016/21 carried out an assessment of the standing stocks in the forest not in yield, and these data (together with model simulations of net biomass and deadwood stock changes over the complete time series) became available in 2022. Therefore C-stock changes in forests not in yield are included since the 2023 submission.

6.2.2.2 Estimation of the annual LUC from and to FL and their splitting into the different subcategories

Total LUC areas to and from forests are available from the individual NFIs, whereby a division of these areas by the respective NFI assessment period leads to data for the annual LUCs. For years after the latest NFI, annual LUC areas calculated from the last inventory are assumed to occur in the subsequent years.

The specific shares of individual land use categories of these LUCs were assessed in the NFIs 2000/02 and 2007/09 and in the NFI 2016/21 (which cover the observation periods between the years of the NFI periods 1992/96 to 2000/02, 2000/02 to 2007/09 and 2007/09 to 2016/21). In case a land use change has been observed at an inventory plot of the NFIs, the type of the non-forest land was recorded. The various past/previous LU categories as assessed by the NFI were aggregated according to the 2006 IPCC Guidelines LU categories (Table 237).

Table 237: LU-classification systems (IPCC 2006 Guidelines and NFI 2000/02, 2007/09 and NFI 2016/21).

Land use categories in the IPCC 2006 GL	LU classifications for LUC from and to forests according to the NFI (2000/02, 2007/09 and NFI 2016/21)
Cropland	Annual cropland Perennial cropland Fallow, agricultural land
Grassland	Grassland (intensive, extensive use) Pastures (incl. slopes)
Wetlands	Water bodies Bogs, peatland Reed area
Settlements	Industry, mining Traffic area Landfills, dumps Urban, residential zone
Other land	Unmanaged alpine dwarf shrub heaths Scree Rock Others

Table 238: Land use changes to forest (% and ha) observed from 1990 to 2021 (covering the NFI periods 1986/90, 1992/96, 2000/02, 2007/09 and 2016/21; based on BFW 2022a).

Categories of land use changes according to the IPCC 2006 GL	1990 – NFI 1992/96		NFI 1992/96 – NFI 2000/02		NFI 2000/02 – NFI 2007/09		NFI 2007/09 – NFI 2016/21	
	LUC to forest land (%)	LUC to forest land [1 000 ha]	LUC to forest land (%)	LUC to forest land [1 000 ha]	LUC to forest land (%)	LUC to forest land [1 000 ha]	LUC to forest land (%)	LUC to forest land [1 000 ha]
Cropland (4.A.2.1)	11.9	6.9	11.9	6.5	6.2	3.4	10.9	6.7
Grassland (4.A.2.2)	55.5	32.0	55.5	30.1	50.2	27.8	42.2	25.8
Wetlands (4.A.2.3)	4.8	2.8	4.8	2.6	8.7	4.8	5.5	3.4
Settlements (4.A.2.4)	6.6	3.8	6.6	3.6	5.0	2.8	7.8	4.8
Other land (4.A.2.5)	21.2	12.2	21.2	11.5	29.9	16.6	33.7	20.6
Total	100.0	57.7	100.0	54.3	100.0	55.4	100.0	61.2

Table 239: Land use changes from forest (% and ha) observed from 1990 to 2021 (covering the NFI periods 1986/90, 1992/96, 2000/02, 2007/09 and 2016/21; based on BFW 2022a).

Categories of land use changes according to the IPCC 2006 GL	1990 – NFI 1992/96		NFI 1992/96 – NFI 2000/02		NFI 2000/02 – NFI 2007/09		NFI 2007/09 – NFI 2016/21	
	LUC from forest land (%)	LUC from forest land [1000 ha]	LUC from forest land (%)	LUC from forest land [1000 ha]	LUC from forest land (%)	LUC from forest land [1000 ha]	LUC from forest land (%)	LUC from forest land [1000 ha]
Cropland (4.A.2.1)	6.2	1.2	6.2	1.1	6.1	1.6	2.7	1.0
Grassland (4.A.2.2)	49.0	9.5	49.0	8.5	56.7	14.5	45.0	16.8
Wetlands (4.A.2.3)	2.6	0.5	2.6	0.4	2.2	0.6	6.7	2.5
Settlements (4.A.2.4)	14.8	2.9	14.8	2.6	20.0	5.1	13.9	5.2
Other land (4.A.2.5)	27.4	5.3	27.4	4.7	15.0	3.8	31.7	11.8
Total	100.0	19.4	100.0	17.3	100.0	25.6	100.0	37.3

As shown in Table 238 and Table 239 the land use changes to and from forests mainly appear to be from/to grassland sites (42–56% or 45–57%, respectively).

For the years 1994 back to 1970 it was assumed that the measured land use changes between two previous NFI periods show the same ratio of distribution between land use change subcategories as between the NFI periods 1992/96 to 2000/02. For the NFI periods 1986/90 and 1992/96 the total areas of LUC to forests and the total areas of LUC from forests are available, but no further distribution into the different LUC subcategories. Consequently, the ratios of change areas from and to FL from/to individual land use categories according to NFI 2000/02 results could be applied directly to split the total LUC areas between NFIs 1986/90 and 1992/96 into the LUC categories. For the years from 1983 back to 1970 (NFIs before NFI 1986/90) only the net changes of the total forest area according to these older NFIs (1961/70, 1971/80, 1981/85) is available. These figures on the net forest area changes plus the information on LUC areas from/to forest according to the more recent NFIs were used to estimate the LUC areas from and to forests for these years: It was assumed that the detected net forest area changes between two NFI periods are based on the same ratio in LUC distribution (LUC to forests vs. LUC from forests) as between the more recent NFI periods. The ratio was always related to the total net increase or loss of forest area between two consecutive previous NFIs. The subsequent classification of the total LUC to/from forest between the LUC sub-categories again assumed the same distribution as between the NFI period 1992/96 to 2000/02. Thus, for the years from 1983 back to 1970 annual LUC areas from and to forest could be estimated.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes between NFI observation periods, while they remain constant within the NFI observation periods. The reason for this is that the average annual LUC area within a NFI observation period can be assessed with sufficient accuracy but not the specific LUC area of single years of the observation period. Interpolations across NFI periods would thus be unsuitable. With NFI 2016/21 new increment and drain data from land-use change sites was derived by observing the stock changes in biomass and dead wood that occurred over a period of 10 years. To accommodate this, LUC areas in transition have been split into two categories – short-term and long-term LUC – and multiplied with the respective average annual growth and harvest rates that were observed during the NFI 2016/21.

For the estimates of changes in litter and soil carbon stocks, the LUC area was further stratified according to five forest growth regions (Bohemian Massif, Inner Alps, Calcareous Alps, Foothills and

Alpine ridge). The area information for these LUC is also based on the results of NFI 2000/02, NFI 2007/09 and NFI 2016/21. The results are finally summed up according to the areas of LUC as shown in Table 238 and Table 239. The specific carbon stocks for litter and soil for each forest growth region are shown in Table 250.

6.2.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The National Forest Inventory (NFI) of Austria is the main data provider for estimating the GHG balance of the Forest land category. Consequently, and for reasons of consistency, the applied forest definition for the reporting follows the definition used within the NFI. The selected parameters are:

- Minimum land area: 0.05 ha;
- Minimum crown cover: 30% (status as observed *in situ* or potential of the standing stock to reach this threshold);
- Minimum height: 2 m (status as observed *in situ* or potential of the standing stock to reach this threshold);
- Average width of forest area more than 10 m.

Permanently unstocked areas that are directly connected with forest in terms of space and forestry enterprise and contribute directly to its management (such as forest hauling systems, wood storage places, forest glades, forest roads) also represent forests. However, areas which are used in short rotation with a rotation period of up to thirty years as well as forest arboreturns, forest seed orchards, christmas tree plantations and plantations of woody plants for the purpose of obtaining fruits such as walnut or sweet chestnut are not defined as forests but rather perennial cropland. Rows of trees (except shelter belts for wind protection) and areas with woody plants in a park structure are not categorised as forests, but rather the land use category to which they belong (e.g. shelter belts in Cropland, woody plants in parks in Settlements).

6.2.4 Methodological Issues

6.2.4.1 Forest Land remaining Forest Land (4.A.1)

6.2.4.1.1 Biomass

The country-specific method for estimating GHG emissions/removals from sector 4.A.1 *Forest land remaining forest land* closely follows the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The use of country-specific conversion factors and biomass functions for tree branches, needles and below ground biomass provide more accurate and appropriate figures for Austrian forests. The main basis of the estimates are measured data for the forest area, stemwood volume increment and drain (harvest and other losses) of the growing stock (for both stemwood over bark with a diameter at breast height > 5 cm) according to the NFI (BFW 2022a; BFW 2011a; GSCHWANTNER et al. 2010; SCHIELER et al. 1995; WINKLER 1997). The NFI was carried out in the periods 1961–70, 1971–80, 1981–85, 1986–90, 1992–96, 2000–02, 2007–09 and 2016–21.

The NFI provides mean values for annual increment and drain between individual NFI observation periods. Each inter-inventory period spans the midpoint of one inventory to the midpoint of the

next inventory e.g. 2001 to 2008 is the period between NFI 2000-02 and NFI 2007-09. However, rather than assume a constant average annual drain and a constant annual increment between inventory periods, relative indices⁹⁴ are used to distribute NFI drain and increment more realistically between the years based on national harvest statistics and relative increment indices based on tree ring analyses. The relative indices for increment are only available until the year 2019. For the years 2020-2022 the average annual increment between the NFI 2007-09 and NFI 2016/21 was used for each year without further adjustment. Once new NFI data is available with the new indices, the time series will be updated accordingly.

In addition to the NFI drain data, which are based on measurements in the forests, further harvest statistics exist (Table 240): the annually reported records of timber harvest (BML 1964–2022) and the Austrian wood balance (BMK 2021). While it is assumed that the NFI provides more accurate figures on the total stemwood drain between inventories, the annually reported records of timber harvest are used to derive annual “relative harvest indices” for individual years (see below). For the corresponding inter-inventory period, the annual indices are calculated from proportional deviation of annual timber harvest values from their respective mean annual timber harvest for the inter-inventory (observation) period. The annual average drain from the NFI for the inter-inventory period is therefore adjusted by multiplying by the annual harvest index. In the same manner, representative Austrian sets of tree ring cores (BFW 2022b, pers. comm.) are used to calculate the relative indices for distribute the average NFI increments over the years of the time series (see para above).

Table 240: Overview of the different harvest statistics in Austria.

Statistics	Characteristics/methodological approach	Units of drain or harvested wood
NFI – national forest inventories	Uses permanently marked grid (4x4 km) all over Austria, periodical investigation of sampling sites; measurements of increment and total stemwood drain (and other parameters) at permanent sampling plots in the forest.	m ³ total stemwood over bark
National annual records of timber harvest (HEM)	No measured data, annual reporting on wood disposal and wood going into self-consumption, declaration provided by forest authorities, wood from non-forest soils is not included; there is some underestimation of harvest in small-sized forest (private owners).	m ³ extracted stemwood under bark
National wood balance (HB)	No measured data, calculations based on NFI and HEM; includes also wood from non-forest areas and takes more possible and suspected domestic wood sources than HEM into account. available for specific years	m ³ extracted stemwood under bark

The above methods allow accurate estimates for individual years for the category 4.A.1 (Table 241). The figures for annual growth and for annual drain, and thus carbon stock changes, may differ significantly year by year and outliers exist (e.g. very low increment in 2003, 2013, 2015, 2018 and 2019; very high harvest rates in 2007 and 2008 due to natural disturbances). Several factors influence growth and drain variations such as weather conditions, timber demand and prices, and forest disturbances such as windthrows and bark beetle infestations. Such factors explain the high annual variations in the CO₂ net removals by Austrian forests.

⁹⁴ Values for the relative variation in the individual years of the time series

Table 241: Increment and drain in the Austrian forests in yield on basis of NFIs and interpolated on basis of relative indices⁹⁵. The bold and non-bold font indicate to which NFI observation period the average and annual increment and drain figures belong.

Year	Average annual increment according to NFI 1000 m ³ o.b.	annual increment interpolated on basis of indices 1000 m ³ o.b.	average annual drain according to NFI 1000 m ³ o.b.	annual drain interpolated on basis of indices 1000 m ³ o.b.
1985	31416	32 243	19846	19 358
1986		30 314		20 201
1987		31 416		19 583
1988		31 416		21 275
1989		30 450		20 265
1990		28 513		23 034
1991	27337	27 241	19521	16 849
1992		25 448		17 958
1993		25 303		17 969
1994		27 067		21 052
1995		28 976		18 461
1996		26 463		20 071
1997	31 255	33 805	18 797	19 690
1998		32 173		18 766
1999		33 968		18 832
2000		30 738		17 752
2001		32 663		18 007
2002		31 343		21 166
2003		26 818		24 317
2004		30 055		23 500
2005	30 371	30 748	25 888	23 483
2006		29 361		27 281
2007		31 904		30 395
2008		32 367		31 076
2009		31 046		24 448
2010		29 651		26 059
2011		31 522		27 324
2012		32 315		26 338
2013		26 955		25 415
2014	29 227	32 251	26 016	24 975
2015		26 924		25 649
2016		30 951		24 499
2017		28 192		25 791
2018		26 289		28 049
2019		25 401		27 628
2020		29 227		24 014
2021		29 227		26 346
2022		29 227		27 688

Given the coverage of the NFI, increment and drain data from the NFI integrate all possible biomass additions to- and losses from Austrian forests. This means that changes in the total standing forest stock due to land use changes, re-growth by forests, traditional (non-commercial) fuel wood

⁹⁵ Please note that these increment and harvest rates do not represent those for “FL remaining FL”, but those for “FL remaining FL” plus all subcategories of LUC from and to FL due to the Austrian-wide assessment of the NFIs.

consumption, forest land conversion, mortality, forest fires (wild-fires) and other damages are represented in the NFI increment and drain data.

In order to fulfil the requirements of the reporting format and to report on the subcategory 4.A.1 *Forest land remaining forest land*, estimates of emissions and removals from biomass with a DBH $\geq$ 5cm due to annual land use changes from and to forests are subtracted respectively from the total biomass increment and drain according to the NFI. The approaches for calculating CO₂ emissions and removals related to land use changes are described in chapter 6.2.4.2. This step thus provides respective biomass increment and drain for forests in yield that are included under Forest land remaining forest land.

For the 2023 submission, a method was developed to estimate net biomass stock changes of forests not in yield back to 1990 based on the NFI 2016/21, which for the first time sampled the above-ground biomass and deadwood stocks in forests not in yield. The simulations were carried out by the Austrian Federal Research Centre for Forests (BFW). For each of these sampled plots, the trees were grouped into 12 species-DBH classes (4 species groups x 3 DBH classes). For each of these classes, parameters describing mortality and harvest were derived based on sampling of *minimally managed protective forests in yield* in the last five NFIs (NFI 1992/96 to 2016/21). In terms of growth, mortality and harvest, this subset of forests in yield were considered as very similar to forests not in yield. Based on these mortality and harvest rates for each of the species-DBH class, new trees are simulated to appear on the plots in each of the previous years back to 1989. The dimensions of the newly-appearing trees, were derived at random from the sample trees in the respective species-DBH class. For past growth, rates of diameter and height growth were derived, again based on the sampling of *minimally managed protective forests in yield* in the last five NFIs. With these rates, the declining dimensions of the standing trees (trees sampled in the plots as well as trees that appear in previous years via reversed mortality simulations) were retrospectively simulated. Based on the above gain and drain simulations, a time series of average per ha net biomass stock change (volume) of these forests was derived for the time series 1990-2019. Multiplication with respective wood densities, biomass expansion factors and carbon contents, and area of *Forest not in yield remaining forest not in yield* (all from the NFI) allowed conversion of the stock change units to kt C. For the years 2020-2022 the value of 2019 was extrapolated. The values will be updated when new NFI data are available. Note that due to this model-approach, it is not possible to split the biomass carbon stock changes in gains and losses, because only a net result is provided. Therefore, "IE" is reported for biomass losses for forests not in yield in the CRF table 4.A.

Wood densities

Shrinkage values, wood densities (absolute dry mass (dm)) and C contents for all tree species in Austria are used to convert the increment and drain of m³ stemwood over bark (o.b.) which is measured by the NFI into t carbon increment and t carbon drain of the stemwood o.b. The mean wood densities according to Table 242 represent aggregated values on basis of the species composition of increment and drain in Austria (see example in Table 243 for last two NFIs) and on country-specific values for the shrinkage and wood densities for all individual tree species (Austrian Standard ÖNORM B3012). These conversion factors are calculated for each inventory period and separately for increment and drain respectively. Between the inventories they show only minor differences (< 1%) because the shares of the tree species change very slowly.

Further details on the approach and methodology are given in (UMWELTBUNDESAMT 2000).

Table 242: Conversion factors for the stemwood o.b. of the Austrian forests; mean of several NFIs.

Conversion factors	Coniferous	Deciduous
m ³ o.b. to t dm (stemwood)	0.38	0.54
t dm to t C (stemwood)	0.50	0.48

Table 243: Share of tree species in total stemwood increment and drain of the NFIs 2007/09 and 2016/21. (BFW 2022a).

Tree species	% in total increment NFI 07/09	% in total drain t NFI 07/09	% in total increment NFI 16/21	% in total drain NFI 16/21
spruce	66.4	68.7	64.5	67.0
fir	4.2	4.0	4.0	4.0
larch	3.9	4.0	4.4	3.9
pine (pinus sylvestris)	4.0	6.3	4.5	6.6
pine (pinus nigra)	0.2	0.6	0.6	0.6
pinus cembra	0.2	0.1	0.2	0.1
weymouth pine (pinus strobus)	0.0	0.0	0.0	0.0
douglas fir	0.1	0.0	0.3	0.1
Total coniferous	79	84	79	82
beech (fagus sylvatica)	9.1	6.8	9.4	6.6
oak	2.2	2.2	2.4	1.6
hornbeam	0.8	0.5	0.9	0.8
ash	2.7	1.2	2.0	2.7
maple	1.4	0.7	1.8	0.7
elm	0.2	0.2	0.2	0.2
chestnut	0.2	0.2	0.1	0.2
robinia	0.3	0.3	0.3	0.4
sorbus, prunus	0.3	0.3	0.5	0.4
birch	0.7	0.9	0.7	0.8
alder	1.3	1.3	1.0	1.5
lime tree (Tilia)	0.4	0.2	0.4	0.2
poplar (Populus alba, Populus tremula)	0.5	0.5	0.6	0.6
poplar (Populus nigra, populus canadensis)	0.4	0.8	0.4	0.6
willow (Salix)	0.4	0.4	0.4	0.4
Total deciduous	21	16	21	18
Total	100	100	100	100

Biomass functions (BF)

The increment and drain of the other tree compartments (branches, needles, roots) are estimated with the help of biomass functions (Table 244:) and C contents for these tree compartments (coniferous: 0.47, deciduous: 0.48). The biomass functions were derived with the help of numerous single tree data from Austrian forest sites (see literature given below). Biomass functions as listed in Table 244: are applied to each single tree at the NFI plots of each NFI period to derive increment and drain of branches and roots of these trees. Only the evergreen needle biomass is estimated (leaves of deciduous trees become part of the soil C pool within one year). The compiled results for each tree species are further extrapolated to the total Austrian (productive) forest. These estimates are also carried out at the Austrian Federal Research Centre for Forests (BFW).

Table 244: Used biomass functions.

Tree species	Tree parts	Input parameter	Literature
Norway spruce (Douglas fir and other coniferous species than listed below)	Branches, needles	Dbh, height, crown ratio	(ECKMÜLLNER 2006)
Fir	Branches, needles	Dbh, crown ratio	(LEDERMANN & NEUMANN 2006)
Pine	Branches, needles	Dbh, height, crown ratio	(ECKMÜLLNER 2006)
Larch	Branches	Dbh, height, crown ratio	(RUBATSCHER et al. 2006)
Beech	Branches	Dbh, crown ratio	(LEDERMANN & NEUMANN 2006)
Oak	Branches	Dbh, crown ratio	(LEDERMANN & NEUMANN 2006)
Oak (coppice)	Branches	Dbh, crown ratio	(HOCHBICHLER et al. 2006)
Hornbeam	Branches	Dbh, crown ratio	(LEDERMANN & NEUMANN 2006)
Ash	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
Other hardwood deciduous species	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
Poplar	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
Other weed tree species	Branches	Dbh, crown ratio	(GSCHWANTNER & SCHADAUER 2006)
All	Roots	Dbh, age	(WIRTH et al. 2004). (OFFENTHALER & HOCHBICHLER 2006)

On basis of the results of these biomass functions the average biomass expansion ratios according to Table 245 for total tree biomass/stemwood biomass were derived. The aggregated expansion factors in Table 245 are not used for the estimates, but are provided as additional information for transparency reasons and to allow comparisons.

Table 245: Average expansion ratios total tree biomass/stemwood biomass for the Austrian forests for the period 1990–2008. Aggregated values derived from the single NFI tree data on basis of the applied biomass functions (based on BFW 2011b, pers. comm.).

Expansion ratio t dm stemwood → t dm whole tree (incl. also below ground biomass)	Coniferous	Deciduous
increment	1.62	1.63
drain	1.60	1.59

The resulting mean annual biomass increments and drain of the other tree biomass compartments (needles, branches, roots) for the individual NFI periods are converted to figures for single years in the same way as described above for stemwood (i.e. using the relative increment and harvest indices).

6.2.4.1.2 Dead wood

The estimates on C-stock changes in dead wood include only standing dead wood, because any falling dead tree (part) is accounted for as a C flux to litter/soil in the modeling of the litter/soil C stock changes (see chapter 6.2.4.1.3.). Since national data on the stock of dead wood are available from the NFI a Tier 3 method was applied.

Based on the data of the NFI the stock of dead wood (on average of all tree species) for the total forest area is 4.5 m³ ha⁻¹ for the inventory period 1992/96, 6.1 m³ ha⁻¹ for the inventory period 2000/02, 8.4 m³ ha⁻¹ for the inventory period 2007/09 and 9.7 m³ for the inventory period 2016/21.

Based on the NFI 2016/21 stock changes in dead wood for forests in yield are available at land use change areas from and to forests. In order to fulfill the requirements of the reporting format and to report only the category *4.A.1 Forest land remaining forest land* without any double-counting, estimates of emissions and removals from C-stock changes of dead wood due to annual land use changes from and to forests are subtracted from the totals derived from the NFI. For the calculation of the C-stock changes the conversion factors for stemwood as shown in Table 242 were used. These conversion factors do not include any estimates for roots and branches of the dead trees. The rationale is that dead roots are already part of the soil C pool and dead trees have usually only a negligible branch mass. It was assumed that the ratio between deciduous and coniferous dead wood is equal to the deciduous/coniferous ratio of the living trees.

For the 2023 submission, a method was developed to estimate net deadwood stock changes for forest not in yield back to 1990 based on the NFI 2016/21, which for the first time sampled the above-ground biomass and deadwood stocks in forests not in yield. From the NFI 2016/21 sampling of these areas, the ratio between the deadwood stock and the standing biomass stock was derived and used as a coefficient by which the simulations of the annual standing biomass stock was multiplied. A time series of average per ha net deadwood stock change (volume) of these forests was derived for the time series 1990-2019. For the years 2020-2022 the value of 2019 was extrapolated. The values will be updated when new NFI data is available. Multiplication with respective wood densities, expansion factors and carbon contents, and area of Forest not in yield remaining forest not in yield (all from the NFI) allowed conversion of the stock change units to kt C.

The results of the NFIs and simulations demonstrate an increase of dead wood in Austria. While not always a major contributor to the total C-balance of Forest land and the LULUCF, the associated annual net C-stock changes, which are equivalent to removals ranging between 257 kt CO₂ and 933 kt CO₂, are nonetheless significant.

6.2.4.1.3 Litter and soil

For the submission 2023, the dynamics of soil carbon in Forest land remaining forest land (forest in yield) were estimated for the first time with the simulation model Yasso20 (VISKARI ET AL, 2022), a more advanced version of the previously used Yasso07 (FINNISH ENVIRONMENT INSTITUTE 2011). This model was selected because it can be parameterised using data from national forest and soil inventories and is thus well-suited for such country-level applications.

The model simulation for Austria was based on data from two monitoring programs, the Austrian National Forest Inventory and the Austrian Forest Soil Survey. The Austrian NFI comprises 11 000 permanent sampling plots that are located on a regular grid. The soil monitoring network is part of this grid and comprises 529 sites. Soil sampling was repeated at 130 sites within the EU wide Bio-Soil project and these data were used to validate the model results. Furthermore, estimated above-ground and belowground litter inputs used to drive the model were previously validated against data from Austrian long-time monitoring sites. The Yasso simulations were carried out by the Austrian Federal Research Centre for Forests (BFW), the same institution responsible for the Austrian National Forest Inventory, the Austrian Forest Soil Survey and other forest monitoring activities.

Yasso20 model simulations of annual soil carbon stocks were made for each of the NFI plots that were considered as *Forest land remaining forest land* since NFI 1986/90 (ca. 8 700 plots). The start of the time series of the simulations was set at 1985 after necessary spin-up simulations starting in 1961 to achieve a relative steady state in the SOC stocks that were on average similar mean measured forest soil carbon stocks from the Austrian Forest Soil Survey (ca. 120 t C/ha). The annual

aboveground and belowground flux of carbon to the soil and the chemical quality of the carbon input were estimated, at single-tree level, on the basis of the results of the Austrian NFIs (standing stock and drain at the plots) and with allometric functions for the conversion of stemwood to total tree biomass (see chapter 6.2.4.1.1). Any litterfall, dead roots input, any harvest residues input (e.g. needles, branches, pieces of stem, stump, roots) and *fallen* dead trees were estimated for the NFI plots and were included as C flux to the litter/soil in the Yasso simulations of the soil C stock changes. Therefore, the Yasso simulations also account for any flux of dead wood to the litter/soil (e.g. falling dead trees and branches, stumps and non-extracted tree parts after harvest). To avoid any double counting all these compartments are not accounted in the estimates of the dead wood stock pool, but only the changes in standing dead wood.

A further improvement in the soil C simulations with Yasso20 was the use of monthly air temperature and annual precipitation data to drive the model, and the use of these annual variations in soil carbon stock changes in the inventory (rather than a stable average stock change over the time series). The needed meteorological time series for each simulated NFI plot were taken from a 1 km² resolution weather data set⁹⁶ provided by the Austrian weather service, *Geosphere Austria* (formerly ZAMG).

The output of Yasso for each NFI plot is a yearly time series of the total litter/soil C pool and its changes, which is divided into the following pools: woody matter, non-woody matter and the acid-, water-, ethanol- and insoluble fractions. Yasso does not allow distinguishing between the C stock changes in the single litter and soil horizons and instead provides totals for the litter layer C plus the soil C pool. Therefore, the total litter and soil C stock changes of the subcategory 4.A.1 Forest land remaining forest land are reported under the mineral soil C pool changes in the CRFs. Note, however, that this removal/emission has to be finally adjusted for soil C stock losses due potential increases in unstocked forest land (particularly forest roads).

Forest roads and other unstocked areas of Forest land for forest management purposes are accounted as Forest land according to the Austrian and FAO forest definitions (see chapter 6.2.3). The Austrian NFIs provide detailed information on the area of forest roads and a further specific study on forest roads in Austria was used (WINKLER 2003). The estimates give an average area of approx. 700 ha per year that is converted from stocked forests to fortified macadam or gravel forest roads in the period covered by NFIs. According to WINKLER (2003), 50% of these fortified forest roads have vegetation (beside the wheel ruts) and the other half has no vegetation. For those without vegetation, 0 t C per ha and for those with vegetation 60 t C per ha was assumed as the respective equilibrium soil C stock (0–50 cm). Assuming an average soil C stock of 130 t C per ha of forests in yield according to the results of the Biosoil project, a given yearly increase in forest road area is associated with a net soil C loss of 100 t C per ha over a 20 year transition period. This approach is completely consistent with the soil C stock discounting method according to the 2006 IPCC guidelines.

Finally, it should be reiterated that the above methods were applied to estimate 4.A.1 soil carbon stock changes in forests in yield. As part of the same national study dedicated to improving Yasso simulations of forest in yield, simulations were also made for forests not in yield. It should however be noted that the above-ground biomass of these areas have only been sampled in the previous NFI cycle, introducing substantial uncertainty into the time series of required C inputs to the soil needed to run the model. The simulations yielded substantial temporal variations in the annual soil

⁹⁶ <https://www.zamg.ac.at/cms/de/forschung/klima/klimatografien/spartacus>

carbon stock changes (-1 to +2.5 t C/ha/yr), but a clear tendency of annual C stock increases across the majority of the period since 1990. Furthermore, the simulated carbon stocks were considerably higher (ca. 161 t C ha) than average forest carbon stocks for forests in yield according to the Austrian Forest Soil Survey (ca. 120 t C ha). Considering the aforementioned factors and the lack of soil C measurements in forests not in yield to validate these simulated stocks and stock changes, it was considered inappropriate to use these simulations in the LULUCF GHG inventory calculations. Therefore, the soil carbon stocks of forests not in yield under 4.A.1 are reported with tier 1 methodology, considered to be in equilibrium.

This latest modelling exercise, conducted for submission 2023, provided a timeseries from 1990-2021. For this submission, the year 2022 was extrapolated with the average modelled value from the period 2009-2019, which represents the period between the mid-points of the last two NFI cycles (NFI 2007/2009 and NFI 2016/2021).

6.2.4.1.4 Biomass burning

The controlled burning of managed forest is not carried out in Austria. CO₂ emissions caused by biomass burning due to wildfires in forests are included in category 4.A.1 *Forest land remaining forest land*, as already reported in previous reports. Estimates of emissions from non-CO₂ gases from this category are reported. Equation 2.27 of the 2006 IPCC Guidelines following a Tier 1 method was applied.

$$L_{\text{fire}} \text{ (t GHG)} = A * M_B * C_f * G_{\text{ef}} * 10^{-3}$$

A area burnt (ha)

M_B mass of available fuel, t dm ha⁻¹ (Table 2.4)

C_f combustion factor

G_{ef} emission factor, g kg⁻¹ dm (Table 2.5)

Data on the annual area affected by wildfires are available for the years 1990 to 2022 from the statistics of the Ministry responsible for forestry (BML) and range between 8 and 270 ha/year. According to the references in the 2006 IPCC Guidelines a mean value of 19.8 t ha⁻¹ biomass consumption was applied. This represents the product of available biomass density on the land before combustion (*M_B*) and the combustion factor (*C_f*). The emission factors (*G_{ef}*) for N₂O and CH₄ were taken from table 2.5 of IPCC 2006 Guidelines.

However, due to the small area concerned, the amounts of N₂O and CH₄ emissions caused by wildfires are negligible, with annual sum N₂O and CH₄ emissions ranging between 0.032 and 1.07 kt CO₂ equivalents.

6.2.4.2 Land Use Changes to Forest Land (4.A.2)

Austria applies the default transition period of 20 years for areas undergoing land conversion. Therefore, all annual LUCs since 1971 are required for the calculation of annual GHG emissions and removals for 1990 onwards.

6.2.4.2.1 Biomass

Based on the results of the NFI 2016/21 the experts of the Federal Research Centre for Forests provided detailed, measured values for increment and drain at the areas of LUC to and from forests (BFW, 2022a). The data are available for coniferous and deciduous trees (diameter at breast height

(dbh) $\geq$ 5cm) and for two age classes of the land-use change lands (long-term ARD areas, where the LUC occurred before the previous NFI period (i.e. before 2007/09) and short term ARD areas, where the LUC occurred after the previous NFI period (i.e. after 2007/09). For the forest biomass with a dbh < 5cm the stock changes were estimated. The respective values for biomass increment and biomass drain (DBH $\geq$ 5 cm), and for biomass stock changes (DBH < 5 cm) are summarised in Table 246 and Table 247.

Table 246: Annual biomass increment and drain (DBH $\geq$ 5 cm) at ARD areas.

	Biomass increment DBH $\geq$ 5 cm. total tree biomass (t/ha/a)		Biomass drain DBH $\geq$ 5 cm. total tree biomass (t/ha/a) ⁹⁷	
	coniferous	deciduous	coniferous	deciduous
long term AR areas	2.11	1.67	0.38	1.19
short term AR areas	1.06	1.05	0.00	0.00
long term D areas	0.18	0.34	0.28	0.26
short term D areas	0.17	0.12	81.15	34.31

Table 247: Annual biomass stock change (DBH < 5 cm) at ARD areas.

	Biomass stock changes DBH < 5 cm (t/ha/a)			
	Above ground		Below ground	
	coniferous	deciduous	coniferous	deciduous
long term AR areas	-0.0027	0.0276	-0.0005	0.0030
short term AR areas	0.0053	0.0723	0.0007	0.0080
long term D areas	0.0017	-0.0048	0.0003	-0.0005
short term D areas	0.0002	0.0076	0.0000	0.0008

The biomass stock changes at the LUC lands to and from forests of the whole time series were calculated with the factors given in in Table 246 and Table 247.

Conversion factors (BF, C)

The detailed biomass assessment at the ARD areas between NFI 2007/09 and NFI 2016/21 allowed the application of the same biomass functions as used in sector 4.A.1. (see Biomass functions (BF)) to derive biomass increment and biomass harvest of trees with a DBH $\geq$ 5cm. The stock changes of biomass < 5 cm is estimated based on counting of trees between the last two NFI periods.

Table 248: C-conversion factors for forest biomass land use changes areas from and to forest land.

Conversion factors t dm to t C	increment		harvest	
	coniferous	deciduous	coniferous	deciduous
Above ground – stem	0.498	0.484	0.497	0.484
other tree compartments – branches. roots	0.473	0.481	0.473	0.480

Over the whole time series, the average annual net C stock change in living biomass (DBH>0) per ha for areas with LUC to forests amounts to:

⁹⁷ Drain on short term D areas is shown as total observed biomass drain caused by deforestation (t/ha) instead of a yearly average over the duration of the assessment period, following the assumption that biomass is not lost continuously but instead within the year in which the deforestation takes place.

$$\Delta C_{BM} = 1.08 \text{ t C ha}^{-1} \text{ a}^{-1}$$

For areas with LUC from forests to other land uses the calculations lead to the following result of average annual net C stock change in living biomass (DBH>0cm) per ha and year over the time series:

$$\Delta C_{BM} = -2.66 \text{ t C ha}^{-1} \text{ a}^{-1}$$

In the year of LUC from forests to other land uses, the following average annual C stock drain in living biomass (DBH>5cm) per ha and year is applied:

$$\Delta C_{BM \text{ drain}} = -58.95 \text{ t C ha}^{-1} \text{ a}^{-1}$$

An overview of the emissions/removals from land use changes to forests is given in Table 236.

6.2.4.2.2 Dead wood

Based on stock changes between the NFIs2007/09 and 2016/21 the experts of the Federal Research Centre for Forests provided detailed, measured values for stock changes of standing dead wood at areas of LUC to and from forests across time. This includes also measurements of changes in dead wood stocks in the transition period which are already present at the LUC areas in the year of land-use change (BFW, 2022a). The stock changes are listed in Table 249. As with living biomass, the change in dead wood biomass per ha is given for short- and long term LUC areas and is calculated over the 20 year transition period as described above.

Table 249: Annual stock changes of dead wood at ARD areas based on the NFI 2016/21 (BFW 2022a).

	Stock changes – dead wood (t/ha/a)
long term AR areas	0.17
short term AR areas	0.05
long term D areas	-0.004
short term D areas	-1.22

6.2.4.2.3 Litter and soil

Soil and litter C stock changes were calculated for all land use change subcategories to and from forests. The soil C stock changes were stratified according to the specific soil C pools of different land use changes and additionally, according to five forest growth regions in Austria (Bohemian Massif, Inner Alps, Calcareous Alps, Foothills and Alpine ridge). To calculate the soil C stock changes due to LUC, a number of data sources were synthesized into a land-use soil C stock look-up table (Table 250). The table provides the estimates of C stocks in mineral soils (0–50 cm) and litter according to different land uses and forest growth regions. As the table shows, agricultural soil C stocks were calculated based on data from the Austrian Soil Information System (BORIS - see references). Forest soil and litter C stocks are based on the results of the EU-wide Biosoil project (BFW 2009) which was carried out on 140 sites of the former forest soil survey (BFW 1992). For the other land use categories, national estimates based on literature values or expert judgement were applied. The estimate and expert judgment of the soil C stocks in areas of settlements and traffic areas is based on the same approach as described in chapter 6.6.4.1.2 (in this chapter information about the assessment of the share of sealed area in settlements is provided). For the “other land uses” of Other land (those which are not alpine shrub lands, rocks and stone slopes) we assume a C stock of only 30 t C ha⁻¹ due to the shallow depth of these soils. Note that where the original data

provide two or more stratified soil C stock values for a given LU category, weighted averages were calculated (weighted by the relative area of each stratum). In this submission the soil carbon stock for Settlements in land conversions between Forest land and Settlements was updated due to a new sealing ratio (see chapter 6.6.4.1.2). In addition, the settlement carbon stock is no longer weighted by stratum and the same C stock is used for all strata, because the new data source for calculating the sealed area does not provide separate information on each stratum.

Table 250: Specific C-stocks (t C ha⁻¹) for litter and soil (0–50 cm) stratified according to five forest growth regions in Austria.

IPCC LU categories	National LU categories	Forest growth regions					Source
		Bohemian Massif	Inner alps	Calcareous alps	Foothills	Alpine Ridge	
		t C ha ⁻¹ (0–50 cm)					
Forest – litter	Forest	40	24	24	19	26	BFW 2009
Forest – mineral soil	Forest	88	91	109	77	117	BFW 2009
Cropland	Cropland	56	90	80	65	90	Umweltbundesamt – see ⁹⁸ below
	Vineyards	58	58	58	58	58	Gerzabek et al. 2005
	Orchards/garden land	78	78	78	78	78	Gerzabek et al. 2005
Grassland	grassland intensive use	75	95	100	79	94	Umweltbundesamt–see footnote ⁹⁸ below
	grassland extensive use	132	130	120	139	139	Umweltbundesamt–see footnote ⁹⁸ below
Wetlands	Surface waters and reed beds:	0	0	0	0	0	expert judgement
Settlements	Settlements and traffic area	43	43	43	43	43	Umweltbundesamt–see chapter 6.6.4.1.2
	Industrial and mining areas, dumps	43	43	43	43	43	Umweltbundesamt–see chapter 6.6.4.1.2
Other land	Alpine shrub lands	119	119	119	119	119	Körner et al. 1993
	Rocks and stone slopes:	0	0	0	0	0	expert judgement
	Other land uses	30	30	30	30	30	expert judgement

For the LUC calculations, the average soil C stocks for each land-use category were furthermore weighted by the respective relative area contributions to the total LUC to forests and the total LUC from forests. The NFIs 2000/02, 2007/09 and 2016/21 specify the LUC areas from and to forests over a broader range of LUC categories than the existing six major IPCC land use categories (see

⁹⁸ The values for forests, cropland and grassland represent regional averages which are based on Austrian soil inventories for forests (BFW 2009) and for agricultural land (AMT DER STEIERMÄRKISCHEN LANDESREGIERUNG 1988–1996, AMT DER TIROLER LANDESREGIERUNG 1988, AMT DER OBERÖSTERREICHISCHEN LANDESREGIERUNG 1993, AMT DER SALZBURGER LANDESREGIERUNG 1993, AMT DER NIEDERÖSTERREICHISCHEN LANDESREGIERUNG 1994, AMT DER BURGENLÄNDISCHEN LANDESREGIERUNG 1996, AMT DER KÄRNTNER LANDESREGIERUNG 1999, compiled in the Austrian Soil Information System BORIS). The data have been stratified according to the Austrian forest growth regions.

Table 250). LUC areas are reported for additional LU substrata for each forest growth region. Consequently, for each land use change category from and to forest area, weighted mean values of soil C-stocks for each subcategory and growth region were calculated for each NFI period (NFI 1992/96 to 2000/02, NFI 2000/02 to 2007/09 and NFI 2007/09 to NFI 2016/21). Given the variation in relative contributions of the strata to LUC to forests and LUC from forests, and variation between the inventory periods, the C stocks for each LU category differ between the respective look-up tables (Table 251, Table 252 and Table 253).

Table 251: Area weighted mean values for carbon stocks in mineral soils (0–50 cm) of land use change areas from and to forest land between the NFI periods 1992/96 and 2000/02 and previous NFIs.

C-stocks (t ha ⁻¹) in soils (0–50 cm) ¹										
Land use categories (IPCC –GPG)	LUC to forest (forest growth regions)					LUC from forest (forest growth regions)				
	Bohemian Massif	Inner alps	Calc. alps	Foot-hills	Alpine Ridge	Bohemian Massif	Inner alps	Calc. alps	Foot-hills	Alpine Ridge
Forest	88	91	109	77	117	88	91	109	77	117
Cropland	56	90	77	65	73	56	-	71	65	90
Grassland	77	123	117	85	125	75	116	115	88	128
Wetlands	-	-	-	-	-	-	-	-	-	-
Settlements	43	43	43	43	43	43	43	43	43	43
Other land	30	53	21	27	51	30	73	40	30	25

¹ - no LUC from/to forest could be observed in these regions

Table 252: Area weighted mean values for carbon stocks in mineral soils (0–50 cm) of land use change areas from and to forest land between the NFI periods 2000/02 and 2007/09.

C-stocks (t ha ⁻¹) in soils (0–50 cm) ¹										
Land use categories (IPCC –GPG)	LUC to forest (forest growth regions)					LUC from forest (forest growth regions)				
	Bohemian Massif	Inner alps	Calc. alps	Foot-hills	Alpine Ridge	Bohemian Massif	Inner alps	Calc. alps	Foot-hills	Alpine Ridge
Forest	88	91	109	77	117	88	91	109	77	117
Cropland	57	90	78	65	81	56	-	-	68	88
Grassland	91	128	117	87	130	75	128	114	124	128
Wetlands	-	-	-	-	-	-	-	-	-	-
Settlements	43	-	43	43	43	43	43	43	43	43
Other land	39	46	49	30	49	-	53	22	13	41

¹ - no LUC from/to forest could be observed in these regions

Table 253: Area weighted mean values for carbon stocks in mineral soils (0–50 cm) of land use change areas from and to forest land between the NFI period 2007/09 and the NFI period 2016/21.

C-stocks (t ha ⁻¹) in soils (0–50 cm) ¹										
Land use categories (IPCC –GPG)	LUC to forest (forest growth regions)					LUC from forest (forest growth regions)				
	Bohemian Massif	Inner alps	Calc. alps	Foot-hills	Alpine Ridge	Bohemian Massif	Inner alps	Calc. alps	Foot-hills	Alpine Ridge
Forest	88	91	109	77	117	88	91	109	77	117
Cropland	60	-	74	66	72	56	-	-	67	-
Grassland	87	128	115	93	128	75	124	114	109	125
Wetlands	-	-	-	-	-	-	-	-	-	-
Settlements	43	43	43	43	43	43	43	43	43	43
Other land	119	67	52	86	71	-	59	29	47	66

¹ - no LUC from/to forest could be observed in these regions

The estimates of the soil C stock changes for LUC areas from and to forests were split into litter (humus layer, see Table 250) and mineral soil (see Table 251, Table 252 and Table 253) and follow the equations below. The changes are estimated annually on a regional basis (forest growth region) and summed up for each LUC subcategory in the CFR tables. Based on the LUC data to and from forest, which are stratified between the forest growth areas in the NFI, soil C stock changes were calculated by applying the corresponding values from the tables above to the equations below. For the years up to 2001, the mineral soil C stocks from Table 251 were applied; between 2002 and 2008, Table 252; and from 2009 onwards, Table 253.

Annual carbon stock changes in soils at LUC areas from and to forest land

$$\Delta SOC = A \cdot (SOC_0 - SOC_{0-T}) / 20$$

ΔSOC = average annual carbon stock change in soils ($t\ C\ a^{-1}$) over the LUC transition period of 20 years

A = conversion area from or to forest land for a transition period of 20 years

SOC_0 = carbon stock in soils after conversion, respectively (e.g. mineral forest soils in the Calcareous Alps $\rightarrow 109\ t\ C\ ha^{-1}$, see Table 252)

SOC_{0-T} = carbon stock in soils before conversion, respectively (e.g. area weighted mean value of soil C stocks from grassland converted to forest land in the Calcareous Alps: $117\ t\ C\ ha^{-1}$, see Table 252).

Annual carbon stock changes in litter at LUC areas from and to forest land:

$$\Delta C_{LT} = A \cdot (C_{LT0} - C_{LT0-t}) / T$$

ΔC_{LT} = average annual carbon stock change in litter ($t\ C\ a^{-1}$)

A = annual area of land converted from forests; or, 20-year LUC area for land converted to forests.

C_{LT0} = carbon stock in litter after conversion, (e.g. $24\ t\ C\ ha^{-1}$ for Calcareous Alps, see Table 250)

C_{LT0-t} = carbon stock in litter before conversion, respectively

T = transition period for the litter carbon stock changes (1 year for LUC areas from forest. 20 years for LUC areas to forest)

Regarding LUCs from and to Wetlands, it is assumed that Wetlands (flooded land) have a soil C stock of $0\ t\ C\ ha^{-1}$. Using the IPCC approach of calculating the C stock change between a period of 20 years leads to unrealistic annual C stock gains (WL to FL) or losses (FL to WL) in mineral soils for these LUCs. Due to a lack of information in literature, no C-stock changes in mineral soil are assumed for LUC between Forest land and Wetlands. The changes WL to FL are higher than those of FL to WL, and FL can be expected to have higher C stocks in soil. Therefore, this approach represents a conservative estimate.

Estimates for the soil C stock changes of the other land-use change categories not involving forests are based on a soil depth of 0–30 cm (see chapters 6.3.1, 6.4.4.2, 6.5.4.2, 6.6.4.1, 6.7.4.1).

6.2.4.2.4 Direct N₂O emissions from N mineralization/immobilization associated with loss of soil organic matter resulting from land use change on mineral soils (4(III))

Increases in available N due to soil C losses from human induced land use changes enhance the mineralisation of soil organic N and therefore cause N₂O emissions. These emissions have been calculated for Grassland converted to forest land because of related C losses in mineral soils. To estimate the associated N₂O emissions, the tier 2 method as provided in the IPCC 2006 GL is applied following eq. 11.1.

To calculate the net annual amount of N mineralized (F_{SOM} , eq. 11.1) from the net carbon stock change (CSC) due to the land use change in the mineral soil, the CSC was divided by the country specific C/N ratio of grassland soils (12, source: see footnote⁹⁸) and multiplied by the default emission factor (EF_1) from Table 11.1 in the IPCC 2006 Guidelines. Then the result was converted from the amount of annual direct N_2O -N to N_2O emissions.

6.2.4.2.5 Indirect N_2O emissions from N leaching and runoff (4(IV))

In addition to the direct N_2O emissions from mineralized soil nitrogen, indirect N_2O emissions occur due to the mineralized N which is leached from the soil. The IPCC 2006 Guidelines provide the following tier 2 methodology in Chapter 11 (eq. 11.10).

F_{CLEACH} is a country-specific factor of 0.15154 (EDER, 2015) and EF_5 is provided in Table 11.3 of the IPCC 2006 Guidelines.

6.2.5 Uncertainty Assessment

The Austrian Federal Research Centre for Forests carried out an in-depth re-assessment of the uncertainty of the biomass C stock changes in Austrian Forests calculated from the NFI (BFW 2010, internal report). A $\pm 40\%$ uncertainty was estimated for the average annual net change in the biomass C stock in the NFI period 2000/02.

It is important to note that due to the design of the NFI the total change in the forest biomass stock also includes the biomass changes caused by LUC to and from forests. So, this $\pm 40\%$ uncertainty is valid for the total biomass changes at “forest land rem. forest land” plus lands of the subcategories with LUC to forests. As a consequence, the estimates of the overall uncertainty of sector 4 were carried out with the total net biomass changes at all forest lands and with the related uncertainty of this total net change.

The stock of dead wood is assessed within the NFI and with the same methods as living biomass. Therefore, we assume that the figures of the dead wood stock change have the same uncertainty as those of living tree biomass ($\pm 40\%$).

For the 2023 submission an improved estimate for the forest soil carbon stock changes on basis of an improved method and model was carried out for the whole time series (see chapter 6.2.4.1.3). For validation purposes, model simulations were conducted on a subset of 123 plots for which soil carbon stocks were measured in 1989 and 2009. The simulated and measured mean soil C stock changes did not differ significantly from one another. However, the comparison showed the spatial variation (standard deviation) of the measured soil carbon stock changes was ca. 3.5 times higher than that of the simulations. This was considered in the uncertainty estimation. For each year of the time series of ca. 8600 plot simulations an average carbon stock change was calculated, together with a respective standard deviation. Based on the above comparison with measured soil carbon stock changes, this standard deviation was increased by a factor of 3.5. For each year, a standard error was calculated (from the increased standard deviation), which was subsequently used to estimate respective 95% confidence intervals. Over the time series an average uncertainty of $\pm 57\%$ was derived, representing a substantial decrease in the soil carbon stock change uncertainties that were reported before the 2023 submission.

The uncertainty of the forest area in yield was estimated with $\pm 2\%$. In addition, the uncertainties of the estimates of the litter/soil C stock changes due to forest road construction (about 10% of the total emissions of the litter/soil pool of 5.A.1) have the following uncertainties associated with the input data: Annual area of forest road construction: $\pm 100\%$ until 1994, $\pm 60\%$ after 1994; soil C stock of the forest road: triangle distribution with 10, 30 and 60 t C ha⁻¹.

For the LUC lands to and from forests the following uncertainties of the input parameters were used. Table 254 shows the uncertainties for the areas of the subcategories with LUC to and from forests:

Table 254: Uncertainties of LUC areas to and from forests.

	before NFI 1985/90 ¹	since NFI 1985/90 ¹
Annual LUC area CL to FL or FL to CL	$\pm 200\%$	$\pm 80\%$
Annual LUC area GL to FL or FL to GL	$\pm 200\%$	$\pm 10\%$
Annual LUC area WL to FL or FL to WL	$\pm 200\%$	$\pm 120\%$
Annual LUC area SL to FL or FL to SL	$\pm 200\%$	$\pm 80\%$
Annual LUC area OL to FL or FL to OL	$\pm 200\%$	$\pm 80\%$
Annual LUC area to or from FL	$\pm 200\%$	$\pm 10\%$

¹ Distributions were truncated at 0, because negative areas are not possible

The uncertainty of the LUC areas to and from forest reflects the statistical design of the NFI. The different uncertainties between the time series reflect the fact that since NFI 1981/85 a fixed grid system has been installed which allows a separate assessment of both, gains and losses of forest land. The NFIs before could only detect the net changes of the forest area between the NFI periods. The differences in the uncertainties of single subcategories reflect the different size of the LUC areas of these subcategories – the constant absolute uncertainty in estimated LUC in ha results in an increasing relative uncertainty the smaller the respective LUC is.

For the litter/soil C stocks of all LUC areas the uncertainties according to Table 255 were used for the estimate of the uncertainties of soil C stock changes. These uncertainties are based on the results of the Austrian soil inventories (Forest land, Cropland and Grassland), on the information of the related literature according to Table 250 (other land) or on expert judgment based on information from related studies. For data based on soil inventories, two-times the standard error of mean was taken as the uncertainty estimate instead of twice the standard deviation as in previous submissions.

Table 255: Uncertainties of the litter/soil C stocks in the forest growth regions according to Table 250.

IPCC LU categories	National LU categories	Forest growth regions					Austria
		Bohemian Massif	Inner alps	Calcareous alps	Foothills	Alpine Ridge	
		%					
Forest – litter	Forest	±29	±34	±29	±29	±16	±13
Forest – mineral soil	Forest	±30	±18	±14	±26	±13	±8
Cropland	Annual cropland, fallows	±4	±20	±18	±3	±12	±2
	Vineyards, Orchards/ garden land	±3	±25	±20	±2	±15	±2

IPCC LU categories	National LU categories	Forest growth regions					Austria
		Bohemian Massif	Inner alps	Calcareous alps	Foothills	Alpine Ridge	
		%					
Grassland	grassland intensive use	±7	±8	±5	±4	±4	±3
	grassland extensive use	±5	±7	±10	±21	±9	±5
Settlements	Settlements and traffic area	Triangle distribution 10–54–75 t C ha ⁻¹					
	Industrial and mining areas, dumps	Triangle distribution 5–30–50 t C ha ⁻¹					
Other land	Alpine shrub lands	Triangle distribution 15–119–567 t C ha ⁻¹					
	Rocks and stone slopes:	Uniform distribution 0–13 t C ha ⁻¹					
	Other land uses	Uniform distribution 0–70 t C ha ⁻¹					

The uncertainties for the N₂O emission factors from soil due to land-use changes can be seen in Table 265, chapter 6.3.5.

For the forest fire estimates default uncertainties for the biomass consumption and emission factors according to the IPCC 2006 GL were used.

Monte-Carlo simulations based on the above uncertainties and distribution assumptions gave an average uncertainty of the total emissions/removals of the complete forest land category of ±4 696 kt CO₂ across the years. This represents on average an uncertainty of ±45%.

As expected from the high share of the Forest land category in the total Austrian area and the large contribution of Forest land to the total GHG balance of the LULUCF sector, the Forest land category has the highest impact on the total sector uncertainty.

6.2.6 Category-specific QA/QC

The NFI is based on a very comprehensive quality assurance system which allows the exact identification of sample points in the field, guarantees the repeated measurement of the right trees (permanent marked grid) and flags up implausible figures for individual parameters during the measurements on site and any missing trees compared to the period before (further details are given in HAUKE & SCHADAUER (2009) and SCHIELER & HAUKE (2001)).

The calculation of the data for category 4.A is embedded in the overall QA/QC-system of the Austrian GHG inventory (see chapter 6.1.4).

6.2.7 Recalculations

The soil carbon stocks of land-use changes from/to settlement were updated on basis of an updated sealing ratio, which caused minor changes for the land-use change subcategory *Settlement to Forest land* for the whole time series in the range of -4.0 and 3.5 kt CO₂e per year compared to the last submission in 2023. The *Forest land* results for the years 2020 to 2022 are extrapolated using the results of the last NFI 2016/21 and relative harvest indices based on the harvest statistics for

these years. By introduction of a new reported year, the derived relative harvest indices for the years since 2020 and the biomass losses due to harvest have changed accordingly. Therefore, the *Forest land* results for the years 2020 and 2021 of this submission differ from those of the 2023 submission by -941 kt CO₂e (2020) and -1 031 kt CO₂e (2021).

6.2.8 Planned improvements

See Chapter 6.1.8.

6.3 Cropland (Category 4.B)

6.3.1 Category description

Emissions and removals from Cropland remaining cropland and Land converted to cropland are reported under Category 4.B Cropland. The calculations were made for all individual years from 1990 to 2022. Some management practices (e.g. slash and burn etc.) and some LUC subcategories (categories 4.B.2.3, 4.B.2.4, 4.B.2.5) do not occur in Austria. Organic soils occur only in the Grassland category in Austria. Changes in dead wood and litter carbon stocks do not occur in Cropland, apart from respective carbon losses in these pools due to Forest land converted to Cropland.

Emissions/removals were estimated for the subcategories and related sources/sinks as shown in Table 256.

Table 256: Sources (or sinks) considered for cropland.

Category/source or sink
4.B Cropland – total
4.B.1 Cropland remaining cropland
- carbon stock change in biomass of “perennial cropland remaining perennial cropland” and carbon stock changes in biomass due to conversions between annual and perennial cropland
- soil carbon stock changes due to management changes in “annual cropland remaining annual cropland” and “perennial cropland remaining perennial cropland” and due to conversions between annual and perennial cropland
- N ₂ O, CH ₄ emissions due to wildfires (“IE” under the Grassland category)
4.B.2 Land converted to cropland
4.B.2.1 Forest land converted to cropland
- carbon stock change in biomass due to LUC from forest land to cropland
- carbon stock change in DOM ⁹⁹ due to LUC from forest land to cropland
- carbon stock change in SOM ¹⁰⁰ due to LUC from forest land to cropland
- N ₂ O emissions from soils due to LUC from forest land to cropland
- N ₂ O emissions from soils due to N leaching and runoff
4.B.2.2 Grassland converted to cropland
- carbon stock change in biomass due to LUC from grassland to cropland
- carbon stock change in SOM due to LUC from grassland to cropland

⁹⁹ DOM = Dead Organic Matter

¹⁰⁰ SOM = Soil Organic Matter

Category/source or sink

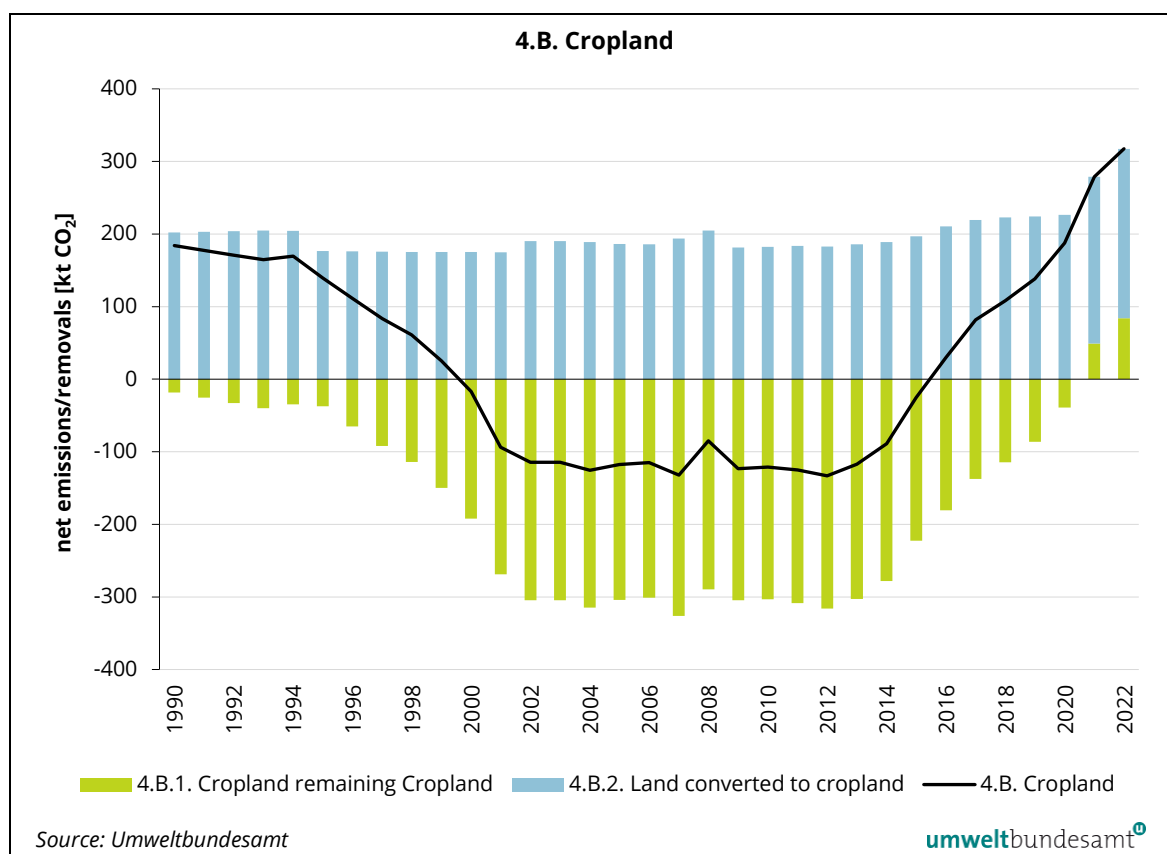
- N₂O emissions from soils due to LUC from grassland to cropland
- N₂O emissions from soils due to N leaching and runoff

In 2022 1.40 million ha were identified as cropland including annual and perennial crops (STATISTIK AUSTRIA 2018, 2021a, 2021b, 2022a). The total Cropland area in Austria has been decreasing over the reported time series.

The total CO₂ emissions and removals of Cropland range between -133 and 318 Gg CO₂, with emissions reported during the 90s, removals between 2000 and 2015, and again emissions since 2016 (

Table 257). The CO₂ emissions during the 90s were mainly caused by the soil C loss caused by conversion from Grassland to annual cropland and from Forest land to Cropland. The net CO₂ removals between 2000 and 2015 are largely due to the increase of soil organic carbon in Cropland remaining cropland, due to specific management measures implemented by the Austrian agri-environmental program, ÖPUL. This program was introduced in 1995, when Austria joined the EU. After a period of net CO₂ removals up to 2015, the net CO₂ emissions from this subcategory were calculated for the year 2016, with emissions increasing since then. The reason for this is that the increases in soil carbon stocks resulting from the ÖPUL programme are starting to level off as the land parcels applying ÖPUL measures reach their new equilibrium soil carbon stocks. Furthermore, the area of Cropland applying certain ÖPUL measures has also been decreasing over time, leading to soil carbon stock losses.

Figure 36: Emissions /removals (+/-) from cropland (1990–2022) by cropland remaining cropland and land use change to cropland in kt CO₂



In 2022 the total land use change area to cropland was 61 657 ha (over a transition period of 20 years). The total annual carbon dioxide emissions of Land converted to cropland over 1990–2022 range from 175 kt CO₂ to 233 kt CO₂ (Table 258).

Figure 37: Emissions /removals (+/-) from cropland (1990–2022) by carbon pools in kt CO₂

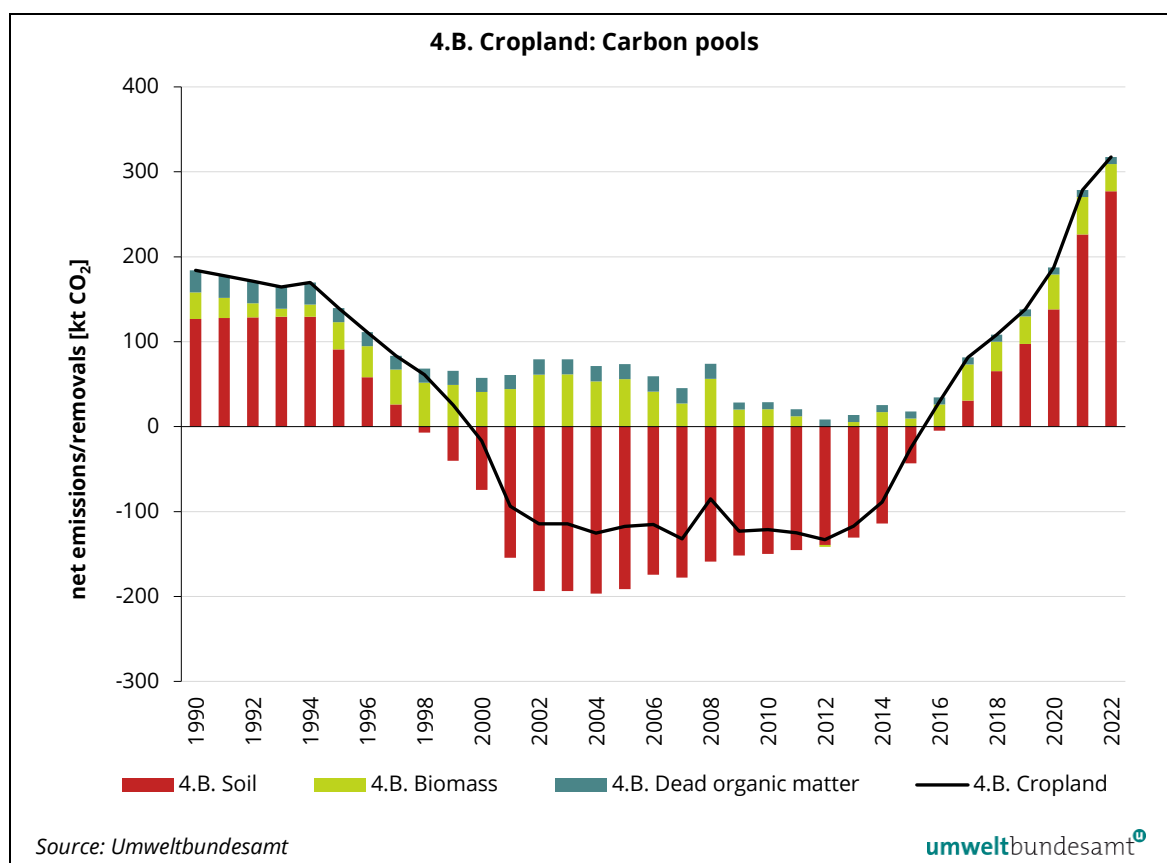


Table 257: Total areas and land-use change areas of cropland (1990–2022) in ha – transition period of 20 years for LUC lands.

	4.B Total cropland	4.B.1.Cropland remaining cropland-total	a. annual remaining annual & perennial remaining perennial	b. annual cropland converted to perennial cropland	c. perennial cropland converted to annual cropland	4.B. 2. Land converted to cropland	2.1 Forest Land converted to cropland	2.2 Grassland Land converted to cropland - total	a. Grassland converted to annual cropland	b. Grassland converted to perennial cropland	2.3 Wetland converted to Cropland	2.4 Settlement converted to cropland	2.5 Other Land converted to cropland
1990	1 500 824	1 465 600	1 445 629	12 443	7 529	35 224	4 125	31 099	30 563	535	NO	NO	NO
1995	1 493 201	1 457 617	1 437 790	12 353	7 474	35 584	4 710	30 874	30 342	532	NO	NO	NO
2000	1 473 875	1 438 802	1 419 170	12 231	7 401	35 073	4 504	30 570	30 044	526	NO	NO	NO
2005	1 464 088	1 429 340	1 409 890	12 118	7 332	34 748	4 463	30 285	29 764	521	NO	NO	NO
2010	1 440 524	1 396 504	1 376 051	11 665	8 788	44 020	3 792	40 228	39 622	606	NO	NO	NO
2011	1 438 296	1 394 129	1 373 994	11 368	8 767	44 167	3 644	40 522	39 829	693	NO	NO	NO
2012	1 436 068	1 391 003	1 371 205	11 053	8 745	45 064	3 497	41 567	40 837	730	NO	NO	NO
2013	1 433 839	1 387 971	1 368 544	10 733	8 694	45 868	3 350	42 518	41 752	767	NO	NO	NO

	4.B Total cropland	4.B.1.Cropland remaining cropland-total	a. annual remaining annual & perennial remaining perennial	b. annual cropland converted to perennial cropland	c. perennial cropland converted to annual cropland	4.B. 2. Land converted to cropland	2.1 Forest Land converted to cropland	2.2 Grassland Land converted to cropland - total	a. Grassland converted to annual cropland	b. Grassland converted to perennial cropland	2.3 Wetland converted to Cropland	2.4 Settlement converted to cropland	2.5 Other Land converted to cropland
2014	1 427 921	1 380 573	1 361 065	10 781	8 727	47 348	3 202	44 145	43 305	841	NO	NO	NO
2015	1 421 392	1 369 941	1 349 549	11 134	9 258	51 451	3 143	48 308	47 294	1 014	NO	NO	NO
2016	1 415 330	1 361 091	1 340 076	11 497	9 518	54 238	3 083	51 155	50 007	1 148	NO	NO	NO
2017	1 408 997	1 353 277	1 331 899	11 868	9 511	55 720	3 023	52 696	51 452	1 245	NO	NO	NO
2018	1 403 582	1 347 301	1 325 976	11 789	9 536	56 281	2 964	53 318	52 032	1 285	NO	NO	NO
2019	1 398 102	1 341 033	1 319 672	11 662	9 700	57 069	2 904	54 165	52 849	1 316	NO	NO	NO
2020	1 391 834	1 333 830	1 312 523	11 428	9 879	58 004	2 844	55 160	53 831	1 329	NO	NO	NO
2021	1 390 513	1 331 564	1 310 237	11 231	10 097	58 949	2 785	56 164	54 820	1 344	NO	NO	NO
2022	1 391 342	1 329 685	1 308 381	10 980	10 323	61 657	2 657	59 000	57 633	1 367	NO	NO	NO

Table 258:Emissions /removals (+/-) from cropland (1990–2022) in kt CO₂ and N₂O emissions in kt CO₂eq; other land use changes are not occurring.

	4 B Total Cropland_CO ₂	4 B 1 Cropland remaining Cropland_CO ₂	a. Annual remaining annual and perennial remaining perennial cropland_CO ₂	b. Annual cropland converted to perennial cropland_CO ₂	c. Perennial cropland converted to annual cropland_CO ₂	4 B 2 Land converted to cropland_CO ₂	2.1 Forest land converted to cropland_CO ₂	2.2 Grassland converted to cropland_CO ₂	2.2.a Grassland converted to annual cropland_CO ₂	2.2.b Grassland converted to perennial cropland_CO ₂	4(III)B2_N ₂ O emissions due to C losses in managed soils_N ₂ O in CO ₂ eq	4(IV)A2_N ₂ O emissions from N leaching and runoff_N ₂ O in CO ₂ eq
1990	183.91	-18.21	-13.61	-13.47	8.88	202.12	94.12	108.00	106.71	1.29	11.91	1.35
1995	139.51	-37.16	-32.67	-13.30	8.81	176.66	69.47	107.19	105.91	1.28	12.00	1.36
2000	-17.00	-192.06	-187.59	-13.19	8.72	175.05	68.91	106.15	104.88	1.27	11.83	1.34
2005	-117.57	-304.01	-297.05	-15.84	8.89	186.44	82.27	104.17	103.18	0.99	11.61	1.32
2010	-121.20	-303.41	-298.50	-15.14	10.23	182.21	41.33	140.88	138.98	1.90	14.76	1.68
2011	-124.97	-308.71	-300.92	-18.30	10.51	183.74	40.46	143.28	139.95	3.33	14.79	1.68
2012	-133.17	-315.89	-308.38	-18.00	10.48	182.73	39.62	143.11	140.78	2.33	15.10	1.72
2013	-117.07	-302.70	-295.76	-17.42	10.48	185.63	38.79	146.84	144.47	2.38	15.37	1.75
2014	-89.00	-278.09	-279.92	-8.52	10.35	189.09	37.95	151.14	147.88	3.26	15.87	1.80
2015	-25.43	-222.34	-230.43	-1.87	9.96	196.91	37.54	159.37	153.80	5.57	17.27	1.96
2016	29.64	-180.77	-189.12	-2.53	10.88	210.41	37.13	173.28	168.33	4.95	18.21	2.07
2017	81.56	-137.63	-145.84	-3.22	11.44	219.18	36.72	182.46	178.18	4.28	18.70	2.13
2018	108.32	-114.57	-111.91	-14.06	11.41	222.89	36.30	186.58	183.41	3.17	18.88	2.15
2019	138.10	-86.30	-82.64	-14.99	11.32	224.40	35.82	188.58	185.57	3.01	19.15	2.18
2020	187.57	-39.00	-33.44	-17.08	11.52	226.57	35.33	191.24	188.59	2.66	19.46	2.21
2021	278.72	48.97	53.00	-15.74	11.72	229.75	34.84	194.90	192.19	2.71	19.78	2.25
2022	317.46	84.06	88.58	-16.51	11.99	233.40	34.49	198.91	195.99	2.92	20.74	2.36

6.3.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The data for total Cropland areas were taken from national statistics (STATISTIK AUSTRIA 2021a, STATISTIK AUSTRIA 2021b, STATISTIK AUSTRIA 2018, STATISTIK AUSTRIA 2022a, STATISTIK AUSTRIA 2022b, STATISTIK AUSTRIA 2023h), that were processed in the *LU Area Statistics* element of the Austrian system for land representation (see 6.1.3.1). The area of Cropland remaining cropland represents the total Cropland area minus Land converted to cropland.

Since 1990 the Cropland area statistics of „Statistik Austria“ has been used for the activity data. These data are based on the Farm Structure Survey (FSS). In the years when the full FSS was conducted (1990, 1995, 1999, 2010 and 2020) these data were taken (ÖSTAT 1991, 1998, STATISTIK AUSTRIA 2001, 2013, 2022a). 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, 2018). Since joining the EU in 1995, Austria operates the IACS data base, which in contrast to FSS is updated yearly, but includes only Cropland area (and Grassland area) of farms that receive support under the CAP. Nonetheless, the proportion of total Cropland in the IACS data base has increased over time, with almost all Cropland now included. (see below).

For the total annual cropland area the data from the FSS differ somewhat from the IACS data. In most years the area taken from the FSS database is slightly larger, because a larger number of farms is included in FSS compared to IACS. Since the 2022 submission the annual total cropland area is simply interpolated (linear) for the non-FSS years and over certain intermediate random sample FSS years (e.g. 2003 and 2005), for which time series consistency issues were identified. For the coming years until the next FSS we extrapolate using the relation factor of the FSS 2020 and IACS annual cropland area of every year.

Data for perennial cropland area (viticulture, orchards, house gardens, Christmas trees and perennial energy crops) were also taken from the full and random sample FSS data, with intermediate years interpolated.

In the orchards time series there are two discontinuities which led to substantial area changes:

- Between 1968 and 1969 there was a sharp increase in the orchard area, probably caused by the inclusion of extensive orchards area for the first time.
- Between 1982 and 1983 there was a considerable decrease in the orchard area probably due to the changed delimitation: the threshold for the minimum unit was raised from 0.5 to 1 ha. In addition, from 1983 on, municipalities were no longer obliged to report small areas and unproductive agricultural areas, which were reported before under the orchards category.

For time series consistency, the area for orchards was extrapolated backwards until 1960.

In the time series for house gardens two sharp changes occurred:

- Between 1982 and 1983: this is probably due to the changed delimitation: the threshold for the minimum unit was raised from 0.5 to 1 ha. In addition, from 1983 on municipalities were no longer obliged to report small areas and unproductive agricultural areas, which were reported before under the house gardens category.

- Between 1994 and 1995: This might be a result of the new Common Agricultural Policy (CAP) of the EU, because house gardens are no longer supported under this policy, and it is likely that these areas were then reported under cropland or grassland.

For time series consistency the area of house gardens between 1960 and 1995 was therefore interpolated to remove the above potential systematic errors during this period.

Since the 2022 submission, the planted vineyard area of the basic vineyard surveys (Weingarten-grunderhebungen) for the years 2009, 2015 and 2020 (Statistik Austria 2011, 2016, 2021) was used for the viticulture area, as these explicitly comprise the vineyard area planted with vine stems. For time series consistency the area of vineyards between 2009, 2015 and 2020 was interpolated.

After the above filtering and interpolation steps have been performed, the annual time series of total Cropland area undergoes a minimal correction in the *LULUC Data Integration* element of the Austrian system for land representation to ensure full consistency in the land transition matrices (see 6.1.3.1).

Areas for land-use change/conversions between grassland, annual cropland and perennial cropland have been estimated from spatially-explicit data from the Integrated Administration and Control System – Land Parcel Information System (IACS-LPIS). The processing of these data take place within a dedicated element (the *IACS-LPIS (CL<->GL)* element) of the Austrian system for land representation. In Austria the majority of farmers participate in the CAP and therefore the IACS data base comprises about 99% of the total agricultural area according to the FSS (2020: IACS: 2 564 931 ha, FSS: 2 602 666 ha, BML, 2023). LPIS is a part of IACS and contains a geographical representation of the agricultural parcels of land per farm. It includes quantitative data including parcel area and boundaries and qualitative data including crop description. In Austria, it is obligatory that, in the case of application for/-receipt of CAP subsidies, agricultural land parcels are identified at the plot level (graphically and digitally) using farm maps (cartographic documents which comprise an aerial photograph and the outline of the individual parcels).

By means of these data, detailed information on the area of Cropland (annual, perennial) and Grassland, as well as changes between the two categories, are derived. However, as IACS data is primarily used for yearly administration of payments, it does not contain a fully-consistent and complete identification of land use and management of parcels over time. Furthermore, in 2016, the format of the data changed from a classical database structure to a GIS system, whereby the individual fields and land parcels (and associated land use and management information) are now spatially delineated. Some workaround is thus necessary for the analysis of time series (see next paragraphs).

For the previous 2023 submission, a single processing routine was developed for the *IACS-LPIS (CL<->GL)* element to analyse and quantify all respective changes between annual cropland, perennial cropland and grassland. The routine is implemented in five steps:

- **Sampling of IACS GIS data for the years 2016 onwards.** Using the centre points (centroids) of the 100m x 100m cells of the INSPIRE geographical grid system, land use and management information are systematically sampled from the IACS GIS data for each year from 2016 onwards. Specifically, information on the agricultural land use (*Schlagnutzungsart*) is queried each year from each of the fixed sample points. It should also be noted that respective cadastral parcel-IDs of the 2016 *Digitale Katastralmappe* (DKM; digital cadastral map, polygon data set) have been assigned to each INSPIRE grid point to allow the data from the IACS GIS system to be joined with IACS data from the previous database format.

- **Merging of data from 2016 onwards with the IACS data from the previous database format (2002-2015).** An SQL query of the previous database generated a 2002-2015 time series of agricultural land use (*Schlagnutzungsart*) and area size for each cadastral parcel-ID contained within the database. Due to some inconsistency and incompleteness issues in the previous database, as well as the consequence that data from 2016 onwards can only be joined at the aggregated land parcel level, a subset of the queried data was retained for analysis of LUCs. The selection of the subset was based on land parcels that are:
 - available for all years; and
 - relatively constant in terms of area size over the time series; and
 - categorised by relatively homogenous land-use

This subset of 2002-2015 data are then merged with the IACS GIS data for the years 2016 onwards using cadastral parcel-IDs as the joining variable common to both datasets. The result is a 2002-2022 time series of IACS agricultural land use (categorised as *annual cropland*, *perennial cropland*, *grassland* and *other* based on the *Schlagnutzungsart*) for each INSPIRE grid point of the Austrian territory, albeit incomplete for the years 2002-2015.

- **Correction of short-term land use changes/conversions.** For each INSPIRE grid point, the routine checks for- and subsequently corrects short-term land-use changes/conversions between annual cropland, perennial cropland, grassland and other. The check and correction is implemented to detect annual changes in agricultural land use, and check when the subsequent land use remains stable for at least the following five years. If within the subsequent 5 years, another land-use change/conversion (backwards to the initial subcategory) is detected, the initial land-use change/conversion is removed by correcting the land use to that of the previous year. Obviously, the routine would be limited in being able to detect and correct short-term land-use changes/conversions in the last five of the time series. Therefore, the above detection and correction process is first applied to the time series up to the last five available years. The partially corrected time series is subsequently analysed to quantify the respective sum of areas for each land-use conversion category (e.g. annual cropland to grassland, grassland to annual cropland etc) for each year. Comparison of the corrected and uncorrected timeseries up to the last five available years, allows respective relative reduction factors for each land-use conversion to be calculated and applied to the total annual land use changes/conversions for the last five years of the time series.
- **Calculation of land-use changes/conversions as percentages of total analysed Cropland area, harmonisation and extrapolation over the time series.** After the above correction for short-term land-use changes/conversions, the annual land-use change/conversion areas in ha are expressed as percentages of the total cropland area per year in the respective analysed datasets (which does not represent total Cropland area of Austria). For conversions between the annual and perennial cropland, as well as changes from grassland to annual/perennial cropland, the change/conversion areas are expressed in percentages of the total analysed Cropland area in the same year. For changes from annual/perennial cropland to grassland, the annual changes are expressed as percentages of total analysed Cropland area in the previous year. The rationale behind using Cropland area, rather than respective Cropland and Grassland areas is that the time series for this total analysed Cropland area in the inventory is considered more reliable than the total analysed Grassland area.

The result of the above is a time series of land-use changes/conversions between annual cropland, perennial cropland and grassland expressed as percentages of the analysed total Cropland area (total area either in the same year or the year before). Before these can be

applied to calculate total land-use changes/conversions over the Austrian territory the data from 2002 to 2015 are first harmonised with those from 2016 onwards. First of all, the values for changes/conversions between 2015-2016 are omitted, because of the sharp peaks caused by the change from an aggregate land-parcel classification to a classification at ha resolution. Secondly, we adjust the average level of the respective changes/conversions between 2002-2015 to that of the average changes/conversions from 2016 onwards. As 2002-2015 represents only a subset of the land parcels within IACS, a systematic bias is expected in the data pre-2015 and is thus corrected for by the difference in mean land use changes/conversions between 2002-2015 and 2016 onwards. After this level correction, the gaps introduced by omitting the land use changes/conversions between 2015-2016 are filled by interpolation.

Finally, the historic annual land-use changes/conversions outside of the IACS data range (between 2001/2002 back to 1970/1971) are filled by extrapolating the respective mean annual shares of land use changes/conversions calculated between 2002/2003 and 2004/2005.

- **Total area estimates of land-use changes/conversions for the Austrian territory.** The result of the above four steps of the processing routine is a 1971-2022 time series of annual land-use changes/conversions between annual cropland, perennial cropland and grassland expressed as percentages of total analysed Cropland area (in the same year or in the year before). These resulting shares of land-use changes/conversions for the individual years of the whole time series are multiplied with the total Austrian Cropland area of the respective year to get the final land-use change/conversion areas between annual cropland, perennial cropland and grassland. In 2022, the following land-use change areas derived from the above method amounted to:
 - Annual cropland to perennial cropland – 0.03% of the total Cropland area in 2022
 - Perennial cropland to annual cropland – 0.04% of the total Cropland area in 2022
 - Grassland to perennial cropland – 0.004% of the total Cropland area in 2022
 - Grassland to annual cropland – 0.31% of the total Cropland area in 2022
 - Annual cropland to grassland – 0.17% of the total Cropland area in 2021
 - Perennial cropland to grassland – 0.004% of the total Cropland area in 2021

The areas of the LUC Forest land to Cropland are provided by the *NFI* element of the Austrian system for land representation (see chapter 6.2.2.2).

LUCs from Wetlands, from Settlements and from Other land to Cropland do not occur in Austria. This assumption is based on the fact that the Cropland area shows a steady decrease and that the areas of Wetlands, Settlements and Other land are simply not suitable for conversion to Cropland:

- a. Settlement areas increased steadily in the last decades mainly by LUC from agricultural areas.
- b. Settlement areas and soils – once converted – cannot usually be used for cropland cultivation.
- c. There is also a higher economic value for land dedicated to building land than agricultural land i.e. there is no economic incentive for re-conversion.
- d. Other lands are located in high altitude or very steep areas and therefore have unfavorable ecological conditions for cultivating crops.

6.3.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The STATISTIK AUSTRIA (2008) classification was used for land use definitions:

- Annual cropland (arable land planted with annual crops such as e.g. cereals, corn, rape, field vegetables, strawberries, potatoes, soya beans, energy grass);

Perennial cropland (viticulture, orchards, plantations for fruits, tree nurseries, Christmas trees, perennial woody energy crops with a rotation period < 30 years);

- House gardens (farm-based gardens devoted to the cultivation of agricultural products mostly used for non-profit household demand of the farmer's family. This category includes annual as well as perennial crops).

6.3.4 Methodological Issues

6.3.4.1 Cropland remaining Cropland (4.B.1)

This section provides information about emissions/removals for cropland remaining cropland and comprises:

- a. annual remaining annual cropland
- b. perennial remaining perennial cropland
- c. annual cropland converted to perennial cropland
- d. perennial cropland converted to annual cropland

The areas of annual crops and woody perennial species like orchards, vineyards, perennial house gardens, plantations for Christmas trees and woody energy crops are considered in line with the 2006 IPCC GL, Vol. 4, Ch. 5.1 (IPCC 2006).

The carbon stock changes of living biomass in the subcategory "annual cropland remaining annual cropland" are considered to be zero. For annual crops in the subcategory "annual cropland remaining annual cropland" the increase in biomass stocks in a single year is assumed to be equal to biomass losses from harvest and mortality in the same year – thus there are no net emissions/removals from biomass in the subcategory "annual cropland remaining annual cropland" (IPCC 2006, Vol. 4, Ch. 5.2.1.1).

Emissions/removals were estimated for the changes in woody perennial biomass stocks of the subcategory "perennial cropland remaining perennial cropland" (above-ground and below-ground biomass, see chapter 6.3.4.1.1). In addition, according to 2006 IPCC GL (IPCC 2006), the emissions/removals from stock changes in living biomass (above-ground and below-ground) at conversion areas between annual and perennial croplands have to be considered (IPCC 2006, Vol. 4, Ch. 5.3). Consequently, these emissions/removals were estimated for conversion areas from annual cropland to perennial cropland and vice versa. For that purpose, the carbon stocks of annual crops and perennial crops were estimated and applied to estimate the related emissions/removals (see chapters 6.3.4.1.2 and 6.3.4.1.3).

All biomass stocks and stock changes for Cropland remaining cropland were estimated using country-specific values. The root/shoot ratio of 0.3 for Christmas trees as well as for energy crops (wood) was used for the below-ground biomass. This root/shoot ratio was derived from the results of the

Af-/Reforestation assessment (see chapter 6.2.4.2.1, Tier 2 for below-ground biomass-accumulation according to the IPCC 2006 GL).

The above- and belowground biomass stock and stock changes of orchards and vineyards are estimated using country specific values from a national study undertaken in 2016 and 2017 (see chapter 6.3.4.1.1).

Dead organic matter (DOM) (including the two pools dead wood and litter) is considered not occurring in Cropland remaining cropland. This corresponds to the Tier 1 method according to the IPCC 2006 GL (Vol.4, Ch. 5.2.2.1).

All soil carbon stocks and soil carbon stock changes were estimated using country specific values.

The methodology for the assessment of the mineral soil carbon stock changes (CSC) in annual cropland remaining annual cropland and perennial cropland remaining perennial cropland is based on the results of national studies of long-term field experimental plots (SPIEGEL et al., 2007, UMWELTBUNDESAMT 2010). These studies made it possible to assess the impact of different management regimes (e.g. tillage and organic inputs) on soil carbon stocks and subsequently to estimate the appropriate management factors for the inventory calculations. The method assigns land units into combinations of three tillage types (no-tillage, reduced tillage and full tillage) with variations of input types and input type combinations:

- with/without input from cover crops (between two main crops or evergreen system), which are incorporated into the soil,
- with/without manure input and
- with low/high crop residues input.

The area with cover crops (greening measures) was calculated based on IACS data for 2002 and 2016, the greening areas in the years in between were interpolated. The following rules were applied:

- For 2002, the area of the greening variant E (rape) was excluded, because rape is managed as a main crop and harvested; thus the remains are not incorporated in the soil in spring-time.
- For 2016 the area of the greening variant “evergreen system” had to be adapted, because actually only a share (about 29 %) of these areas is covered by cover crops.

The total annual carbon dioxide removals/emissions of 4.B.1 range between -326 and + 84 kt CO₂ (see Table 258).

In the following subchapters the methodologies and applied factors for the estimates are explained in detail.

6.3.4.1.1 Changes in carbon stock in biomass of annual cropland remaining annual cropland and perennial cropland remaining perennial cropland (4.B.1.a)

In accordance with the 2006 IPCC GL, Vol. 4, Ch. 5.2.1.1, the carbon stock changes of living biomass in the subcategory “annual cropland remaining annual cropland” are estimated to be zero.

For the subcategory “perennial cropland remaining perennial cropland” the C stock changes in biomass are estimated. Perennial cropland includes:

- Viticulture (vineyards),

- Orchards: this category includes plantations of woody plants for the purpose of obtaining fruits (99 % of the total orchard area) as well as tree nurseries (1% of the total orchard area),
- Gardens: a 50% share of house gardens is assumed to be perennial,
- Energy crops: short rotation plantations < 30 years (perennial woody energy crops) and
- Christmas tree plantations.

The observation period started in 1960 and is based entirely on the activity data from Statistik Austria derived from the Farm Structure Surveys (FSS) data (ÖSTAT 1991, 1994, 1998, STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013, 2014, 2018, 2022a), yearly agricultural statistics (STATISTIK AUSTRIA 1960–2020, STATISTIK AUSTRIA 2021a, 2022b, 2023h) and vineyards survey (STATISTIK AUSTRIA 2011, 2016, 2021b). As the time series from the 1960's showed some inconsistencies due to the intervals of full agricultural surveys and changes in data collection, the data of the time series were interpolated and thus smoothed across these inconsistent periods. As activity data for perennial cropland, except vineyards since 2009, are available only from Farm Structure Surveys, the areas of the last available FSS are reported until the next FSS data are available. The vineyard area is taken from the vineyard surveys (Weingartengrunderhebungen) for the years 2009, 2015 and 2020 (Statistik Austria 2011, 2016, 2021b), with the years between surveys interpolated.

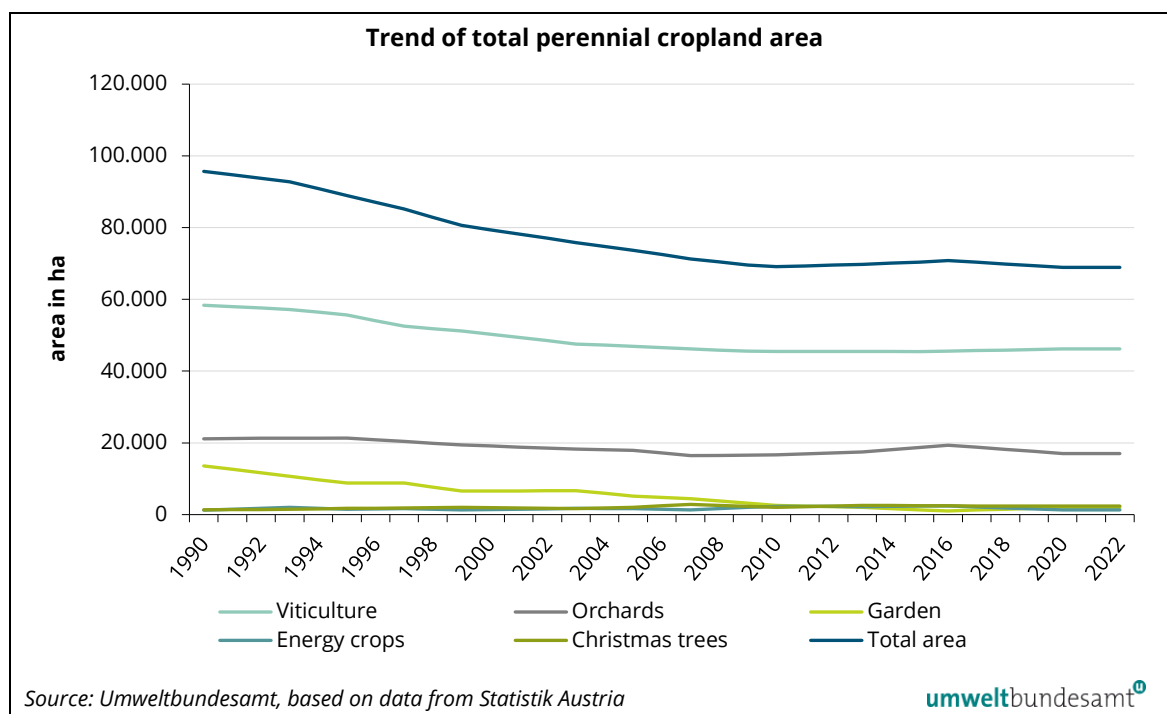
Table 259: Estimated total area of perennial crops from 1990–2022 in ha.

	Viticulture	Orchards	Garden	Energy crops	Christmas trees	Total area
1990	58 364	21 146	13 572	1 254	1 347	95 683
1995	55 627	21 335	8 774	1 463	1 754	88 953
2000	50 304	19 140	6 609	1 403	1 962	79 418
2005	46 892	17 882	5 191	1 700	2 048	73 713
2010	45 517	16 671	2 576	2 330	2 002	69 096
2011	45 502	16 928	2 393	2 299	2 204	69 325
2012	45 486	17 185	2 209	2 267	2 406	69 554
2013	45 470	17 442	2 026	2 236	2 608	69 782
2014	45 454	18 088	1 690	2 298	2 554	70 084
2015	45 439	18 734	1 355	2 359	2 499	70 386
2016	45 584	19 380	1 019	2 421	2 445	70 849
2017	45 729	18 789	1 279	2 149	2 421	70 367
2018	45 874	18 198	1 539	1 878	2 396	69 886
2019	46 020	17 607	1 799	1 606	2 372	69 404
2020	46 165	17 016	2 060	1 334	2 348	68 923
2021	46 165	17 016	2 060	1 334	2 348	68 923
2022	46 165	17 016	2 060	1 334	2 348	68 923

Figure 38 illustrates the decrease of the total perennial cropland area from 1990 to 2009 and the subsequent stabilisation of areas thereafter. The decrease up to 2009 was mainly caused by the continuous decline in the fruit growing area (orchards) and, in particular, the house garden area. The area under vine production – which has the highest share of perennial crop area – increased until 1990, resulting in a net sink of the entire perennial crop category in the first years of the 1990's. However, the decline of the vine area after 1990 led to perennial biomass losses (and thus emissions) after 1994. The related losses of older perennial biomass at the end of rotation periods is not compensated by the growth of the replanted areas of "perennial cropland remaining perennial cropland" due to conversions and a related imbalance in the age-area distribution in "perennial cropland remaining perennial cropland". The above dynamics are thus driving a general trend of biomass C loss from this subcategory. The variability in biomass C stock changes from year to year

is also caused by the conversions from perennial cropland to other agricultural land uses. Such changes are usually due to economic reasons and are carried out at the end of the rotation period.

Figure 38: Trend of total perennial cropland area (ha) from 1990–2022.



In 2016 and 2017, a national survey to estimate the biomass for viticulture and orchards was conducted. Winemakers and orchard farmers were contacted with the support of the Austrian agricultural chamber. In the case of vineyard/orchard clearing, the farmers were asked to weigh the cleared biomass and to fill out a questionnaire and provide information on their plantations (species, weight of above and belowground biomass of the plants, number of weighted plants, number of plants per ha, age of the plants). From the results of the survey of 28 vineyards and 20 orchards, average Austrian biomass stocks at the end of the rotation period, annual biomass growth rates and the average rotation periods for these perennial cultures were derived (Table 260). The annual biomass growth rates were determined by means of regression analysis. For the conversion from fresh biomass to dry matter the country specific values of 0.56 for wine and 0.5 for orchards were applied.

Table 260: Biomass carbon stock and annual biomass carbon accumulation rate of perennial cropland cultures.

Perennial crop	Carbon stock of above- and belowground biomass at end of rotation period (t C ha ⁻¹)	Annual increase in above- and below-ground biomass carbon stock (t C ha ⁻¹ a ⁻¹)	Rotation period (years)	Method
Vineyards	3.37	0.096	35	country specific values
Orchards	13.41	0.745	18	country specific values
House gardens	13.41	0.745	18	country specific values
Christmas trees	46.8	4.68	10	country specific values
Energy wood crops	39	6.50	6	country specific values

For calculating the carbon stock change of living biomass of vineyards remaining vineyards the following equation was applied using country specific data:

$$\text{Annual change in biomass} = (\text{area of viticulture remaining viticulture} * \text{annual carbon accumulation rate}) - (\text{area of viticulture remaining viticulture 35 years earlier} * 0.029 \text{ (i.e. proportion of area at end of rotation period)} * \text{biomass carbon stock at end of rotation period})$$

From the national survey on viticulture a country-specific average value for total above and below ground vineyard biomass stock at the end of rotation period of 3.37 t C ha⁻¹ was estimated. The annual accumulation rate of vineyard biomass is 0.096 t C ha⁻¹ a⁻¹ and the rotation period of wine is 35 years.

For orchards the carbon stock of above and below ground biomass stock at the end of rotation period amounts to 13.41 t C ha⁻¹. Based on the information provided by the farmers the average rotation period of orchards is 18 years. The annual biomass accumulation rate is 0.745 t C ha⁻¹ a⁻¹.

For calculating the carbon stock change of living biomass from orchards remaining orchards the following equation was applied using country specific data:

$$\text{Annual change in biomass} = (\text{area of orchard remaining orchard} * \text{annual carbon accumulation rate}) - (\text{area of orchard remaining orchard 18 years earlier} * 0.056 \text{ (i.e. proportion of area at end of rotation period)} * \text{biomass carbon stock at end of rotation period})$$

For 50% of the house garden area, the same emission factor as for orchards is applied. It is assumed that this perennial proportion of house garden area is covered completely by orchards.

Viticulture and orchards have by far the highest proportion of the perennial cropland area. Therefore, their biomass emission factors are considered in the LUCs and conversions involving perennial cropland. Weighted means for perennial cropland biomass in case of conversions or LUCs is calculated on basis of the different areas and emission factors for vineyards and orchards. The approach is considered to provide the most accurate estimates of perennial biomass stocks and stock changes for Austria and is justified as follows:

- vineyards and orchards have by far the highest proportion of the perennial cropland area (about 95% including the orchard share of house gardens), and therefore their biomass carbon stock change factors are representative and suitable for land-use changes/conversions of perennial cropland;
- the area of the other perennial cultures (perennial energy crops, Christmas trees) is not only much smaller, but also more stable across time (Figure 38); and
- the respective stocks and stock change factors are country-specific values that have been derived from national biomass sampling studies of perennial crop types.

Therefore, the weighted mean factors from vineyards and orchards are considered to be appropriate, since they represent the subcategories with the highest shares in perennial cropland area and have undergone the most significant decreases in area in the past.

In relation to the area of land-use conversions, it is assumed that land-use changes/conversions involve vineyards and orchards crops in the same ratio as their area distribution, based on means for the years back to 1990. As such, the following values are applied for perennial croplands in case of LUCs and conversions: an average perennial biomass carbon stock before conversion of 6.09 t C ha⁻¹ and an average annual biomass carbon accumulation rate of 0.27 t C ha⁻¹ a⁻¹.

Christmas trees and woody energy crops have only a small share of the perennial cropland area and the calculation is based on country specific values (Tier 2). For Christmas trees and woody energy crops a country specific steady state of biomass increase over 10 years and 6 years of rotation period, respectively, was assumed. The energy wood crop cultivation was assumed to start in 1990 (according to Statistik Austria), so after a rotation period of 6 years, that is from 1996 onwards, the energy wood crops cause gross emissions parallel to gross removals in the growing biomass.

For calculating the carbon stock change of living biomass from Christmas tree cultures remaining Christmas tree cultures the following equation was applied using country specific data:

$$\text{Annual change in biomass} = (\text{area of Christmas tree cultures remaining Christmas tree cultures} * \text{Carbon accumulation rate}) - (\text{area of Christmas tree cultures remaining Christmas tree cultures 10 years earlier} * 0.1 \text{ (i.e. proportion of area at end of rotation period)}) * \text{biomass carbon stock at end of rotation period}$$

According to BMLFUW (2000) and expert judgement a country specific average value of 36 t C ha⁻¹ for the carbon stock of Christmas trees at harvest (above-ground biomass) was used. The rotation period for Christmas trees is 10 years, which leads to an accumulation rate of 3.6 t C ha⁻¹ a⁻¹ in above-ground biomass. By using the root/shoot ratio of 0.3 for Christmas trees, which was derived from the results of the Af-/Reforestation assessment (see chapter 6.2.4.2.1), also the belowground biomass was estimated. So, 4.68 t C ha⁻¹ a⁻¹ annual total biomass accumulation rate and a total biomass carbon stock of 46.8 t C ha⁻¹ at harvest was computed and applied for Christmas trees cultures (above-ground and below-ground) for all years.

For energy wood crops a country specific value of 30 t C ha⁻¹ for the carbon stock at harvest for above ground biomass was used (SPLECHTNA & GLATZEL 2005). According to this literature the rotation period for energy wood crops is six years. This leads to an annual carbon accumulation rate in above ground biomass of 5 t C ha⁻¹ a⁻¹ for energy crops. By using the root/shoot ratio of 0.3 for energy crops (wood), which was derived from the ARD-NFI-results, the belowground biomass could be estimated as well. Including the root biomass, a factor of 6.5 t C ha⁻¹ a⁻¹ total annual biomass accumulation rate and a total biomass carbon stock of 39 t C ha⁻¹ at harvest was computed and applied for energy wood crops biomass (above-ground and below-ground) for all years.

For calculating the carbon stock change of living biomass on energy wood crops the following equation was applied:

$$\text{Annual change in biomass of energy crops} = (\text{area of energy wood crops remaining energy wood crops} * \text{Carbon accumulation rate}) - (\text{area of energy wood crops remaining energy wood crops 6 years earlier} * 0.166 \text{ (i.e. proportion of area at end of rotation period)}) * \text{biomass carbon stock at end of rotation period}$$

6.3.4.1.2 Changes in carbon stocks in biomass of annual cropland converted to perennial cropland (4.B.1.b)

The total conversion area from annual cropland converted to perennial cropland over a transition period of 20 years was 10 980 ha in 2022.

The applied method is consistent with the 2006 IPCC approaches for LUCs (IPCC 2006, ch. 5.3 “Land converted to cropland”, ch. 5.3.1.1 for biomass calculations). It is important to note that the 2006 IPCC GL do not foresee any method for conversions between annual and perennial cropland in the cropland category. However, annual cropland and perennial cropland have different C stocks and C accumulation rates in both biomass and soil. Therefore our approach to account for the C stock

changes due to conversions between annual cropland and perennial cropland gives a more accurate picture of the emissions/removals of the subcategory “cropland remaining cropland”. This approach regarding soil C stock changes of such conversion lands does not represent any double accounting to the estimates in the soil C pool (the estimates in chapters 6.3.4.1.4. and 6.3.4.1.6), because the estimates of the soil C stock changes in these subcategories only account for the change in “land management factors” of “annual cropland remaining annual cropland” and for the change between the equilibrium soil C stocks of annual cropland and perennial cropland (or vice versa) when conversions between these two cropland subcategories occur. The activity data for estimating these emissions/removals strictly represent the areas of these “cropland remaining cropland” subcategories.

In accordance with the method described in chapter 5.3.1.1 and equation 2.15 and 2.16 of the 2006 IPCC GL the biomass gains or losses of annual crops due to LUC to/from annual cropland have to be accounted once, namely in the initial year of LUC (even though annual crops represent a biomass C pool only during the growing season and not during the whole year).

For the calculation of the annual change in carbon stocks in living biomass of annual cropland converted to perennial cropland the 2006 IPCC GL equations 2.15 and 2.16 were applied (IPCC 2006). For perennial cropland a weighted average annual growth according to the Austrian survey on viticulture and orchards ($0.27 \text{ t C ha}^{-1}\text{a}^{-1}$) was assumed for each year of the whole transition period of 20 years (see chapter 6.3.4.1.1).

$$\text{Annual change in biomass} = \text{conversion area for a transition period of 20 years} * \Delta C_{\text{growth}} + \text{annual area of currently converted land} * L_{\text{conversion}}$$

$L_{\text{conversion}}$ = $C_{\text{after}} - C_{\text{before}}$

C_{after} = carbon stock immediately after conversion is 0

ΔC_{growth} = country-specific value for perennial crops carbon accumulation rate is $0.27 \text{ t C ha}^{-1}\text{a}^{-1}$ (annual growth rate in each year of the whole transition period of 20 years)

C_{before} = country specific value of carbon stock of annual crops before conversion is $6.67 \text{ t C ha}^{-1}\text{a}^{-1}$ (biomass loss accounted only for the year of conversion)

For the annual cropland biomass losses in the year of conversion from annual to perennial cropland, the country-specific average biomass stock in annual cropland was calculated from national statistics (STATISTIK AUSTRIA 2007). For all annual crops mentioned in the Statistical Report, the harvested yield biomass has been taken and the related biomass of straw, leaves or other aboveground plant parts not covered by the “yield biomass” have been estimated on basis of plant specific expansion factors to yield to total aboveground biomass. Root/shoot ratios for the individual crops of the United States Department of Agriculture were applied to estimate the total plant biomass. Since the U.S. are located also in the temperate region, the use of the U.S. root/shoot ratios seem most appropriate. These factors represent the average root/shoot values from 1990–2005 for different types of annual crops (WEST 2008). The estimated Austrian aboveground biomass in annual crops was multiplied with the root/shoot ratios to provide an estimate of the belowground biomass. The means of the annual aboveground and below ground biomass of the crops were calculated and weighted by the related area of these crops in Austria to get the average annual cropland biomass. The estimated annual cropland biomass stock represents the peak annual cropland biomass during the growing season and the average for a time-period of 10 years.

This led to a figure of 6.67 t C ha⁻¹ for the biomass in annual cropland that is used for the estimates of LUCs to and from annual cropland. This country specific value is 33.4 % higher than the 2006 IPCC GL default value (5.0 t C ha⁻¹).

6.3.4.1.3 Changes in carbon stocks in biomass of perennial cropland converted to annual cropland (4.B.1.c)

The total conversion area from perennial cropland converted to annual cropland over a transition period of 20 years was 10 323 ha in 2022.

The rationale for these estimates and the applied methods are described in chapter 6.3.4.1.2. For the calculation of the annual change in carbon stocks of living biomass of perennial cropland converted to annual cropland the 2006 IPCC GL equations 2.15 and 2.16 were applied (IPCC 2006). For the perennial cropland biomass before conversion the average value of 6.09 t C ha⁻¹ was applied. This weighted mean is derived from the Austrian survey on carbon stocks of vineyards and orchards (see chapter 6.3.4.1.1)

According to the 2006 IPCC GL the gains of the annual cropland biomass during LUCs to annual cropland are accounted only once, in the initial year of LUC to annual cropland (see also chapter 6.3.4.1.2 for the considerations in behind):

$$\text{Annual change in biomass} = \text{annual area of currently converted land} * (L_{\text{conversion}} + \Delta C_{\text{growth}})$$

$$L_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

$$C_{\text{after}} = \text{carbon stock immediately after conversion is 0}$$

$$\Delta C_{\text{growth}} = \text{country-specific value for annual crops carbon accumulation rate is } 6.67 \text{ t C ha}^{-1} \text{a}^{-1} \text{ (see chapter 6.3.4.1.2; accounted only for the year of LUC)}$$

$$C_{\text{before}} = \text{country-specific value for carbon stock of perennial cropland biomass before conversion is } 6.09 \text{ t C ha}^{-1} \text{ (accounted only for the year of conversion)}$$

6.3.4.1.4 Changes of carbon stocks in mineral soils of “annual cropland remaining annual cropland” and “perennial cropland remaining perennial cropland” (4.B.1.a)

According to national soil inventories organic soils are not occurring in Cropland in Austria (see chapter 6.4.4.1.3).

Emissions/removals due to mineral soil C stock changes in “annual cropland remaining annual cropland” were calculated using a country-specific methodology (Tier 2). For the soil organic carbon content the Austrian specific average value of 50 t C ha⁻¹ for 0–30 cm depth of cropland was assumed for 1990 which is based on the results of the Austrian soil inventory (GERZABEK et al. 2003., STREBL et al. 2003). This assumption is supported by the fact that the soil inventories were carried out between 1988 and 1996. Furthermore, we assumed that this Austrian specific soil C stock for cropland represents a steady state that already includes the effects of the management for the period before 1990 and that cropland management was rather stable in that pre-1990 period.

The SOC gains and losses due to applied agricultural management practices in the two cropland remaining cropland categories (annual cropland and perennial cropland) are calculated following closely the 2006 IPCC GL, where the IPCC equation 2.25 includes a management factor (F_{MG}), a land-use factor (F_{LU}) and an input factor for input of organic matter (F_I) (Table 5.5, IPCC 2006).

In a study by the Austrian Agency for Health and Food Safety (AGES) and Umweltbundesamt (UMWELTBUNDESAMT 2010) the IPCC default management factors for SOC (soil organic carbon) stock change were assessed against results from national long-term field experiments of AGES (SPIEGEL et al., 2007). The results of the C stock change rates for the agricultural experimental plots were allocated to different management types (management factors) like tillage types and input types:

- The country-specific land-use factor (F_{LU}) for long-term cultivated cropland soils of 0.93 is applied according to the results of the long-term field experiments of AGES (UMWELTBUNDESAMT 2010).
- The stock change factors for management (F_{MG}) were also applied according to the results of the long-term field experiments of AGES (UMWELTBUNDESAMT 2010, SPIEGEL et al. 2007), showing the effects of different tillage types (minimum, reduced and conventional tillage) on soil organic carbon. According to these results, F_{MG} -full and F_{MG} -reduced have the same country specific management factor of 1.0. For F_{MG} -no-till, the country specific management factor of 1.09 was derived (UMWELTBUNDESAMT 2010).
- Country-specific stock change factors for input (F_I) were also derived: F_I -Low does not occur in Austria, F_I -medium was assigned a management factor of 1.0 according to UMWELTBUNDESAMT (2010), F_I -high-without manure was assigned with a factor of 1.05 and for the input type F_I -high-with manure a factor of 1.11 was derived as mean value of results in the long-term field experiments (UMWELTBUNDESAMT 2010). Table 261 shows the revised national factors used compared to the respective IPCC default values (for cool, temperate, moist regime).

Table 261: Relative stock change factors for cropland according to IPCC default values and revised national factors

Factor value type	Level	IPCC default 2006 IPCC GL (cool, temperate, moist regime)	Applied revised national factors (UMWELTBUNDESAMT 2010)
Land use (F_{LU})	F_{LU} Long-term cultivated	0.69	0.93
Tillage (F_{MG})	F_{MG1} Full	1.00	1.00
	F_{MG2} Reduced	1.08	1.00
	F_{MG3} No-Till	1.15	1.09
Input (F_I)	F_{I1} Low	0.92	0.95
	F_{I2} Medium	1.00	1.00
	F_{I3} High – without manure	1.11	1.05
	F_{I4} High – with manure	1.44	1.11

Based on the above national factors, the area of annual cropland is distributed between the respective tillage and input types so that the corresponding factors can be applied.

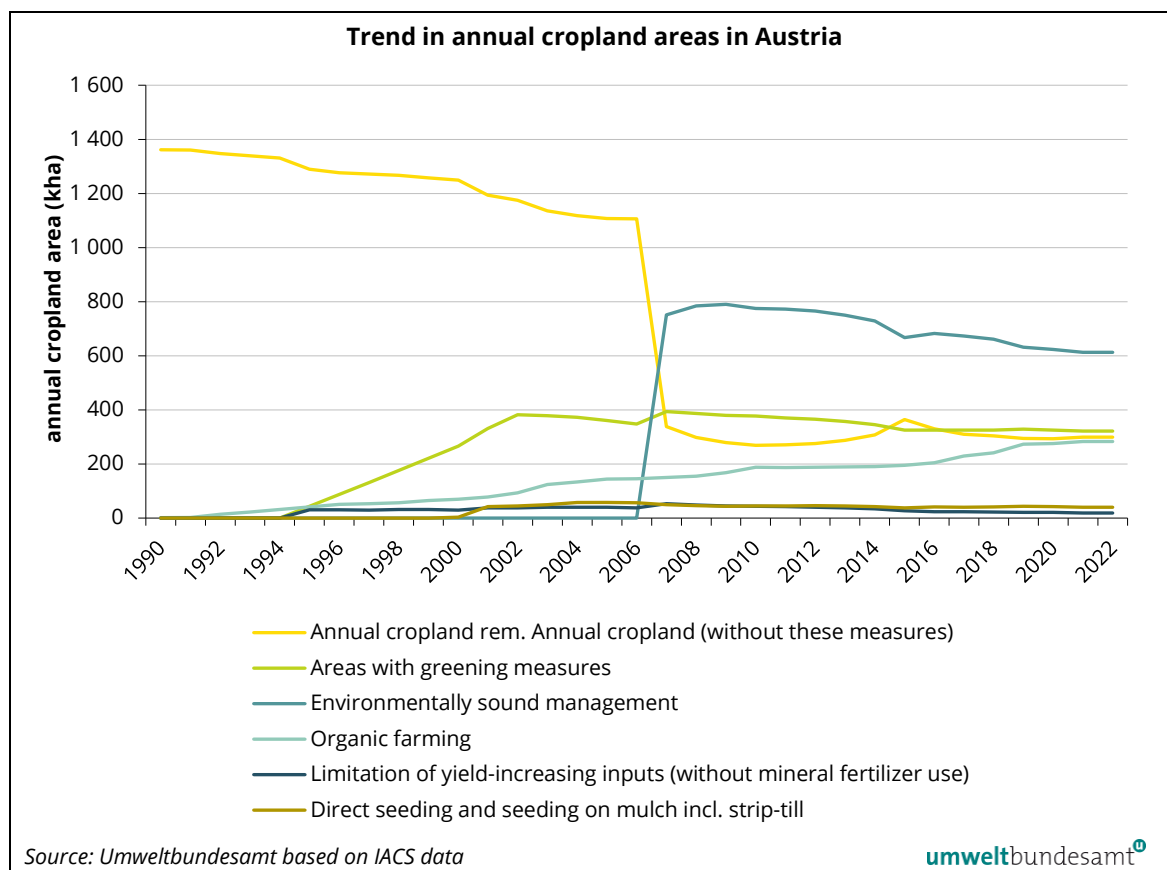
As a starting point, the annual cropland area per year was split between areas implementing no measures or areas implementing one of four Agri-environment-climate Measures (AECM) according to the Austrian ÖPUL program (BMLFUW, 2016a, BML 2023c), which is part of the CAP Strategic Plan of the Common Agricultural Policy. ÖPUL started in 1995, but these single management measures started in different years (see BMLFUW, 2016a). The five groups are as follows:

- cropland with organic farming
- cropland with limitation of yield-increasing inputs (without mineral fertilizer use)
- cropland with environmentally sound management (UBAG, UBB)

- cropland with direct seeding and seeding on mulch incl. strip-till
- the area of annual cropland without measures

These areas are available for the whole time series (Figure 39) and were taken from the agricultural statistics based on IACS data.

Figure 39: Trend of annual cropland areas in Austria with selected Agri-environment-climate measures (kha).



The areas within each of the five groups were further subdivided according to the results of an IACS data analysis and the FSS survey, resulting in combinations of different tillage and input regimes. Twenty-four combinations resulted from the following three tillage types and eight input combinations:

1. Three tillage types: area with no-tillage, area with reduced tillage and area with full tillage. The percentage share of cropland areas with these three tillage types was applied according to the results of the full FSS in 2010 (STATISTIK AUSTRIA, 2013). According to this FSS 973 069 ha (73.3%) of annual cropland were managed with full tillage (conventional ploughing method with mouldboard plough and implement combinations). 326 731 ha (24.6%) were managed by conservation or reduced tillage methods (ploughless tillage systems, with cultivator, harrow) and only 28 349 ha (2.1%) were managed by direct seed without previous tillage (no-tillage systems). The share of no-tillage systems was confirmed by the figures of the follow-up FSS in 2016. The relative trend across years was adjusted by the trend of the AECM cropland area with direct seeding and seeding on mulch incl. strip-till. This approach is justified by the relationship of this AECM type with reduced tillage approaches.
2. Eight input combinations depending on inputs from cover crops, manure crop residues:

- a. With-/without input from cover crops at cropland, specifically at the areas of two dedicated AECM measures : “Cover crops at arable land – intermediate crops (cover crops between two main crops)” and “Cover crops at arable land – “Evergreen” system (both compiled in the trend line “areas with greening measures” in Figure 39 above).
- b. With-/without manure input: on basis of figures for the livestock number of each cropland farm. The indicator “Livestock units (LU) per hectare” was calculated at farm level and if the value was > 0.5 LU/ha, a manure input to cropland is assumed.
- c. Crop types with low or high crop residues input: The different annual crop types in the Austrian cropland were divided into crops with high residues and crops with low residues based on BMLFUW (2017).

Based on IACS data for the years 2002 and 2016, the annual cropland areas of each of the five AECM groups (and the respective divisions across the three tillage regimes) were distributed between the eight possible input combinations. The respective shares derived in 2002 and 2016 were interpolated to derive respective areas for 2003 to 2015, while the shares of 2016 were assumed to remain constant to extrapolate the areas for 2017 onwards. The respective shares of 2002 were extrapolated back to 1990 taking into account that greening measures (affecting the assignment “with-/without input from cover crops) were first implemented in 1995.

The possible combinations and related soil C stock change factors are shown in Table 262.

Table 262: Possible combinations of management types of annual cropland areas and assigned management factors.

Tillage	Cover crops	Manure	Crop residues	F _{LU}	F _{MG}	F _I	Average equilibrium cropland soil C stock in 1990 (from soil inventories) (t C ha ⁻¹ for 0–30 cm)	Estimated reference soil C stock based on the factor combination F _{LU} 0.93, F _{MG} 1.0, F _I 1.0 as typical for the management before 1990 (t C ha ⁻¹ for 0–30 cm)	Estimated new equilibrium soil C stock after 20 years according to management measure combination in line (t C ha ⁻¹ for 0–30 cm)	Yearly soil C stock change according to management measure combination in line (t C ha ⁻¹ a ⁻¹)
Full	No	Yes	Low	0.93	1.0 (full)	1.0 (Medium)	50	53.8	50	0
Full	No	Yes	High	0.93	1.0 (full)	1.0 (Medium)	50	53.8	50	0
Full	No	No	Low	0.93	1.0 (full)	1.0 (Medium)	50	53.8	50	0
Full	No	No	High	0.93	1.0 (full)	1.0 (Medium)	50	53.8	50	0
Full	Yes	Yes	Low	0.93	1.0 (full)	1.11 (High – with manure)	50	53.8	55.5	0.28
Full	Yes	Yes	High	0.93	1.0 (full)	1.11 (High – with manure)	50	53.8	55.5	0.28
Full	Yes	No	Low	0.93	1.0 (full)	1.05 (High – w.out manure)	50	53.8	52.5	0.13
Full	Yes	No	High	0.93	1.0 (full)	1.05 (High – w.out manure)	50	53.8	52.5	0.13
Reduced	No	Yes	Low	0.93	1.0 (reduced)	1.0 (Medium)	50	53.8	50	0
Reduced	No	Yes	High	0.93	1.0 (reduced)	1.0 (Medium)	50	53.8	50	0
Reduced	No	No	Low	0.93	1.0 (reduced)	1.0 (Medium)	50	53.8	50	0
Reduced	No	No	High	0.93	1.0 (reduced)	1.0 (Medium)	50	53.8	50	0
Reduced	Yes	Yes	Low	0.93	1.0 (reduced)	1.11 (High – with manure)	50	53.8	55.5	0.28
Reduced	Yes	Yes	High	0.93	1.0 (reduced)	1.11 (High – with manure)	50	53.8	55.5	0.28
Reduced	Yes	No	Low	0.93	1.0 (reduced)	1.05 (High – w.out manure)	50	53.8	52.5	0.13
Reduced	Yes	No	High	0.93	1.0 (reduced)	1.05 (High – w.out manure)	50	53.8	52.5	0.13
No	No	Yes	Low	0.93	1.09 (no)	1.0 (Medium)	50	53.8	54.5	0.23

Tillage	Cover crops	Manure	Crop residues	F _{LU}	F _{MG}	F _i	Average equilibrium cropland soil C stock in 1990 (from soil inventories) (t C ha ⁻¹ for 0–30 cm)	Estimated reference soil C stock based on the factor combination F _{LU} 0.93, F _{MG} 1.0, F _i 1.0 as typical for the management before 1990 (t C ha ⁻¹ for 0–30 cm)	Estimated new equilibrium soil C stock after 20 years according to management measure combination in line (t C ha ⁻¹ for 0–30 cm)	Yearly soil C stock change according to management measure combination in line (t C ha ⁻¹ a ⁻¹)
No	No	Yes	High	0.93	1.09 (no)	1.0 (Medium)	50	53.8	54.5	0.23
No	No	No	Low	0.93	1.09 (no)	1.0 (Medium)	50	53.8	54.5	0.23
No	No	No	High	0.93	1.09 (no)	1.0 (Medium)	50	53.8	54.5	0.23
No	Yes	Yes	Low	0.93	1.09 (no)	1.11 (High – with manure)	50	53.8	60.5	0.52
No	Yes	Yes	High	0.93	1.09 (no)	1.11 (High – with manure)	50	53.8	60.5	0.52
No	Yes	No	Low	0.93	1.09 (no)	1.05 (High – w.out manure)	50	53.8	57.2	0.36
No	Yes	No	High	0.93	1.09 (no)	1.05 (High – w.out manure)	50	53.8	57.2	0.36

For the subcategory “perennial cropland remaining perennial cropland” the soil carbon stock changes have also been calculated based on the assignment of the three factors F_{LU} , F_{MG} and F_I (Table 261). The IPCC default value for F_{LU} is applied according to 2006 IPCC GL, table 5.5, for perennial/tree crops, which is 1.0. For vineyards as well as for orchards, soil erosion measures (AECM) were introduced in 1995. For these areas, selected management factors derived for annual croplands were extrapolated to the perennial croplands, based on the following assumptions. A management factor F_{MG} for reduced tillage 1.0 (see Table 261) was assigned due to year-round, area-wide cover crops (greening) at the machine tracks in vineyards and orchards (BMLFUW, 2016a, BML, 2023). All the other vineyards and orchards were categorized as full tillage; however, no difference in the management factor was assumed ($F_{MG} = 1.0$, see Table 261). In contrast, a differentiation was made for the input factor, F_I . For the areas with the soil erosion measure, an input factor F_I of 1.05 was applied, which is the Austrian value for annual croplands with high input – without manure, see Table 261. This was justified because of the year-round, area-wide cover crops (greening) at the machine tracks in vineyards and orchards implementing these soil erosion measures (BML, 2023).

The areas, where these soil erosion measures are applied, are taken from IACS data.

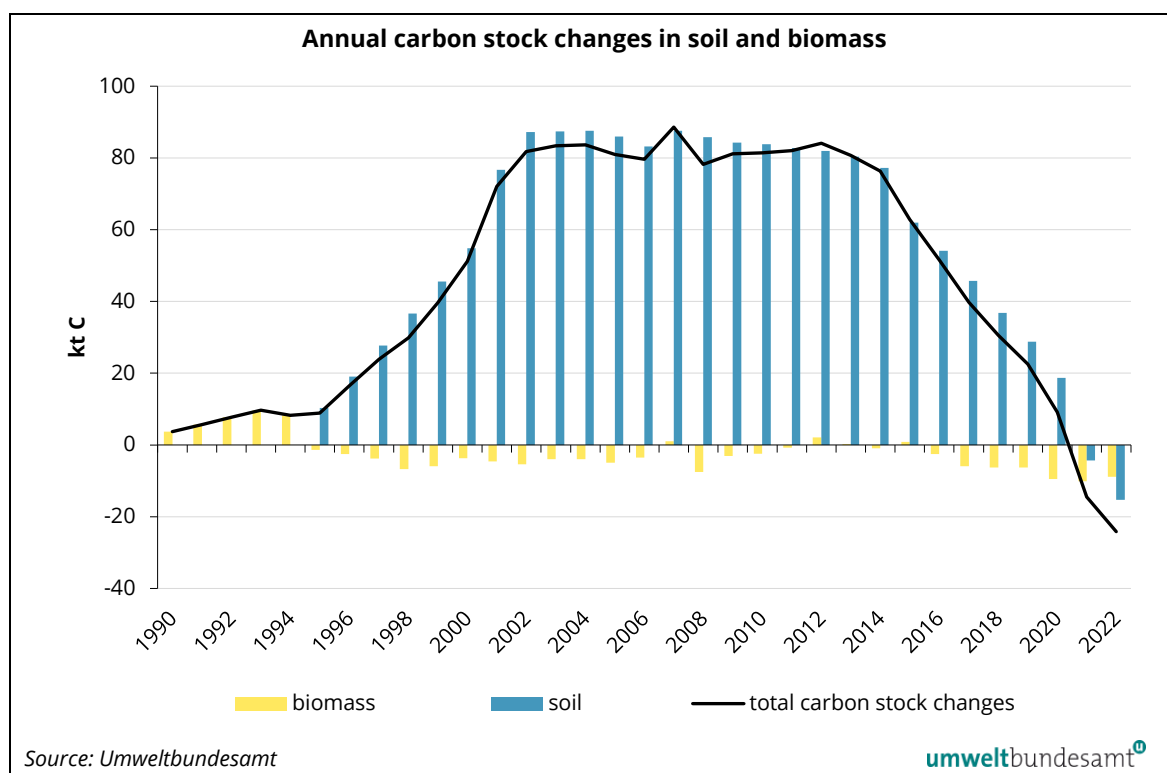
Table 263: Perennial cropland management measures and assigned management factors.

Management measures	F_{LU}	F_{MG}	F_I	Average equilibrium perennial cropland soil C stock in 1990 (from soil inventories) (t C ha ⁻¹ for 0–30 cm)	Estimated reference soil C stock based on the factor combination F_{LU} 1.0, F_{MG} 1.0, F_I 1.0 as typical for the management before 1990 (t C ha ⁻¹ for 0–30 cm)	Estimated new equilibrium soil C stock after 20 years according to management measure combination in line (t C ha ⁻¹ for 0–30 cm)	Yearly soil C stock change according to management measure combination in line (t C ha ⁻¹ a ⁻¹)
Cropland with soil erosion measure: vineyards	1.0	1.0	1.05	57	57	59.85	0.14
Cropland with soil erosion measure: orchards	1.0	1.0	1.05	57	57	59.85	0.14
Other perennial cropland without soil erosion measures	1.0	1.0	1.00	57	57	57.00	-

Inter-annual variations in the emissions/removals within the subcategory cropland remaining cropland are driven to a large extent by changes in the soil carbon stocks. Soil carbon stocks have increased to varying extents depending on specific management changes in agricultural land as defined and promoted in the Austrian Agri-environment-climate Scheme – ÖPUL (relevant ÖPUL measures are cover crops, organic farming, tillage reduction). In 1995 with Austria's joining of the EU, the first Agri-environment Scheme was applied and accordingly led to an estimated increase of the annual soil carbon stock change by more than 40 kt C a⁻¹. In the following CAP periods from 2000–2006 and 2007–2013 further increases in the annual C stock changes occur due to the increase of areas where the specific Agri-environment Measures were implemented (see Figure 40). However, Figure 40 shows a decrease in the mineral soil C stock gains since 2015, as the areas implementing the ÖPUL measures reached the end of the 20-year transition period and achieved their new equilibrium soil C stocks. It is planned to further resample the long-term experimental plots in order to

check the appropriateness of the 20-year transition period for soil C stock changes due to cropland management changes in Austria.

Figure 40: Annual carbon stock changes in soil and biomass of the subcategory annual cropland remaining annual cropland and perennial cropland remaining perennial cropland (kt C).



It should be noted that the Agri-environment measures caused an increase of the average mineral soil carbon stock of annual cropland in Austria from 50 t C ha⁻¹ to about 51 t C ha⁻¹ for 0–30 cm depth across the whole time series. In response to a 2023 ARR review recommendation regarding transparency, the following information is provided: For soil carbon stock changes resulting from land-use changes/conversions, we use national average carbon stocks for the pre and post conversion land uses that are constant in time (see respective land-use change chapters). Therefore, the estimated losses of mineral soil carbon in e.g. the land-use change category cropland to settlement do not take into account the losses of “additional” soil carbon that was previously gained due to management improvements in cropland. Nonetheless, the land-use change loss of this “additional” carbon from management improvement is in fact calculated under Cropland remaining cropland.

The basis for the mineral soil carbon stock changes in annual cropland remaining annual cropland and perennial cropland remaining perennial cropland are the *total* cropland areas implementing the respective ÖPUL measures. As such any decrease in the areas implementing certain measures, regardless whether this is due to changes in agricultural management or due to land-use change or conversion, is fully accounted for in Cropland remaining cropland. Indeed, the total Cropland area implementing certain measures that enhance soil carbon have been decreasing recently, again due to changes in agricultural management, but also partially due to land-use changes and conversions from Cropland. As it is these activity data on total areas which feed into the subcategory inventory model, this has led to the calculation of a recent net decrease in mineral soil carbon stocks of

Cropland remaining cropland in the last two years (Figure 40). These losses represent a partial re-emission of the soil carbon gains achieved with the ÖPUL management improvement measures, which again is partially due to land-use changes and conversions from Cropland. This approach likely represents a minor misallocation of emissions and removals between Cropland remaining cropland and respective conversion subcategories (e.g. Cropland converted to Settlements). However, the approach avoids any potential double accounting and thus ensures complete and accurate estimates of emissions and removals at the LULUCF sector level.

6.3.4.1.5 Changes of carbon stock in soils of annual cropland converted to perennial cropland (4.B.1.b)

The conversion area from annual cropland to perennial cropland (in conversion status for a time period of 20 years) changed from 10 733 ha to 12 443 ha from 1990 to 2022.

The rationale for estimating the soil C stock changes of this conversion has been given in chapter 6.3.4.1.2.

Emissions/removals were calculated by country-specific average values for carbon stocks in mineral soils of annual and perennial cropland. According to the Austrian soil inventories (GERZABEK et al. 2003) the C-stock of soils in perennial cropland is between 48–67 t C ha⁻¹ (0–30 cm) with a weighted mean of 57 t C ha⁻¹.

According to the 2006 IPCC GL (Equation 2.25, IPCC 2006) annual rates of carbon stock change are estimated as the difference in stocks at two points in time divided by the time dependence of the stock change factors.

*Annual change in carbon stock of mineral soils in annual cropland converted to perennial cropland = ΔSOC_{20} * conversion area for a transition period of 20 years*

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = 0.35 \text{ t C ha}^{-1} \text{ a}^{-1}$$

ΔSOC_{20} *average annual carbon stock change in soils of annual cropland converted to perennial cropland (t C ha⁻¹ a⁻¹) over a conversion transition period of 20 years*

SOC_0 *carbon stock in soils 20 years after conversion from annual to perennial cropland (i.e. average C stock in 0–30 cm of perennial cropland soils in Austria) → 57 t C ha⁻¹*

SOC_{0-T} *carbon stock in Austrian annual cropland soils before conversion (i.e. average C stock in 0–30 cm of annual cropland soils in Austria; see chapter 6.3.4.1.4) → 50 t C ha⁻¹*

The average carbon stock in Austrian soils of perennial cropland is 57 t C ha⁻¹. For annual cropland, the average mineral soil carbon stock is 50 t C ha⁻¹. For these two values, the average annual change in soil C stock for the area over the transition period (20 years) was calculated and the average annual change in soil C stock was then multiplied by the conversion area.

6.3.4.1.6 Changes of carbon stocks in soils of perennial cropland converted to annual cropland (4.B.1.c)

The area in conversion from perennial cropland to annual cropland for a time period of 20 years is rather stable and ranges from 7 332 ha to 10 323 ha from 1990 to 2022.

The rationale for estimating the soil C stock changes of this LUC has been given in chapter 6.3.4.1.2.

Emissions/removals were calculated by country specific values for carbon stocks in mineral soils of perennial cropland and annual cropland, respectively. Calculation steps and input data are the same as in chapter 6.3.4.1.5:

$$\Delta SOC_{20} = (SOC_0 - SOC_{0-7})/20 = -0.35 \text{ t C ha}^{-1} \text{ a}^{-1}$$

*Annual change in carbon stock of mineral soils in perennial cropland converted to annual cropland = ΔSOC * conversion area for a transition period of 20 years*

ΔSOC_{20} *average annual carbon stock change in soils of perennial cropland converted to annual cropland (t C ha⁻¹ a⁻¹) over a conversion transition period of 20 years*

6.3.4.1.7 Biomass burning

Since this 2024 submission, emissions from wildfires on Cropland and Grassland are estimated and reported due to the availability of a new data source, the Forest Fire Database (BOKU, 2023). However, the available activity data in the Forest Fire Database does not distinguish between Cropland and Grassland, meaning that Cropland wildfires are included elsewhere under the Grassland category. For more information about the respective methodology see chapter 6.4.4.1.5.

6.3.4.2 Land use changes to Cropland (4.B.2)

6.3.4.2.1 Forest land converted to cropland (4.B.2.1)

The methodology and activity data are described in the chapters 6.2.2 and 6.2.4.2. The area in conversion from Forest land to Cropland (for a time period of 20 years) ranged from 2 657 ha in 2022 to 4 792 ha in 1994 causing annual net emission rates from 34.5 kt CO₂ to 97.2 kt CO₂, respectively, due to the loss of biomass and C stock changes in soil and litter.

For the calculation of the annual change of carbon stocks the IPCC Tier 3 approach is used. Emissions/removals were calculated by country specific values. The changes of the soil carbon stocks were stratified according to five forest growth regions. The stratified LUC areas and soil C stocks according to these growth regions were used for the estimates. The method is described in chapter 6.2.4.2.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes between NFI observation periods while they remain constant within the NFI observation periods (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of FL to CL which, as a consequence, also change in a stepwise fashion for certain pools (e.g. biomass, dead wood, litter; Table 258). An interpolation across observation periods is considered unsuitable and is therefore not carried out.

Direct N₂O emissions from N mineralization/immobilization associated with loss of soil organic matter in mineral soils resulting from Forest land converted to Cropland (4(III))

To estimate the associated N₂O emissions the Tier 2 method as provided in the IPCC 2006 GL is applied (Eq.11.1).

To calculate the net annual amount of N mineralized (F_{SOM} , eq. 11.8) from the net carbon stock change (CSC) in the mineral soil due to the land use change, the CSC was divided by the country specific C/N ratios of forest land soils (19, source: see BFW, 1992) and multiplied by the default

emission factor (EF_1) from Table 11.1 in the IPCC 2006 GL. Finally, the result was converted from the amount of annual direct N_2O -N to N_2O emissions.

Indirect N_2O emissions from N leaching and runoff (4(IV))

In addition to the direct N_2O emissions from managed soils, related indirect emissions also occur. The IPCC 2006 Guidelines provide a Tier 2 methodology in Chapter 11 (eq. 11.10) which is applied. $Frac_{LEACH}$ is a country specific factor of 0.15154 (EDER et al., 2013) and the emission factor EF_5 is taken from Table 11.3 of the IPCC 2006 Guidelines.

6.3.4.2.2 Grassland converted to cropland (4.B.2.2)

This section provides information about emissions/removals for Grassland converted to cropland and comprises:

- a. Grassland converted to annual cropland
- b. Grassland converted to perennial cropland

Data for land-use change from Grassland to Cropland were estimated from IACS as described in chapter 6.3.2. The use of the IACS system for the assessment of the conversions/LUCs within and between Cropland and Grassland (see chapter 6.3.2) allows a more accurate annual assessments of these activities since 2002. This leads to higher annual variations in this period than before 2002. Activity data of Grassland converted to cropland in the 20 year conversion status are reported in Table 257. Emissions were estimated applying a country-specific methodology (Tier 2) for biomass carbon stocks and for soil carbon stocks.

The average area undergoing land use change from Grassland to annual cropland over a period of 20 years is 37 980 ha, ranging from 29 617 ha to 57 633 ha for the period 1990 to 2022. Subsequent annual emissions from these land conversions ranged between 103 and 196 kt CO_2 .

The average area undergoing land-use change from Grassland to perennial cropland over a period of 20 years for 1990–2022 is 738 ha.

Changes of carbon stock in biomass of grassland converted to annual cropland

Country-specific data for gGrassland biomass from the Agricultural Research and Education Centre Raumberg-Gumpenstein (Höhere Bundeslehr- und Forschungsanstalt Raumberg-Gumpenstein) were used. According to the research results the stubble biomass is 0.5 t C ha^{-1} and the root biomass is 2.1 t C ha^{-1} . For the aboveground grassland biomass a value of 3.1 t C ha^{-1} was applied (detailed description see chapter 6.4.4.2.2). That leads to a country specific value for the carbon stock of above ground and below ground Grassland biomass before conversion of 5.7 t C ha^{-1} . For the calculation of the annual change in carbon stocks in living biomass of Grassland converted to cropland equations 2.15 and 2.16 were applied (IPCC 2006).

$$\text{Annual change in biomass} = \text{annual area of currently converted land} * (L_{\text{conversion}} + \Delta C_{\text{growth}})$$

$$L_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

$$\Delta C_{\text{growth}} = \text{country specific value for annual carbon accumulation rate in annual crops is } 6.67 \text{ t C ha}^{-1} \text{ a}^{-1} \text{ (see Chapter 6.3.4.1.1, accounted only for the year of LUC)}$$

$$C_{\text{after}} = \text{carbon stock immediately after conversion is 0}$$

$$C_{\text{before}} = \text{country specific value for carbon stock of grassland biomass before conversion is } 5.7 \text{ t C ha}^{-1} \text{ (see Chapter 6.4.4.2.2; biomass loss accounted only in the year of LUC)}$$

Changes of carbon stock in biomass of grassland converted to perennial cropland

For perennial cropland a weighted mean for annual growth according to the Austrian survey on viticulture and orchards ($0.27 \text{ t C ha}^{-1} \text{ a}^{-1}$, see chapter 6.3.4.1.1) was used for the whole LUC transition period of 20 years:

$$\text{Annual change in biomass} = \text{conversion area for a transition period of 20 years} * \Delta C_{\text{growth}} + \text{annual area of currently converted land} * L_{\text{conversion}}$$

$$L_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

For the calculation the following values were used:

$$\Delta C_{\text{growth}} = \text{annual carbon accumulation rate in perennial crops is } 0.27 \text{ t C ha}^{-1} \text{ a}^{-1} (\text{annual growth rate in each year of the whole LUC transition period of 20 years})$$

$$C_{\text{after}} = \text{carbon stock immediately after conversion is } 0$$

$$C_{\text{before}} = \text{country specific value for carbon stock of grassland biomass before conversion. } 5.7 \text{ t C ha}^{-1} (\text{description see Chapter 6.4.4.2.2. biomass loss accounted only in the year of LUC}).$$

The data in the CRF table represent Grassland converted to annual cropland and Grassland converted to perennial cropland separately.

Changes of carbon stock in mineral soils of grassland converted to annual cropland

Only mineral soils were considered in this category assuming that Grassland on organic soils was not converted to cropland (soil inventories have shown that Cropland with organic soils does not exist in Austria).

Emissions/removals were calculated by country-specific average values for carbon stocks in mineral soils of Grassland and Cropland. For the estimates, specific 0–30 cm depth values of 70 t C ha^{-1} for Grassland and 50 t C ha^{-1} for annual cropland were used which are based on the results of the Austrian soil inventories (GERZABEK et al. 2003, STREBL et al. 2003). For the calculation of the annual change of carbon stocks in Grassland soils converted to annual cropland soils the following equation according to IPCC was applied.

$$\Delta \text{SOC} = (\text{SOC}_0 - \text{SOC}_{0-7})/20 = -1.0 \text{ t C ha}^{-1} \text{ a}^{-1}$$

$$\text{annual change in carbon stock of mineral soils converted from grassland to cropland} = \Delta \text{SOC} * \text{conversion area for a transition period of 20 years}$$

$$\Delta \text{SOC} = \text{average annual carbon stock change in soils of grassland converted to annual cropland } (\text{t C ha}^{-1} \text{ a}^{-1}) \text{ over a LUC transition period of 20 years}$$

$$\text{SOC}_0 = \text{carbon stock in cropland soils 20 years after conversion from grassland to annual cropland} \rightarrow 50 \text{ t C ha}^{-1}$$

$$\text{SOC}_{0-7} = \text{carbon stock in Austrian grassland soils before conversion} \rightarrow 70 \text{ t C ha}^{-1}$$

Changes of carbon stock in mineral soils of grassland converted to perennial cropland

The land-use change area from Grassland to perennial cropland ranges from 495 ha to 1 367 ha per year for the period 1990–2022 considering the area to be 20 years in the conversion category.

Emissions/removals were calculated by country specific average values for carbon stocks in mineral soils of grassland and perennial land. For the estimates, specific 0–30 cm depth values of 70 t C ha^{-1} for Grassland and 57 t C ha^{-1} for perennial cropland were used, based on the results of the Austrian soil inventories (GERZABEK et al. 2003, STREBL et al. 2003). For the calculation of the annual change

of carbon stocks in Grassland soils converted to perennial cropland soils the following equation was applied.

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = -0.65 \text{ t C ha}^{-1} \text{ a}^{-1}$$

*annual change in carbon stock of mineral soils converted from grassland to perennial cropland = ΔSOC * conversion area for a transition period of 20 years*

ΔSOC = average annual carbon stock change in soils of grassland converted to perennial cropland ($\text{t C ha}^{-1} \text{ a}^{-1}$) over a LUC transition period of 20 years

SOC_0 = carbon stock in perennial cropland soils 20 years after conversion from grassland $\rightarrow 57 \text{ t C ha}^{-1}$

SOC_{0-T} = carbon stock in grassland soils before conversion $\rightarrow 70 \text{ t C ha}^{-1}$

The data in the CRF table represent grassland converted to annual cropland and grassland converted to perennial cropland.

Direct N₂O emissions from N mineralization/immobilization associated with loss of soil organic matter in mineral soils resulting from Grassland converted to Cropland (4(III))

To estimate the associated N₂O emissions, the Tier 2 method as provided in the IPCC 2006 GL is applied (Eq.11.1).

To calculate the net annual amount of N mineralized (F_{SOM} , eq. 11.8) from the net carbon stock change (CSC) in the mineral soil due to the land use change, the CSC was divided by the country specific C/N ratio of grassland soils (12, source: see footnote⁹⁸) and multiplied by the default emission factor (EF_1) from Table 11.1 in the IPCC 2006 GL. Finally, the result was converted from the amount of annual direct N₂O-N to N₂O emissions.

Indirect N₂O emissions from N leaching and runoff (4(IV))

In addition to the direct N₂O emissions from managed soils, related indirect emissions also occur. The IPCC 2006 Guidelines provide a tier 2 methodology in Chapter 11 (eq. 11.10) which is applied.

F_{LEACH} is a country specific factor of 0.15154 (EDER et al., 2013) and EF_5 is provided in Table 11.3 of the IPCC 2006 Guidelines.

6.3.5 Uncertainty Assessment

For the Monte Carlo simulations the following uncertainties of the input parameters were used:

Table 264: Uncertainties of areas in the CL category.

	Before 2001	Since 2001
Total cropland	±4%	±4%
Perennial cropland	±20%	±20%
Annual LUC area CL to FL or FL to CL	see Chapter 6.2.5., Table 254	see Chapter 6.2.5., Table 254
Annual LUC area pCL to aCL. aCL to pCL. GL to pCL	±300% ¹	±260% ¹
Annual LUC area GL to aCL	±200% ¹	±150% ¹

¹ For area uncertainties > 100%, distributions were truncated at 0 as negative areas are not possible

These uncertainty estimates originate from:

- Total cropland: based on information from data source (Statistik Austria)
- Perennial cropland: based on information from data source (Statistik Austria)
- Annual LUC area pCL to aCL, aCL to pCL, GL to pCL: Expert judgement from two agricultural experts on the basis of the original data
- Annual LUC area GL to aCL: Expert judgement from two agricultural experts on the basis of the original data

Table 265: Uncertainties of the input data for the emission factors in the CL category (distributions were truncated at the minima and maxima)

	stock	growth rate or emission factor
Annual CL biomass	±15%	±15%
Vineyards	±17%	±42%
Orchards	±23%	±33%
Perennial energy plants	Triangle Distribution with 21-30-45 t C ha ⁻¹	Triangle Distribution with 3.5-5.0-7.5 t C ha ⁻¹
Christmas trees	±40%	±40%
Grassland biomass	±45%	±45%
Soil C stock change in CL rem CL		±40%
Soil C stocks for LUC to CL	see Chapter 6.2.5. Table 255	
N ₂ O emission factor for soil at LUC to CL (default)		Triangle Distribution with 0.003-0.01-0.03
C/N ratio grassland soils	±55%	
C/N ratio forest soils	±58%	
C/N ratio cropland soils	±10%	
N ₂ O emission from leaching and run-off – FRACleach		±130%
N ₂ O emission from leaching and run-off – emission factor (default)		Triangle Distribution with 0.0005-0.0075-0.025

These uncertainties were derived from the following sources:

- Annual CL biomass: for yield based on an assessment from the annual yield statistics; for the expansion factors based on expert judgement
- Vineyards and orchards biomass: based on the survey results
- Perennial energy plants: assessment based on the results of the study that was used [SPLECHTNA & GLATZEL 2005]
- Christmas trees: assessment based on the results of the study that was used [BMLFUW 2000]
- Grassland biomass: for yield based on an assessment from the annual yield statistics; for the expansion factors based on expert judgement
- Soil C stock change in CL rem CL: assessment based on the results of UMWELTBUNDESAMT 2010
- N₂O emission factors for soil at LUC to CL: IPCC 2006 GL
- C/N ratios of soils: assessment on basis of the Austrian soil inventory results

On basis of these input uncertainties the Monte Carlo simulations led to an average uncertainty in the total emissions/removals of the Cropland category over the time series of ± 105 kt CO₂ (range: ± 87 kt CO₂ to ± 128 kt CO₂). The average relative uncertainty is $\pm 169\%$ (range: $\pm 41\%$ to $\pm 1\,457\%$) depending on the absolute value of the net emissions or removals of the sector. Years with net emissions and removals of the cropland subcategory close to 0 show logically very high relative uncertainties up to more than one thousand %.

It should be noted that the net emission/removals of the Cropland category are the result of subtractions between emissions and removals of several subcategories and pools. Only in single cases are they are correlated. In line with error propagation laws, the uncertainty of such net values based on subtractions of uncorrelated parameters are additive and therefore rather high in relative terms.

6.3.6 Category-specific QA/QC

The calculation of the data for category 4.B is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.3.7 Recalculations

The approach for calculating long-term land-use changes and conversions between Cropland and Grassland applies a stability threshold to determine if an annual conversion is long- or short-term. Additional years in the time series therefore lead to a revised and improved identification of short-term and long-term conversions in recent years, which propagate over the entire time series. These area improvements caused upward revisions of the annual net emissions for the whole time series of the *Cropland* category that range from 14 to 25 kt CO₂e per year compared to the last submission in 2023.

6.3.8 Planned improvements

See Chapter 6.1.8.

6.4 Grassland (Category 4.C)

6.4.1 Category description

In this category emissions/removals from Grassland (Grassland remaining grassland and Land converted to grassland) are considered. In 2022 1.6 million ha of Austria were managed as Grassland. This area estimation is based on new land assessment of spatially-explicit, national datasets introduced for this submission as part of the improved Austrian system for land representation (for detailed descriptions see chapters 6.1.3.1 and 6.4.2). Since 1990 the area of grassland has generally been decreasing each year. Total Grassland includes one cut meadows, two cut meadows and three or more cut meadows, permanent pastures, litter meadows, rough pastures, alpine meadows and pastures, grassland where agricultural grassland management was stopped and fallow grassland

(grassland in good agricultural and ecological condition no longer used for production; formerly called "GLÖZ").

The annual CO₂ emissions from the Grassland category in Austria amounted to 697 kt CO₂ in 1990 and 444 kt CO₂ in 2022. The main drivers of the emissions are carbon stock changes in mineral soils and biomass due to LUC from Forest land to Grassland, as well as carbon stock losses from drained organic soils under Grassland remaining grassland.

Since 2006 an increase of LUC areas from cropland to grassland can be observed.

Some management practices (e.g. slash and burn etc.) and some subcategories (4.C.2.3. 4.C.2.4. 4.C.2.5) do not occur in Austria. Furthermore, changes in dead wood and litter carbon stocks do not occur in Grassland, apart from respective carbon losses in these pools due to Forest land converted to Grassland. Drained organic soils are considered to occur in Austria only in the Grassland remaining grassland subcategory.

Table 266: Sources (or sinks) considered for grassland.

Category/source or sink
4.C Grassland – total
4.C.1 Grassland remaining grassland
emissions from drained organic soils in grassland
- N ₂ O, CH ₄ emissions due to wildfires
4.C.2 Land converted to grassland
4.C.2.1 Forest land converted to grassland
- carbon stock change in biomass due to LUC from forest land to grassland
- carbon stock change in DOM due to LUC from forest land to grassland
- carbon stock change in SOM due to LUC from forest land to grassland
4.C.2.2 Cropland converted to grassland
- carbon stock change in biomass due to LUC from cropland to grassland
- carbon stock change in SOM due to LUC from cropland to grassland

Figure 41: Emissions/removals (+/-) from grassland (1990–2022) by grassland remaining grassland and land use change to grassland in kt CO₂

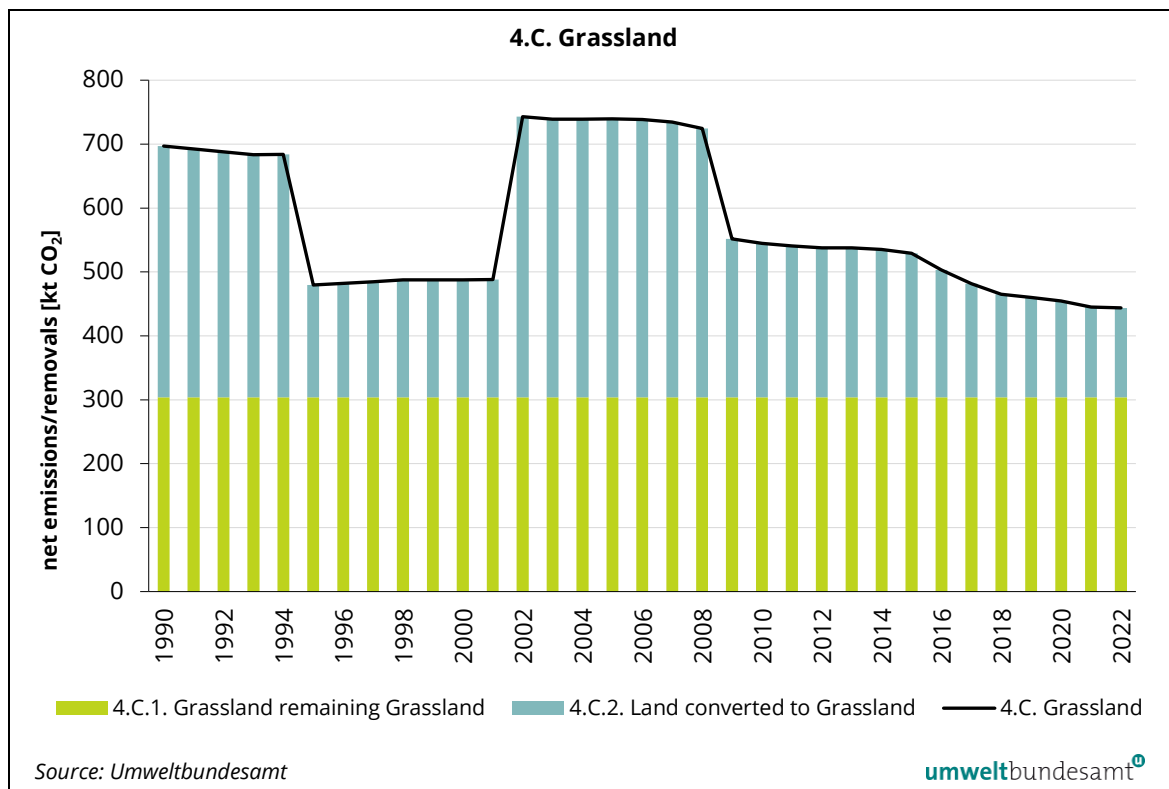


Figure 42: Emissions/removals (+/-) from grassland (1990–2022) by carbon pools in kt CO₂

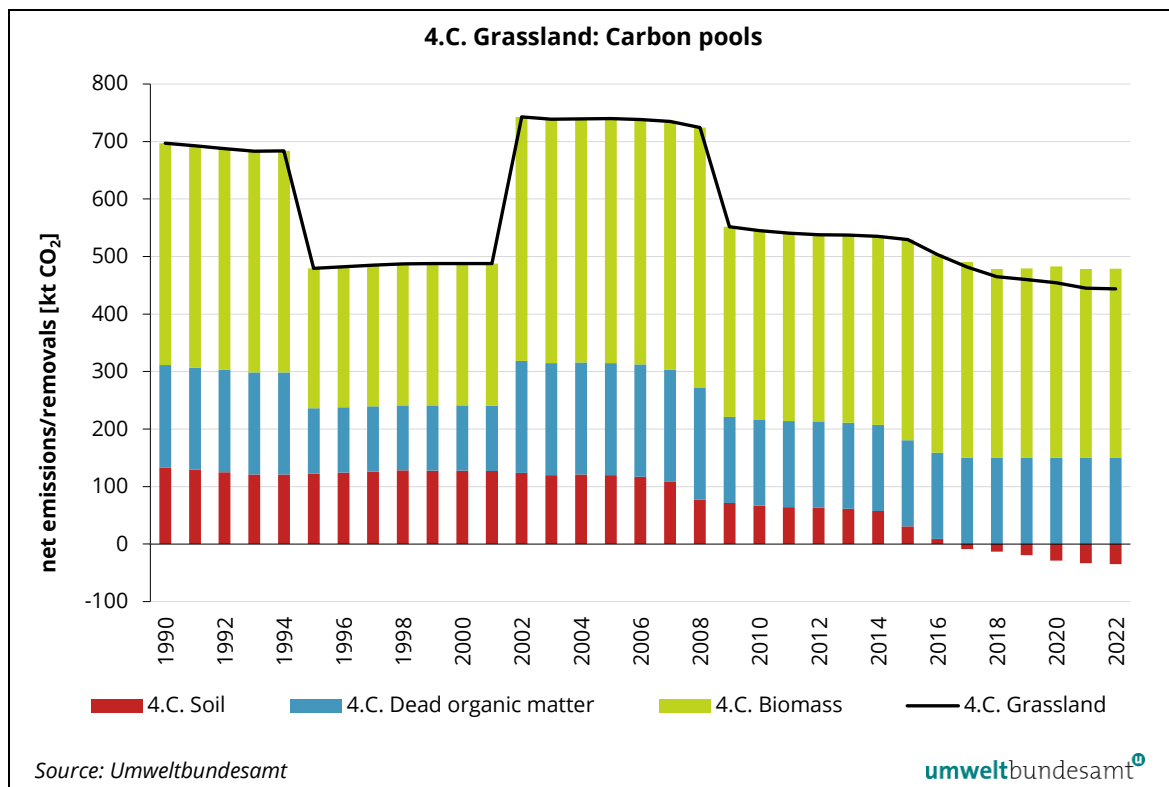


Table 267: Total areas and land-use change areas of grassland 1990–2022 in ha; transition period of 20 years for LUC lands.

	C. Total grassland	1. Grassland remaining grassland	2. Land converted to grassland	2.1 Forest Land converted to grassland	2.2 Cropland converted to grassland – total	a. annual cropland converted to grassland	b. Perennial cropland converted to grassland	2.3 Wetlands converted to grassland	2.4 Settlements converted to grassland	2.5 Other land converted to grassland
1990	1 812 380	1 755 264	57 116	32 467	24 648	24 399	250	NO	NO	NO
1995	1 756 134	1 694 591	61 543	37 069	24 474	24 226	248	NO	NO	NO
2000	1 718 139	1 658 448	59 691	35 442	24 249	24 003	246	NO	NO	NO
2005	1 677 919	1 617 476	60 444	36 433	24 010	23 767	243	NO	NO	NO
2010	1 651 036	1 578 317	72 719	33 840	38 879	38 590	289	NO	NO	NO
2011	1 643 600	1 570 202	73 398	33 534	39 863	39 587	277	NO	NO	NO
2012	1 635 656	1 562 324	73 332	33 228	40 103	39 839	264	NO	NO	NO
2013	1 628 296	1 554 444	73 853	32 923	40 930	40 642	287	NO	NO	NO
2014	1 625 657	1 550 924	74 733	32 617	42 116	41 701	416	NO	NO	NO
2015	1 625 654	1 543 473	82 180	33 001	49 180	48 392	788	NO	NO	NO
2016	1 624 741	1 536 419	88 322	33 384	54 937	53 947	991	NO	NO	NO
2017	1 624 498	1 531 325	93 172	33 768	59 404	58 378	1 026	NO	NO	NO
2018	1 623 337	1 528 815	94 522	34 152	60 370	59 320	1 050	NO	NO	NO
2019	1 622 241	1 526 079	96 162	34 535	61 627	60 527	1 100	NO	NO	NO
2020	1 621 933	1 523 107	98 826	34 919	63 907	62 767	1 140	NO	NO	NO
2021	1 617 752	1 517 548	100 204	35 303	64 902	63 706	1 196	NO	NO	NO
2022	1 611 421	1 510 530	100 892	34 825	66 067	64 832	1 235	NO	NO	NO

Table 268: Emissions/removals (+/-) from grassland in kt CO₂ and CH₄ in CO₂eq (1990–2022).

	4.C Total grassland	1. Grassland remaining grassland	2. Land converted to grassland	2.1 Forest land converted to grassland	2.2 Cropland converted to grassland-total	2.2.a Annual cropland converted to grassland	2.2.b Perennial cropland converted to grassland	2.3 Wetlands converted to grassland	2.4 Settlements converted to grassland	2.5 Other Land converted to grassland	4(I)C Wetlands drainage and rewetting_CH ₄ in CO ₂ eq	4(V)C1_Biomass burning wildfires_CO ₂ eq	4(V)C1_Biomass burning wildfires_CH ₄ in CO ₂ eq	4(V)C1_Biomass burning wildfire_N ₂ O in CO ₂ eq
1990	697.11	304.10	393.01	478.78	-85.76	-85.19	-0.58	NO	NO	NO	26.64	NA	NE	NE
1995	479.72	304.10	175.62	260.76	-85.14	-84.57	-0.57	NO	NO	NO	26.64	NA	NE	NE
2000	487.88	304.10	183.78	268.14	-84.36	-83.79	-0.57	NO	NO	NO	26.64	NA	NE	NE
2005	739.67	304.10	435.57	518.07	-82.50	-81.92	-0.58	NO	NO	NO	26.64	NA	0.00	0.00
2010	544.96	304.10	240.85	374.10	-133.25	-132.61	-0.64	NO	NO	NO	26.64	NA	0.01	0.00
2011	540.51	304.10	236.41	374.39	-137.98	-137.32	-0.66	NO	NO	NO	26.64	NA	0.01	0.00
2012	537.74	304.10	233.64	375.18	-141.54	-140.91	-0.63	NO	NO	NO	26.64	NA	0.04	0.01
2013	537.55	304.10	233.45	375.97	-142.51	-141.88	-0.63	NO	NO	NO	26.64	NA	0.02	0.00
2014	535.22	304.10	231.12	376.75	-145.64	-144.85	-0.79	NO	NO	NO	26.64	NA	0.01	0.00
2015	529.40	304.10	225.30	375.86	-150.56	-149.24	-1.32	NO	NO	NO	26.64	NA	0.02	0.01
2016	503.34	304.10	199.24	374.97	-175.73	-173.68	-2.05	NO	NO	NO	26.64	NA	0.01	0.00
2017	481.84	304.10	177.74	374.08	-196.34	-193.96	-2.38	NO	NO	NO	26.64	NA	0.03	0.01
2018	464.93	304.10	160.83	373.19	-212.36	-209.91	-2.45	NO	NO	NO	26.64	NA	0.03	0.01
2019	460.19	304.10	156.09	372.02	-215.92	-213.39	-2.53	NO	NO	NO	26.64	NA	0.03	0.01
2020	454.39	304.10	150.29	370.84	-220.56	-217.92	-2.64	NO	NO	NO	26.64	NA	0.01	0.00
2021	445.00	304.10	140.90	369.67	-228.77	-226.02	-2.75	NO	NO	NO	26.64	NA	0.02	0.00
2022	443.82	304.10	139.72	372.08	-232.35	-229.49	-2.87	NO	NO	NO	26.64	NA	0.01	0.00

6.4.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

In previous submissions, total Grassland area was estimated from national statistics on agricultural land use (STATISTIK AUSTRIA, 1960–2021). However, as part of continuous inventory QA/QC, consistency issues in these statistics were identified. These statistics represent Grassland under agricultural ownership only, despite the existence of other Grassland areas in Austria. As an interim solution in the 2022 and 2023 submissions, national statistics on agricultural Grassland area were used as a first estimate, that was iteratively corrected as part of the process to ensure area consistency in the national land transition matrices. However, as detailed in section 6.1.3.1, the Austrian system for land representation, in particular the methods for estimating Grassland areas, has been fundamentally improved for this 2024 submission.

National statistics on the total agricultural Grassland area are generated by Austrian Farm Structure Surveys 1993, 1995 (full survey), 1997, 1999 (full survey), 2003, 2005, 2007, 2010 (full survey) and 2020 (full survey) (ÖSTAT 1994, 1998, STATISTIK AUSTRIA 2001, 2005, 2006, 2008, 2013, 2018, 2022a). The full surveys are based on the responses to questionnaires sent to all farms and forest enterprises and cover 90% of the area of Austria. In the years between two full surveys the data have been interpolated (eg. 2010–2020). For the years after the last FSS survey year in 2020, agricultural Grassland areas for 2021 and 2022 are extrapolated using the long-term annual trend derived from the 2003 and 2020 area estimates. In previous submissions, the inter-/extrapolated time series from the national statistics (albeit with corrections for alpine pastures as described in the 2015 submission (UMWELTBUNDESAMT 2015)) were considered as robust estimates of the total Grassland area in Austria. However, after consultations with the providers of these statistics, it emerged that the decline in Grassland area according to these statistics is overestimated. Given that the statistics are based only on grassland areas owned by farmers, the estimates do not adequately account for areas of Grassland, that are no more owned by farmers, but nonetheless do not lose their status as managed Grassland per national land use definitions (e.g. Grasslands that are no longer owned by farmers, but are used for hunting by the new owners).

The time series of areas derived from the FSS statistics therefore no longer serve as the basis for Grassland area estimations. As part of the *LULUC Mapping* element (6.1.3.1) of the Austrian system for land representation, a spatially-explicit quantification of Grassland is derived from the best-estimate 2022 status layer. By integrating multiple national layers, in particular the 2022 IACS-LPIS (AMA, 2022) and DKM layers (BEV, 2023c), as well as a custom-made agriculture layer (based on the LISA light- (BEV 2023b), DLM-Gebietsnutzung (BEV, 2023e) and the CLC+ Backbone (EEA, 2023b) datasets), a complete and spatially-explicit estimate of total Grassland area for 2022 was derived. This estimate then feeds into the *LULUC Data Integration* element, where the annual time series of respective land-use changes to and from Grassland are used to extrapolate the annual Grassland area from 2022 back to 1970.

The areas of the Forest land converted to Grassland are provided by the *NFI* element of the Austrian system for land representation (see chapter 6.2.2.2), while conversions of Cropland to Grassland are provided by the *IACS-LPIS (CL<->GL)* element (see Chapter 6.3.2).

Based on expert judgement, it is assumed that LUCs from wetland, from settlement and from other land to grassland do not occur in Austria. This assumption is based on the fact that the grassland

areas show a steady decrease. In addition, wetland, settlement and other land areas are not suited (anymore) for a land use as grassland:

- Drainage of wetlands for the purpose of grassland use was carried out in Austria in former decades. For reasons of nature conservation new drainages do not occur for many years.
- Settlement areas increased steadily in the last decades mainly by LUC from agricultural areas.
- Settlement areas and soils – once converted – cannot be used for grassland.
- There is also a higher economic value for land dedicated to building land than agricultural land i.e. there is no economic incentive for re-conversion.
- “Other lands” are found at the highest elevations or steepest areas of Austria. The subsequent unfavorable ecological conditions do not allow any agricultural use.

6.4.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The STATISTIK AUSTRIA (2014) classification for grassland was used for land use definitions:

- One cut meadows,
- Two cut meadows,
- Three and more cut meadows,
- Litter meadows,
- Permanent Pastures,
- Rough Pastures,
- Alpine meadows and pastures,
- Grassland where grassland management was stopped and/or the area is no longer managed agriculturally
- Fallow grassland: grassland in good agricultural and ecological condition no longer used for production (since 2016 GLÖZ G is called *fallow grassland*, see STATISTIK AUSTRIA 2016).

In addition, grassland not owned by farmers is included in this category.

6.4.4 Methodological Issues

Emissions were estimated by applying country-specific methodologies (Tier 2) for both biomass carbon stocks and soil carbon stocks.

6.4.4.1 Grassland remaining grassland (5.C.1)

The area of Grassland remaining grassland in 2022 was estimated at 1.5 million ha.

The annual CO₂ emissions from Grassland remaining grassland between 1990 and 2022 are 304.1 kt CO₂ representing only constant emissions from drained organic soil. Due to recent research results carbon stock changes in mineral soils of Grassland remaining grassland are reported as zero (detailed information see following chapter 6.4.4.1.2).

6.4.4.1.1 Changes in carbon stocks in biomass of Grassland remaining grassland

According to IPCC 2006 Guidelines the biomass carbon stock changes of Grassland remaining grassland are assumed to be zero.

6.4.4.1.2 Changes in carbon stocks in mineral soils of Grassland remaining grassland

In previous submissions a Tier 2 method was used for estimating the changes of mineral soil carbon stocks due to management changes in Grassland remaining grassland. The method closely followed the approach presented in the IPCC 2006 Guidelines.

Recently, an Austrian project was completed, which assessed the mineral soil carbon stock changes at long-term experimental grassland plots with different management regimes of in terms of different fertiliser applications and cutting frequencies. This analysis was complemented by studying the mineral soil carbon stock changes at a large number of agricultural practice grassland sites in Upper Austria, stratified according to site and climatic conditions as well as different management types (DERSCH et al. 2023). The study showed significantly higher mineral soil carbon stocks in the upper 10 cm of soil only for those experimental plots with solid manure fertilisation. All other studied differences in management had no significant impact on the carbon stock of the top soil layer. In the last years, the solid manure fertilization decreased in Austria, which – based on the results from the experimental plots - would suggest a recent trend towards a decrease in mineral soil carbon stocks in grassland. On the contrary, significant increases in mineral soil carbon stocks in topsoils (0-10 cm) were detected at the managed grassland sites in Upper Austria that were sampled by DERSCH et al (2023) and by repeated measurements of grassland sites in Lower Austria by another study (WENZEL et al. 2022). The reasons for these increases are not yet known. The conflicting results of the above studies therefore do not currently allow for an accurate national assessment of the changes in mineral soil carbon stocks in grassland due to changes in management. Furthermore, nation-wide reassessments of the soil inventories are not available. Therefore, it was decided to revoke the previous approach of estimating the mineral soil carbon stock changes in Grassland remaining grassland and substitute it with an assumption that mineral soil carbon stocks in this subcategory are in equilibrium (Tier 1 – no change in management). This is considered an interim solution until nation-wide reassessments of the soil inventories become available and/or until the influencing parameters for the grassland soil carbon stock changes reported in literature are well understood. Only then, accurate management factors for Grassland remaining grassland can be derived and implemented in the GHG inventory.

6.4.4.1.3 Changes in carbon stocks of organic soils of Grassland remaining grassland

The area of organic grassland soils was estimated with data from the soil inventories of the Federal Provinces of Austria which are compiled in the Austrian Soil Information System – BORIS – (<http://www.borisdaten.at/>). The carbon content from the upper soil horizon (weighted mean for 0–30 cm) was calculated from the 2 x 2 km or 4 x 4 km grid samples from the agricultural soil inventories. Sites with more than 17% C_{org} were selected as “organic soils” according to the Austrian definition for such soils (NESTROY et al. 2000) and their area was extrapolated to the total Grassland area in Austria.

The estimation resulted in a total area of 12 954 ha organic grassland soils. It was assumed that these are deep drained. No organic cropland soils were identified by this analysis.

The emissions from drained organic grassland soils were estimated according to the IPCC (2013) Wetland Supplement which provides updated default emission factors for drained organic soils. The on-site emissions are calculated with the default emission factor of Table 2.1 of the Wetland Supplement (-6.1 t C/ha.a). In addition, the off-site emissions from drainage of organic soils were estimated following eq. 2.5 of the Wetland supplement and by using the default DOC emission factors from Table 2.2 for temperate climate as provided in the the Wetland supplement. The emission factor for off-site emissions amounts to -0.3 t C/ha.a . The resulting average annual on- and off-site emissions from drained organic grassland soils in Austria are 304.1 kt CO_2 .

Related CH_4 emissions (sector 4(II)) were estimated as well and are explained in the following chapter. The associated N_2O emissions are reported in sector Agriculture (3.D.6) in line with the IPCC (2006) Guidelines.

6.4.4.1.4 CH_4 emissions from drainage and rewetting and other management of organic soils (4.(II))

The IPCC (2013) Wetlands supplement provides a default method for CH_4 emissions from drained organic inland soils. Equation 2.6 was applied to estimate these emissions. A default fraction of total area of drained organic soil which is occupied by ditches was taken from Table 2.4 for deep drained grassland in temperate climate. The emission factors for the drained soil ($\text{EF}_{\text{CH}_4\text{ land}}$, Table 2.3) and for ditches ($\text{EF}_{\text{CH}_4\text{ ditch}}$, Table 2.4), both for deep drained grassland in temperate climate were applied, resulting in average annual emissions of 0.95 kt CH_4 .

6.4.4.1.5 Biomass burning

In this 2024 submission, emissions caused by biomass burning are estimated for this category for the first time. Emissions due to wildfires in Cropland and Grassland are estimated and reported together under category 4(V)C.1 Grassland remaining Grassland, because the activity data can not be separated between these categories. Estimates of wildfire emissions of CH_4 and N_2O from this category are reported. Based on the IPCC 2006 Guidelines, equation (2.27) following a Tier 2 method was applied.

$$L_{\text{fire}} (\text{t GHG}) = A * M_B * C_f * G_{\text{ef}} * 10^{-3}$$

A area burnt (ha)

C_f combustion factor

M_B mass of available fuel, t dm ha^{-1} (Table 2.4)

G_{ef} emission factor, $\text{g kg}^{-1} \text{ dm}$ (Table 2.5)

Data on the area affected by wildfires is based on the Forest Fire Database ("Waldbrand-Datenbank Österreich") of the Institute of Silviculture, BOKU (BOKU, 2023). In addition to forest fires and reed belt burnings, the database includes yearly area data on open field burning back to 2001. The average national biomass stock of grassland and cropland biomass constitutes the mass of available fuel (4.4 t/ha). The default factor for C_f was taken from table 2.6 of the IPCC 2006 Guidelines for wheat residues which appeared most suitable (0.9). The default emission factors (G_{ef}) for N_2O and CH_4 are derived from table 2.5 of the IPCC 2006 Guidelines (for agricultural residues).

The total Cropland and Grassland area affected by fires varies greatly from year to year, with an average for the whole time series of 40 ha . Therefore, the amounts of N_2O and CH_4 emissions caused by wildfires on Cropland and Grassland are negligible, with annual sum N_2O and CH_4 emissions

ranging between zero and 0.04 kt CO₂ equivalents. Due to the negligible GHG emission contribution in years, for which the areas of such fires were recorded (since 2001), it is considered appropriate to report these emissions for the years before with “not estimated”.

6.4.4.2 Land use change to Grassland (4.C.2)

6.4.4.2.1 Forest Land converted to Grassland (4.C.2.1)

The methodology and activity data are described in Chapters 6.2.2 and 6.2.4.2. The area in conversion from Forest land to Grassland for a time period of 20 year ranges from 32 467 ha to 37 716 ha between the years 1990 and 2022. The main part of conversion occurs from forests to pasture causing annual emissions due to the loss of biomass and C stock changes in soil and litter between 260.8 kt CO₂ and 522.8 kt CO₂.

For the calculation of the annual change of carbon stocks an IPCC Tier 3 approach is used. Emissions/removals were calculated by country-specific values. The changes of soil carbon stocks were stratified according to five forest growth regions. The stratified LUC areas and soil C stocks according to these growth regions were used for the estimates. The method is described in Chapter 6.2.4.2.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes from NFI observation periods while they remain constant within each NFI observation period (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of FL to GL which, as a consequence, also change in a stepwise fashion for certain pools (e.g. biomass, dead wood, litter). The significant contribution of this category to the total GL results is indicated by the same stepwise changes in the emissions/removals of the total GL category (Table 267). An interpolation across these steps is considered unsuitable and is therefore not carried out.

6.4.4.2.2 Cropland converted to Grassland (4.C.2.2)

The average annual land use change area from annual cropland to grassland from 1990–2022 is 2 474 ha. The average annual land use change area (1990–2022) from perennial cropland to grassland is 42 ha. The total area in conversion status for a time period of 20 years amounts to 24 648 ha in 1990 and 66 067 ha in 2022. Considering the area of the 20 years transition period this leads to annual removals of -85.8 kt CO₂ in 1990 and -232.4 kt CO₂ in 2022.

The use of the IACS system for the assessment of conversions from Cropland to Grassland (see chapter 6.3.2) allows more accurate annual assessments of the activities since 2002. This leads to higher annual variations in this period than before 2002. Since 2008 a higher conversion rate from Cropland to Grassland has been observed. This is likely caused by the changed framework conditions due to EU regulations concerning the protection of grasslands.

Changes of carbon stock in biomass of annual cropland converted to grassland

The carbon stock of living biomass in annual cropland was estimated by using country-specific data from Statistik Austria (STATISTIK AUSTRIA 2007). The average mean of the above and belowground biomass of the annual crops in cropland was estimated with 6.67 t C ha⁻¹ (see Chapter 6.3.4.1.2).

A country-specific carbon stock in living grassland biomass was estimated. The calculation was done by using country-specific grassland biomass data from Statistik Austria (STATISTIK AUSTRIA 2007) and from the Agricultural Research and Education Centre (AREC) Raumberg-Gumpenstein (Höhere Bundeslehr- und Forschungsanstalt Raumberg-Gumpenstein – HBLFA).

The national mean Grassland biomass C stock was calculated from the mean biomass yields of the subcategories one cut meadows, two cut meadows, litter meadows, rough pastures and cultivated pastures, which were weighed by the total area of these different grassland categories. The weighting factors are based on the respective 1996-2005 average area contributions of the different grassland types to the total grassland area. The calculation led to an average biomass yield per year of 6.2 t dm ha⁻¹ for Austrian grasslands, these are 3.1 t C per ha and year.

As recommended by the ERT and in order to make the estimation process more transparent the weighting factors are presented in the table below.

Table 269: Area weighted mean values of grassland biomass.

	area in ha (avg 10 year)	weighting factor	yield in t (avg 10 year)	contribution to weighted mean (t dm ha ⁻¹)
one cut meadows	54 827	0.05	3.2	0.2
two and more cut	844 126	0.78	6.8	5.3
litter meadows	17 126	0.02	3.5	0.1
culture pastures	74 839	0.07	6.7	0.5
rough pastures	90 264	0.08	2.4	0.2
weighted grassland yield (t dm ha ⁻¹)				6.2
weighted grassland yield (t C ha ⁻¹)				3.1

The country-specific root-to-shoot ratios from the Agricultural Research and Education Centre Raumberg-Gumpenstein (Höhere Bundeslehr- und Forschungsanstalt Raumberg-Gumpenstein – HBLFA) were used. According to the research results, the above ground stubble biomass is 1.0 t dm ha⁻¹ (0.5 t C ha⁻¹) and the root biomass is 4.2 t dm ha⁻¹ (2.1 t C ha⁻¹; average of 5 years).

The total Grassland biomass of 5.7 t C ha⁻¹ comprises the above ground biomass (3.1 t C ha⁻¹) plus the root biomass (2.1 t C ha⁻¹) and the stubble biomass (0.5 t C ha⁻¹). This value is 16% lower than the IPCC default value for cold temperate wet regions (IPCC 2006; table 6.4)

For the calculation of the annual change in carbon stocks of living biomass of annual cropland converted to grasslands, the following equations were applied – equations 2.15 and 2.16 (IPCC 2006).

$$\text{Annual change in biomass} = \text{annual area of currently converted land} * (L_{\text{conversion}} + \Delta C_{\text{growth}})$$

$$L_{\text{conversion}} = C_{\text{after}} - C_{\text{before}}$$

$$C_{\text{after}} = \text{carbon stock immediately after conversion is 0}$$

$$\Delta C_{\text{growth}} = \text{country specific value for grassland biomass } 5.70 \text{ t C ha}^{-1} \text{a}^{-1} (\text{accounted only for the year of LUC})$$

$$C_{\text{before}} = \text{country specific value of carbon stock of annual crops before conversion is } 6.67 \text{ t C ha}^{-1} \text{a}^{-1} (\text{see Chapter 6.3.4.1.2; accounted only for the year of LUC})$$

Changes of carbon stock in biomass of perennial cropland converted to grassland

The area of annual land use change from perennial cropland converted to Grassland in 2022 is 42 ha. The general equation and methodological approach is described above, using the same biomass stock for Grassland biomass (5.7 t C ha⁻¹) to calculate gains after conversion. The lost perennial cropland biomass due to this LUC is 6.09 t C ha⁻¹ (see chapter 6.3.4.1.1):

$$C_{\text{before}} = \text{country specific value (Tier 2) of biomass carbon stock of perennial crops before conversion is } 6.09 \text{ t C ha}^{-1}$$

The results in the CRF table provide the biomass carbon stock changes of annual cropland converted to grasslands and perennial cropland converted to grasslands separately, as well as the sum of these subcategories.

Changes of carbon stock in mineral soil of annual cropland converted to grassland

The area in conversion from annual cropland converted to Grassland for a time period of 20 years amounts to 24 399 ha and 64 832 ha in the years 1990 and 2022, respectively.

The IPCC method, described in the subchapters “Changes of carbon stock in mineral soil grassland to annual cropland” and “Changes of carbon stock in mineral soil grassland to perennial cropland” (see chapter 6.3.4.2.2), was employed to estimate changes in soil C stocks.

Specific, Austrian 0–30 cm depth stock values of 70 t C ha⁻¹ for Grassland and 50 t C ha⁻¹ for annual cropland were used which are based on the results of the Austrian soil inventories (GERZABEK et al. 2003, STREBL et al. 2003).

$$\text{Average annual carbon stock change (t C ha}^{-1} \text{ a}^{-1}) = (SOC_0 - SOC_{0-20})/20 = 1.0$$

SOC_0 carbon stock in soils 20 years after conversion from annual cropland to grassland → 70 t C ha⁻¹

SOC_{0-20} carbon stock change in cropland soils before conversion → 50 t C ha⁻¹

Changes of carbon stock in mineral soil of perennial cropland converted to grassland

The area in conversion status from perennial cropland converted to Grassland for a time period of 20 years amounts to 250 ha and 1 235 ha in the years 1990 and 2022.

Specific, Austrian 0–30 cm depth stock values of 70 t C ha⁻¹ for Grassland and 57 t C ha⁻¹ for perennial cropland were used which are based on the results of the Austrian soil inventories (GERZABEK et al. 2003, STREBL et al. 2003).

$$\Delta SOC = (SOC_0 - SOC_{0-20})/20 = 0.65 \text{ t C ha}^{-1} \text{ a}^{-1}$$

$$\text{annual change in carbon stock of mineral soils converted from grassland to perennial cropland} = \Delta SOC * \text{conversion area for a transition period of 20 years}$$

SOC_0 carbon stock in soils 20 years after conversion from perennial cropland to grassland → 70 t C ha⁻¹

SOC_{0-20} carbon stock in Austrian perennial cropland soils before conversion → 57 t C ha⁻¹

The results in the CRF table provide the soil carbon stock changes of annual cropland converted to grasslands and perennial cropland converted to grasslands separately, as well as the sum of these subcategories.

6.4.5 Uncertainty Assessment

Table 270: *Uncertainties of areas in the GL category.*

	Before 2001	Since 2001
Total grassland	±8%	±8%
Area of organic grassland soils	Triangle distribution 9 800 – 12 954 – 40 000 ha	
Annual LUC area CL to FL or FL to CL	see Chapter 6.2.5. Table 254	see Chapter 6.2.5. Table 254
Annual LUC area pCL to GL	±300% ¹	±260% ¹
Annual LUC area aCL to GL	±200% ¹	±150% ¹

¹ For area uncertainties > 100%, distributions were truncated at 0 as negative areas are not possible

These uncertainties were derived from the following sources:

- Total grassland: based on information from data source (Statistik Austria)
- Area of organic grassland soils: assessment on basis of the soil inventory results
- Annual LUC area pCL to GL: expert judgement from two agricultural experts on basis of the original data
- Annual LUC area aCL to GL: expert judgement from two agricultural experts on basis of the original data

The uncertainties of the emission- and carbon stock change factors, as well as respective input values used to derived them, were given in the Chapters 6.2.5 and 6.3.5. The uncertainties for the emission factors from organic soils were taken from the corresponding tables in IPCC (2013) Wetlands supplement.

The Monte Carlo simulations resulted in the following average uncertainty for the total emissions/removals of the Grassland category in the time series: ±665 kt CO₂. With these values, the Grassland category contributes (after the forest land category and HWP) the third highest share to the uncertainty of the total emissions/removals of the total LULUCF sector. The relative uncertainties in the single years range from ±93 to ±152%. The higher relative uncertainties occur in the most recent years when the net emissions/removals were generally lower than in the previous years. The uncertainties of the Grassland category emissions are mainly influenced by the high emission share as well as uncertainty of the drained organic soil area (a currently running project will improve this situation, see chapter 6.1.8).

It should be noted that the net emission/removals of the Grassland category are the result of subtractions between emissions and removals of several subcategories and pools. Only in single cases are they correlated. In line with error propagation laws the uncertainty of such net values based on subtractions of uncorrelated parameters are additive and therefore rather high in relative terms.

6.4.6 Category-specific QA/QC

The calculation of the data for category 4.C is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.4.7 Recalculations

The previous approach for estimating mineral soil carbon stock changes in Grassland remaining grassland was revoked, due to conflicting soil carbon observations from national long-term observations of grassland sites that were synthesised as part of a comprehensive national study. As of this 2024 submission, an interim assumption that mineral soil carbon stocks in this subcategory are in equilibrium (Tier 1 – no change in management) is applied. In addition, wildfires at Grassland (and Cropland included in the Grassland figures) were estimated for the first time for submission 2024. Finally, the approach for calculating long-term land-use changes and conversions between Cropland and Grassland applies a stability threshold to determine if an annual conversion is long- or short-term. Additional years in the time series therefore lead to a revised and improved identification of short-term and long-term conversions in recent years, which propagate over the entire time series. These area improvements caused upward revisions of the annual net emissions for the whole time series of the *Grassland* category. The annual emissions are in the range of 11 to 13 kt CO₂e per year higher compared to the previous submission in 2023.

6.4.8 Planned improvements

See Chapter 6.1.8.

6.5 Wetlands (Category 4.D)

6.5.1 Category description

In this category emissions/removals from the subcategories “Wetlands remaining wetlands” and “Land converted to wetlands” are considered.

The wetland area ranges from 133 981 ha in 1990 to 154 617 ha in 2022. Along the time series a steady increase in wetland area could be observed.

The shares of the different previous land use types before conversion to wetland vary between the years. Since 2005 the wetland area was surveyed annually, while interpolations were carried out for the years before. As a consequence, the LUC areas to WL and the emissions show higher year-to-year variations in the years after 2005. The slightly higher rate of conversions to Wetlands over the last decade have driven the slightly higher emissions of the category as a whole.

Table 271 and Table 272 show the land use change and removals/emissions from LUC to wetlands from 1990–2022.

Figure 43: Emissions/removals (+/-) of wetlands (1990–2022) by wetlands remaining wetlands and land use change to wetlands in kt CO₂

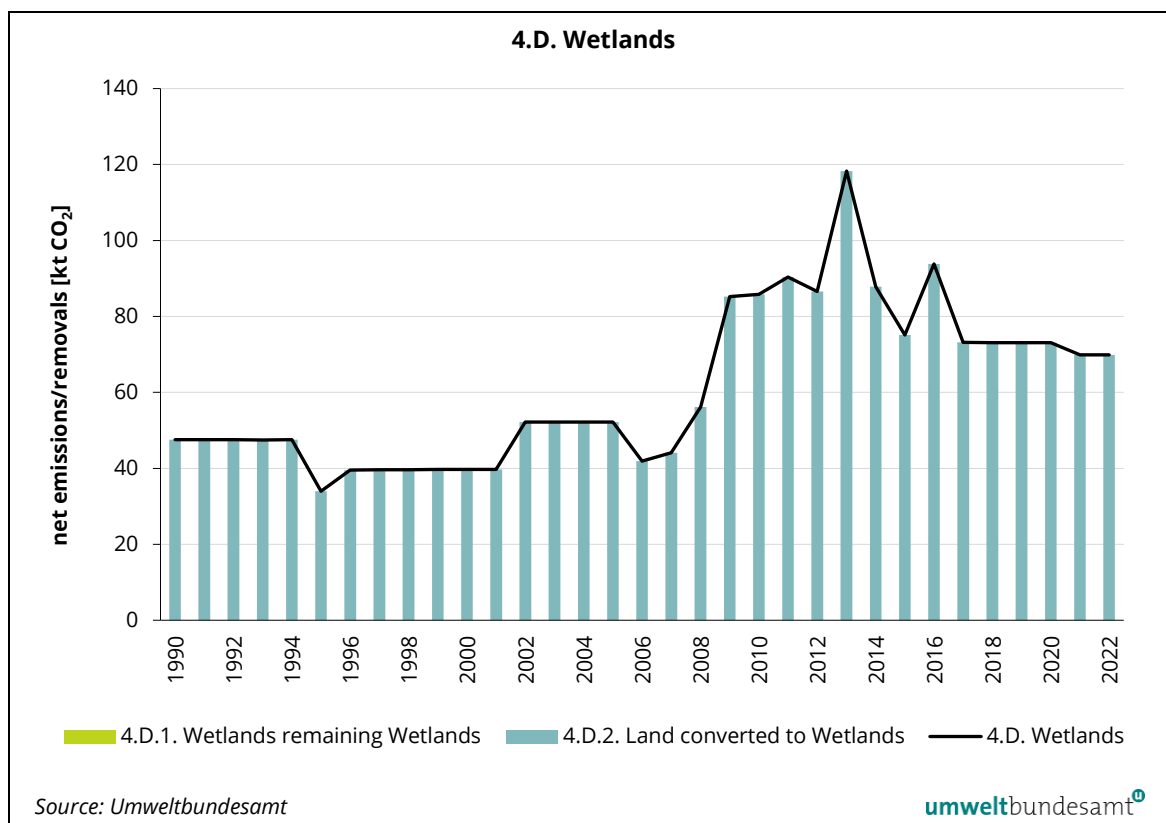


Table 271: Total areas and land-use change areas of wetland 1990–2022 in ha.

	4 D Total wetland	1. Wetland remaining wetland	2. Land converted to wetland	2.1 Forest land converted to wetlands	2.2 Cropland converted to wetlands	2.3 Grassland converted to wetlands	2.4 Settlements converted to wetlands	2.5 Other Land converted to wetlands
1990	133 981	124 464	9 517	1 706	NO	7 811	NO	NO
1995	136 260	122 084	14 177	1 948	NO	12 228	NO	NO
2000	139 869	120 618	19 251	1 863	NO	17 388	NO	NO
2005	143 478	121 557	21 921	1 806	NO	20 115	NO	NO
2010	146 576	123 653	22 924	1 898	NO	21 026	NO	NO
2011	147 627	124 346	23 280	2 037	NO	21 244	NO	NO
2012	148 501	125 040	23 461	2 175	NO	21 286	NO	NO
2013	150 897	125 733	25 163	2 314	NO	22 849	NO	NO
2014	151 838	126 427	25 411	2 453	NO	22 958	NO	NO
2015	152 176	126 938	25 238	2 628	NO	22 611	NO	NO
2016	153 411	127 714	25 697	2 803	NO	22 895	NO	NO
2017	153 663	128 491	25 173	2 978	NO	22 195	NO	NO
2018	153 915	129 267	24 648	3 153	NO	21 495	NO	NO
2019	154 167	130 044	24 123	3 327	NO	20 796	NO	NO
2020	154 418	130 820	23 598	3 502	NO	20 096	NO	NO
2021	154 518	131 597	22 921	3 677	NO	19 244	NO	NO
2022	154 617	132 691	21 926	3 834	NO	18 092	NO	NO

Table 272: Emissions/removals (+/-) of wetland 1990–2022 in kt CO₂.

	4.D Total Wetland	1. Wetland remaining wetland	2. Land converted to wetland	2.1 Forest land converted to wetland	2.2 Cropland converted to Wetland	2.3 Grassland converted to wetland	2.4 Settlements converted to wet-land	2.5 Other land converted to wetland	4(V)D1_Biomass burning wild-fires_CO2eq	4(V)D1_Biomass burning wild-fires_CH4 in CO2eq	4(V)D1_Biomass burning wild-fire_N2O in CO2eq
1990	47.57	NO	47.57	28.50	NO	19.06	NO	NO	NA	NE	NE
1995	33.97	NO	33.97	17.97	NO	16.00	NO	NO	NA	NE	NE
2000	39.70	NO	39.70	18.15	NO	21.55	NO	NO	NA	NE	NE
2005	52.21	NO	52.21	24.39	NO	27.81	NO	NO	NA	NO	NO
2010	85.80	NO	85.80	66.84	NO	18.96	NO	NO	NA	0.0069	0.0017
2011	90.36	NO	90.36	66.74	NO	23.62	NO	NO	NA	0.0029	0.0007
2012	86.59	NO	86.59	66.66	NO	19.94	NO	NO	NA	0.0064	0.0016
2013	118.28	NO	118.28	66.57	NO	51.71	NO	NO	NA	NO	NO
2014	87.82	NO	87.82	66.48	NO	21.33	NO	NO	NA	0.0000	0.0000
2015	75.14	NO	75.14	66.40	NO	8.74	NO	NO	NA	0.0002	0.0001
2016	93.79	NO	93.79	66.31	NO	27.48	NO	NO	NA	0.0008	0.0002
2017	73.16	NO	73.16	66.23	NO	6.94	NO	NO	NA	0.0081	0.0020
2018	73.08	NO	73.08	66.14	NO	6.94	NO	NO	NA	0.0010	0.0002
2019	73.09	NO	73.09	66.15	NO	6.94	NO	NO	NA	0.0041	0.0010
2020	73.09	NA	73.09	66.15	NO	6.94	NO	NO	NA	0.0996	0.0244
2021	69.92	NA	69.92	66.16	NO	3.76	NO	NO	NA	0.0001	0.0000
2022	69.92	NA	69.92	66.17	NO	3.76	NO	NO	NA	0.0316	0.0077

6.5.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The Austrian system for land representation, in particular the methods for estimating wetland areas, has been fundamentally improved for this 2024 submission.

In previous submissions, the total wetland area was taken from the regional information derived from the Real Estate Database available since 1995 (BEV 2023a). This database covers the whole area of Austria and gathers the land uses of real estate within the municipalities in digital cadastral maps. It is provided by the Austrian Federal Office of Metrology and Surveying (Bundesamt für Eich- und Vermessungswesen, BEV) and is updated annually since 2005. The change in the annual water body area pre-2005 was calculated from the mean average increase of water bodies for the periods 1971–1981, 1981–1995 and 1995–2005.

Due to the fact that peat areas are protected in Austria, it is assumed that there is no further draining of peat land. According to the peat land database (STEINER & REITER 1992) a constant bog area of 22 239 ha was taken into account for the total reporting period. An ongoing project will detect any further conversions of peatlands to other land uses by the 2025 submission (see chapter 6.1.8).

The statistics, processed in the *LU Area Statistics* element, still inform the estimates of Wetland areas and are used for extrapolating purposes. However, as part of the improved Austrian system for land representation, Wetland areas for recent years are estimated based integrating different national sources of spatially-explicit land use data.

As part of the *LULUC Mapping* element (6.1.3.1) of the Austrian system for land representation, a spatially explicit quantification of Wetlands is derived from the best-estimate 2022 status layer. By integrating multiple national layers, in particular the 2022 DKM (BEV, 2023c), the 2022 Water Body Layer (*Digitales Landschaftsmodell – Gewässer* (BEV, 2023d) and the updated Austrian Bog Catalogue (Umweltbundesamt, 2023e), a complete and spatially-explicit estimate of total Wetland area for 2022 was derived. This estimate, together with LUC estimates from the other elements then feeds into the *LULUC Data Integration* element, where the annual time series of respective land-use changes to and from Wetlands are used to extrapolate the annual Wetland area from 2022 back to 1970.

First of all, the 2022 Wetland area is extrapolated back to 2016 based on the 2017-2022 time series of all land-use changes to and from Wetlands that were quantified from the change areas between the other 2016, 2020 and 2022 GIS layers. The annual total Wetland areas are further extrapolated back to 1970 using the respective statistical time series described above. This is done by separately normalising the entire Wetland statistical time series by the respective 2016 value to create a time series of proportional area changes (relative to 2016 total areas). Multiplying this 1970-2015 time series of relative changes by the 2016 total areas derived from the spatial datasets allows for the final time series of annual total Wetland area for 1970 onwards to be compiled.

After compiling the final time series of total Wetland area for 1970 onwards, the changes in area over time (increase) have to be balanced by respective land-use changes to and from these categories. In Austria the increase of Wetlands (rivers, standing water bodies) is mainly due to the building of water reservoirs e.g. for water power stations or quarry ponds as well as the reconstruction from natural river courses. According to expert judgment, it is considered that these activities occur primarily on grasslands and forest areas and do not affect Cropland, Settlements or Other land. Furthermore national statistics show a steady increase of settlement area and since 2000 and a general increase in other land. Thus, LUC from these categories to Wetlands are considered not occurring in Austria.

Conversions between Wetlands and Forest land are quantified by the *NFI* element (see 6.2.2.2). By accounting for these conversions, a residual net change in Wetland area (a residual increase) is calculated and this is assumed to be explained completely by Grassland conversions to Wetlands, allowing for the annual areas of this conversion category to be quantified as such. The above assumption was verified by the net conversion of Grassland to Wetland derived from analysis of the 2016, 2020 and 2022 GIS layers.

The area in conversion status of land converted to wetland for a time period of 20 years ranges from 9 517 ha to 25 697 ha for the period 1990 to 2022.

6.5.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (e.g. land use and land-use change matrix)

The wetland area in correspondence to the LULUCF category comprises the following subcategories of the national Real Estate Database classification system:

- Rivers
- Lakes and reservoirs
- Water's edge areas

- Undisturbed peatland areas.

As it is not possible to distinguish the areas of managed water bodies from natural lakes and rivers on basis of the used wetland area data sources, all areas of flooded lands remaining flooded are included (IE) in subcategory other wetlands remaining other wetlands.

6.5.4 Methodological Issues

6.5.4.1 Wetlands remaining wetlands

According to the peat land database (STEINER & REITER 1992) the bog/fens area in Austria amounts to 22 239 ha. As bogs/fens are protected in Austria it is assumed that the area remains constant and that peat extraction is not occurring (NO). For the latter reason the bog/fens area is reported under the subcategory other wetlands. Emissions are not occurring because bogs/fens are not managed for peat extraction in Austria. According to the IPCC 2006 GL only emissions from peatlands managed for peat extraction are considered. The Guidelines do not provide methodologies for peatlands remaining peatlands that are not managed for peat extraction (Chapter 6.1).

Flooded Lands are defined as water bodies where human activities have caused changes in the amount of surface area covered by water (e.g. reservoirs for hydro-electricity). As it is not possible to distinguish the areas of managed water bodies from natural lakes and rivers on basis of the used wetland area data sources, all areas of flooded lands remaining flooded are included (IE) in subcategory other wetlands remaining other wetlands. Nonetheless, this does not affect the GHG emission/removal calculations as the IPCC 2006 GL do not provide methodologies for Flooded land remaining flooded land and other wetlands remaining other wetlands.

Consequently, no emissions/removals are estimated from the subcategory wetlands remaining wetlands.

6.5.4.1.1 Biomass burning

The emissions caused by biomass burning due to wildfires in the reed belts are included in category 4(V)D.1 *Wetlands remaining Wetlands*. This category is included since a major wildfire incident occurred in the reed belt of lake Neusiedlersee in 2020. Estimates of emissions of CH₄ and N₂O from this category are reported. Based on the IPCC 2006 Guidelines, equation (2.27) following a Tier 2 method was applied.

$$L_{fire} (t\ GHG) = A * M_B * C_f * G_{ef} * 10^{-3}$$

A area burnt (ha)

M_B mass of available fuel, t dm ha⁻¹ (Table 2.4)

C_f combustion factor

G_{ef} emission factor, g kg⁻¹ dm (Table 2.5)

Data on the area affected by wildfires is based on the Forest Fire Database ("Waldbrand-Datenbank Österreich") of the Institute of Silviculture, BOKU (BOKU, 2023). In addition to forest fires, this database also includes yearly data on reed belt burnings back to 2003. In a national study conducted in the Neusiedlersee area, the biomass stock of reed was measured throughout the whole vegetation period (HÜBL, 1966). According to the study, the dry mass of the biomass of reed amounts to 7.65 t ha⁻¹ in spring, which is the time when the fire occurred. The default factor for C_f was taken from ta-

ble 2.6 of the IPCC 2006 Guidelines for Wheat residues which appeared most suitable (0.9). The default emission factors (G_{ef}) for N_2O and CH_4 are derived from table 2.5 of the IPCC 2006 Guidelines (for agricultural residues).

The total wetland area affected by fires varies greatly from year to year, with an average for the whole time series of 70 ha. Therefore, the amounts of N_2O and CH_4 emissions caused by wildfires are negligible, with annual sum of N_2O and CH_4 emissions ranging between zero and 0.43 kt CO_2 equivalents. Due to the negligible GHG emission contribution in the years, for which the areas of such fires were recorded (since 2003), it is considered appropriate to report the emissions for the years before with “not estimated”.

6.5.4.2 Land use changes to Wetlands (4.D.2)

The increase of wetland area occurs mainly due to the building of water reservoirs e.g. for water power stations or quarry ponds as well as the reconstruction from natural courses of rivers. Therefore the land-use changes to wetland occur in the subcategory land to flooded lands. Land-use changes in the other wetlands subcategories are not occurring. Chapter 6.5.2 describes the methods and spatially-explicit data used to estimate the respective land-use changes: Forest land converted to wetlands and Grassland converted to wetlands.

For lands converted Wetlands, carbon stock changes in biomass occur for conversions from Forest land and Grassland, while changes (losses) in deadwood and litter occur for conversions from Forest land only.

Since a previous review finding, mineral soil carbon stock changes due to conversions to Wetlands (i.e. flooded lands) are assumed not occurring. In submissions before 2014, Wetlands (flooded land) were assumed to have a soil C stock of zero t C ha⁻¹. Using the 2006 IPCC GL approach of calculating the C stock change over a transition period of 20 years led to unrealistic annual C stock losses in mineral soils for such conversions. Consequently, and due to a lack of information in the literature, no C-stock changes in mineral soil are assumed for land converted to Wetlands.

6.5.4.2.1 Forest Land converted to Wetlands (4.D.2.1)

The methodology and activity data are described in Chapters 6.2.2 and 6.2.4.2.

The area in conversion from Forest land to Wetlands for a time period of 20 years ranges from 1 630 ha to 3 834 ha between the years 1990 and 2022. Due to the resulting changes in biomass and loss of forest deadwood and litter, these conversions cause annual emission rates ranging from 18 kt CO_2 to 67 kt CO_2 .

For the calculation of these biomass-, deadwood- and litter carbon stock changes, an IPCC Tier 3 approach based on the NFI was applied.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes between NFI observation periods while they remain constant within the NFI observation periods (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of Forest land to Wetland, which also change in a stepwise fashion for certain pools (e.g. biomass, dead wood, litter). Any interpolation across was considered unsuitable and is therefore not carried out.

6.5.4.2.2 Grassland converted to Wetland (4.D.2.3)

Changes in carbon stocks in biomass of grassland converted to wetland

For the calculation of the annual change in carbon stocks of living biomass in Grassland converted to wetlands the following equation was applied (equation 7.10 in 2006 IPCC GL)

Annual change in carbon stocks of living biomass in land converted to wetland (tonnes C.a⁻¹):

$$\Delta C_{LW flood} = (\text{Sum } A_i \cdot (B_{after} - B_{before}))$$

A_i = annual area of land currently converted to flooded land from original land use. ha

B_{before} = living biomass in land immediately before conversion to wetland = for grassland 5.7 t C ha.a⁻¹ (see Chapter 6.4.4.2.2)

B_{after} = living biomass in land immediately after conversion to wetland (default = 0 t C ha.a⁻¹)

The area in conversion status from Grassland to Wetlands for a time period of 20 years ranges from 7 811 ha to 22 958 ha between the years 1990 and 2022 causing annual emission rates due to the loss of biomass from 3.8 kt CO₂ to 51.7 kt CO₂.

6.5.5 Uncertainty Assessment

The following uncertainties of the activity data were used: Annual LUC area FL to WL – see Chapter 6.2.5, Table 254; annual LUC area GL to WL: ±20%. The uncertainty of these LUCs were estimated by assessing the minimum and maximum potential of available areas that could contribute to such LUCs on basis of the area consistency with other related land use change subcategories and their uncertainties.

The uncertainties of the emission factors are given in Chapter 6.2.5 (Table 255) and Chapter 6.3.5. (Table 265). Since only the subcategories FL to WL and GL to WL exist, no further emission factors and uncertainties were necessary.

The uncertainties of the total wetland emissions/removals range between ±13 and ±49 kt CO₂ with a steady increase across the time series of between ±33 and ±64% of the total category emissions in the single years. The low absolute uncertainty reflects the low LUC activity in this subcategory.

6.5.6 Category-specific QA/QC

The calculation of the data for category 4.D is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.5.7 Recalculations

Activity data for the biomass burning subcategory has been revised due to the availability of a new data source. Also respective CO₂ emissions are, from this submission onwards, reported as NA because loss of biomass due to burning is assumed to be in equilibrium with gains in reed growth,

which are also reported with a notation key (NE), as the IPCC 2006 Guidelines do not provide methodologies for estimating biomass carbon stock changes in Wetlands remaining wetlands that are not managed for peat extraction.

Finally, the improvements in the Austrian system for land representation have led to revised areas of Grassland converted to Wetlands. Due to the above improvements, the annual emissions of the *Wetlands* category are in the range of -10.4 to 0.51 kt CO₂e per year different compared to the last submission in 2023.

6.5.8 Planned improvements

See Chapter 6.1.8.

6.6 Settlements (Category 4.E)

6.6.1 Category description

About 7% (0.56 million ha) of Austria's surface can be allocated to the IPCC land use category Settlements (BEV 2023c). Along the time series a steady increase in settlement areas is observed. In this category only emissions/removals from the subcategories Land converted to settlements are considered, assuming that the carbon pools of Settlements remaining settlements are either in equilibrium or are not occurring. Changes (losses) in dead wood and litter carbon pools occur only for Forest land converted to settlement.

Note that large parts of the total settlement area time series before 2006 had to be interpolated between the years of available survey data (e.g. between 1971 and 1981, 1981–2003 and 2003–2006). As a consequence, the LUC areas to SL and the associated emissions show higher interannual variations in the years after 2005.

The area in conversion status from Land converted to settlements for a time period of 20 years ranges from 128 805 ha to 145 636 ha between the years 1990 and 2022. Due to C stock changes in biomass, dead organic matter and soils, these conversions cause carbon dioxide net emissions ranging from 820 kt CO₂ to 1059 kt CO₂. The conversions from Forest land and Grassland are the main sources of emissions in this subcategory.

Under Land converted to settlements, only conversions from Forest Land, Cropland and Grassland are considered to occur. The proportions of these categories vary between the years, which cause variations in the GHG emissions, implied emission factors and implied carbon stock change factors of this subcategory. Consequently, the trend in total emissions from Settlements does not strictly mirror the trend in the total settlement area.

Table 273 and Table 274 show the land use changes and removals/emissions from LUC to settlements for the period 1990 to 2022.

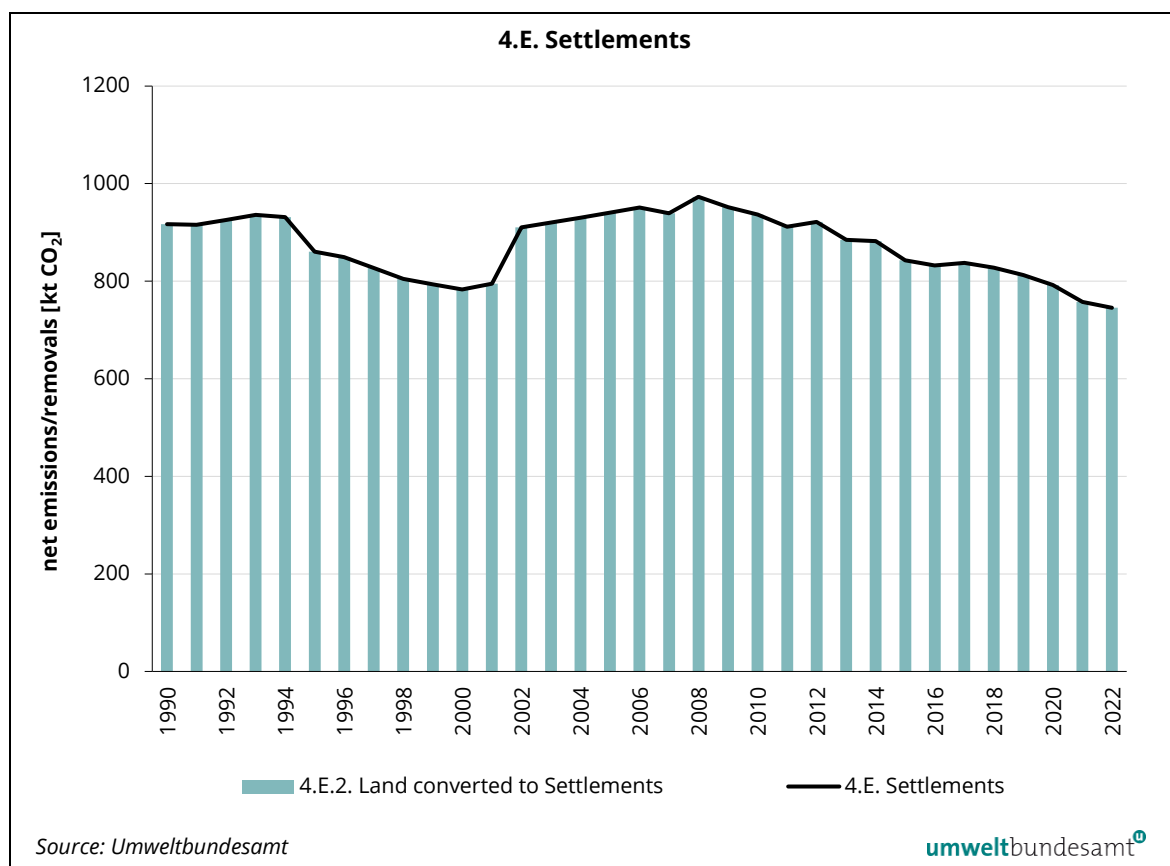
Figure 44: Emissions/removals (+/-) from land use changes to settlements (1990-2022) in kt CO₂

Table 273: Total areas and land use change areas for the subcategory settlements 4.E for the period 1990 to 2022 in ha.

	4.E Total Settlements	4.E.1. Settlements re-maining settlements	4.E.2. Land converted to Settlements	4.E.2.1 Forest Land converted to Settlements	4.E.2.2 Cropland converted to Settlements	4.E.2.3 Grassland converted to Settlements	4.E.2.4 Wetland converted to Settlements	4.E.2.4 Other land converted to Settlements
1990	359 158	216 868	142 289	9 792	49 307	83 191	NO	NO
1995	391 304	247 455	143 849	11 180	50 905	81 764	NO	NO
2000	423 450	281 749	141 700	10 689	67 940	63 071	NO	NO
2005	455 774	315 338	140 436	11 414	52 979	76 042	NO	NO
2010	492 918	348 837	144,081	10 976	48 787	84 317	NO	NO
2011	500 091	355 574	144 516	10 896	49 774	83 846	NO	NO
2012	507 947	362 311	145 636	10 816	52 256	82 564	NO	NO
2013	513 698	369 049	144 649	10 736	54 057	79 856	NO	NO
2014	519 873	375 786	144 088	10 656	58 915	74 517	NO	NO
2015	524 625	382 273	142 352	10 784	60 676	70 893	NO	NO
2016	528 924	388 760	140 164	10 912	58 708	70 544	NO	NO
2017	533 806	395 247	138 559	11 040	56 996	70 524	NO	NO
2018	538 689	401 734	136 954	11 168	58 980	66 807	NO	NO

	4.E Total Settlements	4.E.1. Settlements remaining settlements	4.E.2. Land converted to Settlements	4.E.2.1 Forest Land converted to Settlements	4.E.2.2 Cropland converted to Settlements	4.E.2.3 Grassland converted to Settlements	4.E.2.4 Wetland converted to Settlements	4.E.2.4 Other land converted to Settlements
2019	543 571	408 222	135 350	11 296	60 965	63 089	NO	NO
2020	548 454	414 709	133 745	11 423	64 174	58 147	NO	NO
2021	552 415	421 196	131 219	11 551	63 732	55 936	NO	NO
2022	556 376	427 571	128 805	11 313	62 296	55 196	NO	NO

Table 274: Emissions/removals (+/-) from land use changes to settlement for the period 1990 to 2022 in kt CO₂ and N₂O emissions in CO₂eq.

	4.E.2. Land converted to Settlements_CO ₂	4.E.2.1 Forest land converted to settlements_CO ₂	4.E.2.2 Cropland converted to settlements_CO ₂	4.E.2.3 Grassland converted to settlements_CO ₂	4.E.2.4 Wetland converted to settlements_CO ₂	4.E.2.5 Other Land converted to settlements_CO ₂	4(III)E2_N ₂ O emissions due to C losses in managed soils_N ₂ O	4(IV)A2_N ₂ O emissions from N leaching and runoff_N ₂ O in CO ₂ eq
1990	916.95	264.71	133.98	518.26	NO	NO	78.17	8.88
1995	860.59	217.76	110.45	532.37	NO	NO	78.72	8.95
2000	783.24	213.79	166.94	402.51	NO	NO	73.11	8.31
2005	940.81	331.57	143.23	466.00	NO	NO	76.11	8.65
2010	936.78	257.71	159.32	519.75	NO	NO	79.58	9.04
2011	911.96	256.96	113.81	541.19	NO	NO	79.62	9.05
2012	921.27	256.42	144.49	520.36	NO	NO	79.72	9.06
2013	884.60	255.89	140.94	487.77	NO	NO	78.65	8.94
2014	882.41	255.35	207.61	419.45	NO	NO	77.09	8.76
2015	842.76	256.94	171.99	413.83	NO	NO	75.55	8.59
2016	832.60	258.52	157.92	416.16	NO	NO	74.65	8.48
2017	837.64	260.11	155.24	422.29	NO	NO	74.06	8.42
2018	828.02	261.69	181.48	384.85	NO	NO	72.54	8.24
2019	812.41	263.14	183.62	365.65	NO	NO	71.03	8.07
2020	791.99	264.58	188.23	339.18	NO	NO	69.21	7.87
2021	757.56	266.03	138.08	353.45	NO	NO	67.71	7.70
2022	745.56	263.38	129.78	352.40	NO	NO	66.52	7.56

6.6.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The Austrian system for land representation, in particular the methods for estimating settlement areas, has been fundamentally improved for this 2024 submission.

In previous submissions, the basis for the settlement area was the regional information derived from the Real Estate Database (BEV 2023c). This database covers the whole area of Austria and gathers the land uses of real estate within the municipalities in digital cadastral maps. It is provided by the Austrian Federal Office of Metrology and Surveying (Bundesamt für Eich- und Vermessung-

swesen, BEV) and is updated since 2005 every year. Before 2005, the Real Estate Database was updated less frequently and in previous submissions respective stable mean annual increases were applied to certain parts of the time series pre-2005 to extrapolate the time series back to 1971. These spatially-explicit data source, processed in the *LU Area Statistics* element, still inform the estimates of Settlement areas and are used for extrapolating purposes. However, as part of the improved Austrian system for land representation, settlement areas for recent years are estimated based integrating different national sources of spatially-explicit land use data.

As part of the *LULUC Mapping* element (6.1.3.1) of the Austrian system for land representation, a spatially explicit quantification of Settlements is derived from the best-estimate 2022 status layer. By integrating multiple national layers, in particular the 2022 DKM (BEV, 2023c), a complete and spatially-explicit estimate of total Settlement area for 2022 was derived. This estimate, together with LUC estimates from the other elements then feeds into the *LULUC Data Integration* element, where the annual time series of respective land-use changes to and from Settlements are used to extrapolate the annual Settlement area from 2022 back to 1970.

First of all, the 2022 Settlement area is extrapolated back to 2016 based on the 2017-2022 time series of all land-use changes to and from Settlements that were quantified from the change areas between the other 2016, 2020 and 2022 GIS layers. The annual total Settlement areas are further extrapolated back to 1970 using the respective spatially-explicit Real Estate Database described above. This is done by separately normalising the entire Settlement area time series by the respective 2016 value to create time series of proportional area changes (relative to 2016 total areas). Multiplying these 1970-2015 time series of relative changes by the 2016 total areas derived from the spatial datasets allows for the final time series of annual total Settlement area for 1970 onwards to be compiled.

After compiling the final time series of total settlement area for 1970 onwards, the changes in area over time (increase) have to be balanced by respective land-use changes to and from this category. In Austria the increase in Settlement area is mainly due to conversions from agricultural land (Cropland and Grassland). Conversions between Forest land and Settlements also occur. Land use conversions to/from Settlements involving Wetlands and Other land are considered to be not occurring in Austria.

Conversions between Settlements and Forest land are quantified by the *NFI* element (see 6.2.2.2). By accounting for these conversions, a residual net change in settlement area is calculated and this is assumed to be explained completely by conversions of agricultural land to Settlements. The above assumption was verified by the net conversion of agricultural land to Settlements derived from analysis of the 2016, 2020 and 2022 GIS layers. The relative split between conversions from Cropland and conversions from Grassland are then calculated based on the net change in the Cropland area over time and the potential Cropland area available for conversion to Settlements. To estimate Cropland conversion to Settlements, the annual Cropland area derived from *LU Area Statistics* element is taken to derive the net annual change in Cropland area over time (see 6.3.2). After taking into account conversions to and from Forest land (*NFI* element) and conversions to and from Grassland (*IACS-LPIS (CL<->GL)* element), a residual net change in Cropland remains that is quantified as Cropland conversion to Settlements. After quantifying and accounting for Cropland conversions to Settlements, the remaining residual net change in settlement area is quantified as Grassland conversion to settlements.

6.6.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The settlement area in correspondence to the LULUCF category comprises the following subcategories of the national classification system:

- building land – sealed, partly sealed and unsealed area
- parks and gardens
- roads, railway tracks
- industrial and business areas
- mining areas, dumps, landfills
- other, not further differentiated settlement area

6.6.4 Methodological Issues

6.6.4.1 Land use changes to settlement (4.E.2)

6.6.4.1.1 Biomass

Estimates for living biomass in settlement areas have been revised for this submission based on the results of a new study carried out in 2023 in order to apply the Tier 2a method (eq. 8.2, 2006 IPCC Guidelines). In this study, the share of the crown cover of different vegetation classes was estimated for the settlement area in Austria by using the national, remote sensing dataset “Lisa light 2022” (BEV, 2023b, unpublished). The dataset identifies six land cover classes in settlements based on an automated evaluation of orthophotos and air-borne laser scanning datasets (high vegetation/trees, bare soil/sealed soil, shrubs, buildings, water bodies and low vegetation). The following three vegetation classes were relevant for this analysis: trees (>5m height), shrubs (2 - 5m height) and low vegetation (<2m height). In addition, the national soil sealing layer 2022, which was prepared for the national land utilisation monitoring system (ÖROK, 2023) and provides information on the sealed areas in Settlements, was used to estimate the area of unsealed/sealed soil below the crown cover. With these data sources, a GIS-based analysis was conducted to obtain the crown cover shares of trees, shrubs and low vegetation in settlements (see Table 275).

In the same study, new emission factors for trees based on the analysis of tree cadastres of seven cities in Austria were developed. The following parameters were collected from the cadastres: Tree species, crown diameter, stem circumference, tree height, number of trees and tree age. Based on the stem circumference and the height, the stem volume was calculated with the form factors of Polanschütz (1974). The branch and below-ground biomass was calculated by using the same expansion factors as for the biomass calculations of Forest land (see Table 244:). To obtain the carbon content, the biomass was multiplied with specific carbon contents: 0.48 for deciduous and 0.5 for coniferous trees). Finally, a weighted average tree biomass carbon stock per hectare crown cover was calculated (see Table 275).

The calculation of the C accumulation rate was derived from the age-related linear increases in stem circumference and height of the trees in the dataset. With these linear correlations, it was possible to obtain species-specific growth factors and apply them to all tree compartments. As a next step, the average growth rates per tree species were calculated. The crown cover area-based growth rates for tree species were then weighted by the species contribution to total urban crown

cover to derive a representative, average carbon increment in tons per hectare crown cover (see Table 275).

Most trees in Settlements are first cultured in tree nurseries until they reach a certain size before they are planted. Therefore we determined the average size of newly planted trees based on the information from the tree cadastres and assumed that this amount of carbon was accumulated in a tree nursery which is considered in the perennial cropland subcategory. The average carbon stock of a newly planted tree amounts to 24.25 t C per ha crown cover. To avoid double counting, only the difference between this carbon stock at the time of plantation and the average biomass carbon stock in Settlements can be accounted for in the Settlements category. Therefore, when a land is converted to settlement, the trees accumulate carbon for 15 years to reach the average carbon stock with the calculated average increment rate.

For shrubs and low vegetation, the previously used study on the total living biomass for different ecological sub-systems in Vienna (DÖRFLINGER et al. 1995) was expanded upon by reviewing additional publications (DÖRFLINGER et al., 1996; MAIER et al., 1996). These studies complemented the existing information with additional area data on the different sub-systems. With these data it was possible to calculate the weighted average carbon stocks for shrubs and low vegetation per hectare crown cover/land cover of these vegetation types. For shrubs, it is assumed that it takes 20 years until the average, equilibrium carbon stock is reached (see Table 275). For low vegetation it is assumed that the average carbon stock is reached in the year of land use change and stays in equilibrium afterwards.

Table 275: Overview of emission factors and parameters used to calculate carbon stock changes for land converted to settlements

	Trees	Shrubs	Low vegetation
Average carbon stock per area of crown cover (t C/ha crown cover)	65 t C/ha	30 t C/ha	6.7 t C/ha
Crown/land cover in settlements in 2022 (%)	11.4 %	3.3 %	42.1 %
Carbon accumulation time until average C stock is reached (years)	15 years	20 years	1 year
Annual carbon accumulation per area of crown cover (t C/ha/yr)	2.8 t C/ha/J	1.6 t C/ha/J	C accumulation only in the year of land use change
Annual carbon accumulation per area of settlement (t C/ha/yr)	0.32 t C/ha/J	0.052 t C/ha/J	2.82 t C/ha (= average C stock / area of settlement)

6.6.4.1.2 Litter and soil

For the calculation of the annual changes of carbon stocks in mineral soils of lands converted to settlement, the IPCC approach of 20 years discounting of soil C stock changes is used in combination with country-specific soil data. Areas with dead wood and litter stock losses (i.e. conversions from Forest land) and subsequent emissions are assumed to occur in the year of LUC.

The calculations of emissions from litter and mineral soils due to land use changes from forests to settlement are based on regionally stratified carbon stocks in litter and mineral soils of Forest land (see Chapter 6.2.4.2). These C stocks refer to a mineral soil depth of 0 to 50 cm. The carbon stock of the mineral soils in Settlements (when converted from or to forest) have been updated with the

new sealing ratio as well. The share of sealed area was updated in this submission based on aforementioned “Lisa light” GIS dataset and the updated national soil monitoring data (ÖROK 2023) which introduces a new data source and method to determine the share of sealed areas in the Settlements. Based on this assessment, the share of sealed areas in Settlements was estimated at 52.5% in 2022. As this assessment was only carried out for one single year so far, this value was applied over the whole time series. It is however foreseen, to investigate if the new method can be harmonised with the historical evaluation method to create a time series to estimate if the sealing fraction changes over time.

By expert judgement the carbon stocks on unsealed areas of settlement is estimated to be as high as in intensively managed grassland soils, which for a 0-50 cm depth have a stock of 90 t C ha⁻¹ according to the Austrian soil inventories. As the new sealing fraction is a national average value, the mineral soil carbon stocks of Settlements (in contrast to the regional values of Forest land) are represented by a single, average value of 43 t C ha⁻¹ (= (1-0.525)* 90 t C ha⁻¹) across the five forest growth regions.

Calculations of emissions from soil C stocks changes due to land-use changes from other IPCC land use categories refer to a soil depth of 0–30 cm. Again, the carbon stocks on unsealed areas of settlement is estimated to be as high as in intensively managed grassland soils (70 t C ha⁻¹ for 0–30 cm soil depth). Carbon stocks of sealed areas are assumed to be zero t C ha⁻¹. That results in a carbon stock in soil for settlement area of 33 t C ha⁻¹ (= (1-0.525)* 70 t C ha⁻¹) on average (0–30 cm soil depth). For the pre-conversion 0–30 cm soil depth stocks, the respective average values for Cropland and Grassland based on the Austrian soil inventories (see e.g. 6.3.4.2.2) were used:

- Cropland: 50 t C ha⁻¹
- Grassland: 70 t C ha⁻¹

6.6.4.1.3 Forest Land converted to Settlement (4.E.2.1)

The methodology and activity data are described in Chapters 6.2.2 and 6.2.4.2. The area in conversion status from Forest Land to Settlement for a time period of 20 years ranges from 9 792 ha to 11 565 ha between the years 1990 and 2022, causing annual emission rates from 212 kt CO₂ to 333 kt CO₂ due to the carbon losses from the biomass-, dead organic matter- and soil pools.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes between NFI observations while they remaining constant within each the NFI observation period (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of Forest land converted to settlements which also change in a stepwise fashion for certain pools (e.g. biomass, dead wood, litter). Any interpolation was considered unsuitable and is therefore not applied.

Changes in carbon stocks in biomass of forest land converted to settlement

The annual net emission rates due to loss of forest biomass and increase of settlement biomass range from 72 to 149 kt CO₂ in the years 1990 to 2022.

Changes in carbon stocks in dead organic matter and mineral soils of forest land converted to settlement

Loss of deadwood is estimated based on NFI measurements at deforestation areas. For the calculation of the annual change of carbon stocks in forest litter and mineral soils converted to Settlements, the IPCC Tier 2 approach is used. Emissions/removals were calculated by country-specific values for carbon stocks stratified according to five forest growth regions. The stratified LUC areas and C stocks according to these growth regions were used for the estimates. As mentioned above, only the pre-conversion soil carbon stocks of forest are stratified, while an average, final equilibrium mineral soil carbon stock of Settlements is derived from the new estimate of average soil sealing of the Austrian settlement area. The method is described in Chapter 6.2.4.2.

The annual emission rates due to C stock changes in dead organic matter range from 32 to 66 kt CO₂ in the years 1990–2022.

The annual emission rates due to C stock changes in mineral soil range from 99 to 122 kt CO₂ in the years 1990–2022.

6.6.4.1.4 Cropland converted to Settlement (4.E.2.2)

The area in conversion status from cropland to settlement for a time period of 20 years ranges from 46 502 to 67 940 ha in the years 1990–2022. Note that due to changes in the Austrian system for land representation these data now differ from those previously reported. In the years 1990 to 2022 net emissions range from 87 to 208 kt CO₂. Due to the changes in the area calculation, the updated method to estimate biomass for land converted to settlements and the updated carbon stock for mineral soil in settlements, the results differ substantially from the previous submission and this subcategory is now a source of emissions for the entire time series.

Changes in carbon stocks in biomass of cropland converted to settlement

For the calculation of the annual change in carbon stocks of living biomass in Cropland converted to settlement the IPCC Tier 2 approach is used. The method follows the approaches as described in Chapters 6.3.4.2.2 and 6.4.4.2.2 with the use of country-specific biomass data for annual cropland and settlements as described in Chapter 6.6.4.1.1. The average biomass stock for annual cropland biomass is higher than the average biomass stock of perennial cropland biomass (see Chapter 6.6.4.1.1). The share of annual cropland and perennial cropland which are converted to settlements is not known, but the use of the annual cropland biomass as loss due to LUCs from cropland to settlement represents a conservative estimate. The annual carbon stock gains of perennial plants, particularly trees, in the settlement areas are now estimated with a more refined method as described in Chapter 6.6.4.1.1.

Changes in carbon stocks in soil of cropland converted to settlement

Soil represents a source of net emissions during conversion of cropland to settlement (ranging from 143 to 209 kt CO₂).

6.6.4.1.5 Grassland converted to Settlement (4.E.2.3)

The area in conversion from grassland to settlement for a time period of 20 years ranges from 55 196 ha to 85 638 in the years 1990–2022 resulting in annual emission rates due to C stock changes of biomass and soils from 339 kt CO₂ to 569 kt CO₂. Note that the results differ substantially from

the previous submission due to the changes in the area calculation, the updated method to estimate biomass for land converted to settlement and the updated carbon stock for mineral soil in settlements.

Changes in carbon stocks in biomass of grassland converted to settlement

For the calculation of the annual change in carbon stocks of living biomass in grassland converted to settlement the IPCC Tier 2 approach is used. The method is the same as described in the Chapters 6.3.4.2.2 and 6.4.4.2.2 with country specific biomass data for grasslands and settlements (see Chapter 6.6.4.1.1).

In the years 1990–2022 the annual net removals range from -9 to -83 kt CO₂.

Changes in carbon stocks in soils of grassland converted to settlement

For the calculation of the annual change in carbon stocks of soils in grassland converted to settlement the IPCC Tier 2 approach is used. The method is the same as described in Chapters 6.3.4.2.2 and 6.4.4.2.2 with country specific soil C stocks for grassland and settlement areas (see Chapter 6.6.4.1.2).

The annual emission rate due to loss of soil carbon ranges from 372 to 577 kt CO₂ in the years 1990–2022.

6.6.4.1.6 Direct N₂O emissions from N mineralization/immobilization associated with loss of soil organic matter in mineral soils resulting from land use changes to settlements (4(III))

These emissions were calculated for conversions to Settlements from Forest land, Cropland and Grassland because of related C losses in mineral soils. To estimate the associated N₂O emissions the tier 2 method as provided in the IPCC 2006 GL is applied (Eq.11.1).

To calculate the net annual amount of N mineralized (F_{SOM} , eq. 11.8) from the net carbon stock change (CSC) due to the land use change in the mineral soil, the CSC was divided by the country-specific, and land-use specific C/N ratios:

- for forest soils: 19 (source: BFW 1992),
- for cropland soils: 9 (source: GERZABEK et al, 2003)
- for grassland soils: 12 (source: see footnote⁹⁸).

Then the amount of N was multiplied by the default emission factor (EF_1) from Table 11.1 in the IPCC 2006 GL. Then the result was converted from the amount of annual direct N₂O-N to N₂O emissions.

6.6.4.1.7 Indirect N₂O emissions from N leaching and runoff (4(IV))

In addition to the direct N₂O emissions from managed soils, related indirect emissions also occur. The IPCC 2006 Guidelines provide the following tier 2 methodology in Chapter 11 (eq. 11.10). For $Frac_{LEACH}$ we use a country-specific factor of 0.15154 (EDER et al., 2013) and for EF_5 we use the value provided in Table 11.3 of the IPCC 2006 Guidelines.

6.6.5 Uncertainty Assessment

The following uncertainties of the input data were used:

For the annual LUC area FL to SL see Chapter 6.2.5., Table 254. For the area of LUC from CL to SL and GL to SL an uncertainty of $\pm 100\%$ was assumed.

The uncertainties of the emission factors were given in the Chapter 6.2.5. (Table 255) and Chapter 6.3.5. (Table 265). For the settlement biomass growth rates $\pm 75\%$ based on expert judgement were used.

The uncertainty of the totals of the emissions/removals of the settlement category across the time series ranges from ± 133 kt CO₂ to ± 211 kt CO₂. Expressed in % of the total emissions of the settlement category, the uncertainty lies between ± 27 and $\pm 38\%$ depending on the magnitude of the net emissions in the single years.

It should however be noted that activity data, and particularly carbon stock change factors for settlement biomass and mineral soil, were substantially improved for this 2024 submission. This improvement is not yet reflected in the uncertainty assessment of the category, but will be introduced in an updated uncertainty analysis for the 2025 submission.

6.6.6 Category-specific QA/QC

The calculation of the data for category 4.E is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.6.7 Recalculations

The land use and land-use change assessment for the *Settlements* category was revised as part of the improvements made to the Austrian system for land representation. The spatially explicit data of the previously used Real Estate Databases are now incorporated with additional, national sources of spatially explicit data, to derive improved and consistent estimates of settlement areas and conversions to settlement over the whole time series. Furthermore, the results of a new comprehensive study on biomass stocks and growth rates of settlement trees and shrubs were included in Austria's 2024 inventory submission. Cadastral data on urban trees of several Austrian cities together with a new nationwide assessment of the (crown) cover of trees, shrubs, low vegetation and sealing in settlement using new GIS data were used to improve estimates of the biomass and soil carbon stock changes in *Settlements*. These improvements led to upward revisions of the annual net emissions for the whole time series of the *Settlement* category that were between 275 and 498 kt CO₂e per year higher than the last submission in 2023.

6.6.8 Planned improvements

See Chapter 6.1.8.

6.7 Other Land (Category 4.F)

6.7.1 Category description

Other land is a source of net GHG emissions due to conversions of Forest land to Other land. Over the 1990 to 2022 time series, annual Other land GHG emissions range from 339 to 546 kt CO₂e.

Figure 45: Emissions/removals (+/-) from land use changes to Other Land (1990-2022) in kt CO₂.

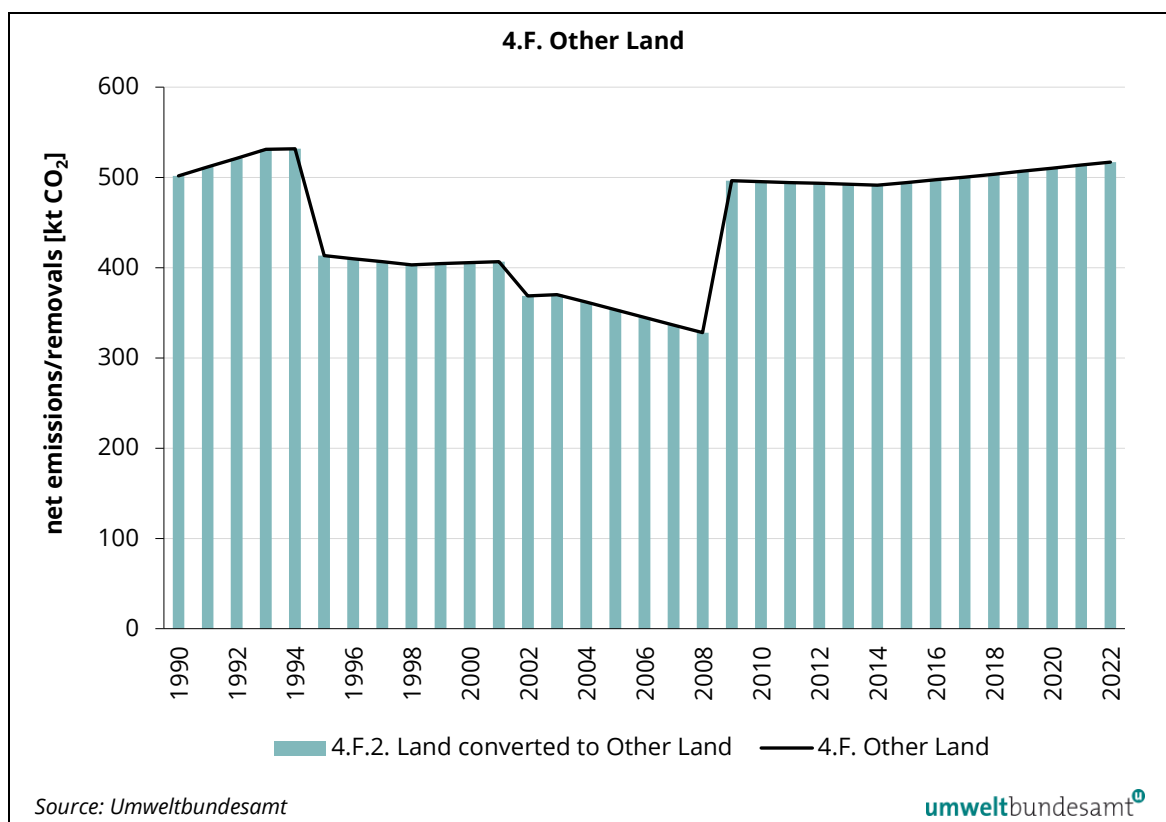


Table 276: Total areas and land-use change areas for the subcategory Other Land 4.F for the period 1990 to 2022 in ha.

	4.F Total Other Land	4.F.1. Other Land remaining Other Land	4.F.2. Land converted to Other Land	4.F.2.1 Forest Land converted to Other Land	4.F.2.2 Cropland converted to Other Land	4.F.2.3 Grassland converted to Other Land	4.F.2.4 Wetland converted to Other Land	4.F.2.4 Settlement converted to Other Land
1990	688 140	670 005	18 134	18 134	NO	NO	NO	NO
1995	681 651	660 947	20 704	20 704	NO	NO	NO	NO
2000	676 836	657 040	19 796	19 796	NO	NO	NO	NO
2005	668 605	650 695	17 910	17 910	NO	NO	NO	NO
2010	661 475	646 378	15 096	15 096	NO	NO	NO	NO
2011	660 635	645 477	15 158	15 158	NO	NO	NO	NO

	4.F Total Other Land	4.F.1. Other Land remaining Other Land	4.F.2. Land converted to Other Land	4.F.2.1 Forest Land converted to Other Land	4.F.2.2 Cropland converted to Other Land	4.F.2.3 Grassland converted to Other Land	4.F.2.4 Wetland converted to Other Land	4.F.2.4 Settlement converted to Other Land
2012	659 796	644 576	15 220	15 220	NO	NO	NO	NO
2013	658 956	643 674	15 282	15 282	NO	NO	NO	NO
2014	658 117	642 773	15 344	15 344	NO	NO	NO	NO
2015	657 277	641 486	15 791	15 791	NO	NO	NO	NO
2016	656 437	640 200	16 237	16 237	NO	NO	NO	NO
2017	655 598	638 914	16 684	16 684	NO	NO	NO	NO
2018	654 758	637 627	17 131	17 131	NO	NO	NO	NO
2019	653 919	636 341	17 578	17 578	NO	NO	NO	NO
2020	653 079	635 055	18 025	18 025	NO	NO	NO	NO
2021	652 240	633 768	18 472	18 472	NO	NO	NO	NO
2022	651 400	632 353	19 047	19 047	NO	NO	NO	NO

Table 277: Emissions/removals (+/-) from land use changes to Other Land for the period 1990 to 2022 in kt CO₂.

	4.F.2. Land converted to Other land	4.F.2.1 Forest land converted to Other land	4.F.2.2 Cropland converted to Other land	4.F.2.3 Grassland converted to Other land	4.F.2.4 Wetland converted to Other land	4.F.2.5 Settlement converted to Other land	4(II)F2 N ₂ O emissions due to C losses in managed soils_N ₂ O in CO ₂ eq	4(IV)A2_N ₂ O emissions from N leaching and runoff_N ₂ O in CO ₂ eq
1990	502	502	NO	NO	NO	NO	11	1.29
1995	413	413	NO	NO	NO	NO	13	1.47
2000	406	406	NO	NO	NO	NO	12	1.41
2005	353	353	NO	NO	NO	NO	12	1.31
2010	495	495	NO	NO	NO	NO	10	1.12
2011	494	494	NO	NO	NO	NO	10	1.12
2012	493	493	NO	NO	NO	NO	10	1.11
2013	492	492	NO	NO	NO	NO	10	1.11
2014	491	491	NO	NO	NO	NO	10	1.10
2015	494	494	NO	NO	NO	NO	10	1.13
2016	497	497	NO	NO	NO	NO	10	1.15
2017	500	500	NO	NO	NO	NO	10	1.17
2018	503	503	NO	NO	NO	NO	11	1.19
2019	507	507	NO	NO	NO	NO	11	1.22
2020	510	510	NO	NO	NO	NO	11	1.24
2021	514	514	NO	NO	NO	NO	11	1.26
2022	517	517	NO	NO	NO	NO	11	1.29

6.7.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The total area of this category is estimated in accordance to the 2006 IPCC Guidelines to avoid double accounting or omission of area. Other land is quantified as the difference between the total area of the Austrian territory and the total estimated area of the previous five land use categories – Forest land, Cropland, Grassland, Wetlands and Settlements. Substantial improvements in the Austrian system for land representation (see 6.1.3.1), has thus led to revisions in the total Other land area; however, these improvements have not affected conversions from Forest land to Other land – the only subcategory causing carbon stock changes and emissions in Other land.

The Real Estate Database (BEV, 2023) of Austria allows an assessment of the area of the category “Other land”. This database covers the whole area of Austria and gathers the land uses of real estate within the municipalities in digital cadastral maps. It is provided by the Austrian Federal Office of Metrology and Surveying (Bundesamt für Eich- und Vermessungswesen, BEV) and is updated since 2005 every year. Before 2005, the Real Estate Database was updated less frequently and in previous submissions respective stable mean annual increases were applied to certain parts of the time series pre-2005 to extrapolate the time series back to 1971.

These statistics are processed in the *LU Statistics* element and feed into the *LULUC Data Integration* element for comparison purposes. For example, if the previous five land use category areas were summed together with the Other land areas according to the Real Estate Database, the resulting sum of annual areas of all land use categories would be 0.8% lower- to 0.1% higher than the total territorial area of Austria. From these small differences, we assume that the Austrian system for land representation gives an accurate picture of how the total Austrian area is distributed between the land use categories over time.

Only conversions from Forest land to Other land are considered to occur in Austria. These assumptions are based on the location for some parts of Forest land in extreme ecological conditions. Any change from other categories to other land would be geographically and/or rationally non-plausible (e.g. any reconversion of wetlands and settlements to other land is unlikely due to the steady increase of wetlands and settlements and the missing incentives for such conversions; Cropland occurs only in ecologically favorable conditions).

Conversions between Other land and Forest land are quantified by the *NFI* element (see 6.2.2.2) of the Austrian system for land representation.

6.7.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The other land area is defined in correspondence to the LULUCF category and contains the following subcategories of the national classification system:

- rocks and screes.
- glaciers.
- unmanaged alpine dwarf shrub heaths.

6.7.4 Methodological Issues

6.7.4.1 Land use changes to other land

6.7.4.1.1 Forest Land converted to Other Land (4.F.2.1)

The methodology and activity data are described in Chapters 6.2.2 and 6.2.4.2. The area in conversion from Forest land to Other land for a time period of 20 years ranges from 15 035 ha to 21 066 ha in the years 1990 to 2022 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 328 kt CO₂ to 532 kt CO₂.

It should be noted that the areas of the annual LUCs to and from forests show stepwise changes between NFI observation periods while they remain constant within the NFI observation periods themselves (for explanation see chapter 6.2.2.2). These stepwise LUC area changes have implications on the emissions/removals of FL to OL which – as a consequence - also change stepwise for certain pools (e.g. biomass, dead wood, litter). Any interpolation across these steps was considered unsuitable and is therefore not carried out.

Changes in carbon stocks in biomass of forest land converted to other land

For the calculation of the annual change in carbon stocks of living biomass of forest land converted to other land the IPCC Tier 3 approach is used (see Chapter 6.2.4.2).

The annual net emission rates due to the loss of biomass on areas of land use change from forest land to other land range from 109 to 228 kt CO₂ in the years 1990–2022.

Changes in carbon stocks in dead organic matter and mineral soils of forest land converted to other land

Loss of deadwood is estimated on the basis of NFI measurements at deforestation areas.

For the calculation of the annual change of carbon stocks in forest litter and mineral soils converted to soils of Other land the IPCC Tier 2 approach is used. Emissions/removals were calculated by country specific values for carbon stocks stratified according to five forest growth regions. The stratified LUC areas and C stocks according to these growth regions were used for the estimates. The methods are described in Chapter 6.2.4.2.

The annual emission rates in the years 1990–2022 due to C stock changes in litter and deadwood range from 49 to 99 kt CO₂ and from 1.3 to 2.6 kt CO₂, respectively.

The annual emission rates due to C stock changes in mineral soils range from 162 to 220 kt CO₂ in the years 1990–2022.

6.7.4.1.2 Direct N₂O emissions from N mineralization/immobilization associated with loss of soil organic matter resulting from land use change on mineral soils (4(III))

Increases in available N due to soil C losses from human induced land use changes enhance the mineralisation of soil organic N and therefore cause N₂O emissions. These emissions were calculated for Forest land converted to Other land because of related C losses in mineral soils. To estimate the associated N₂O emissions the tier 2 method as provided in the IPCC 2006 GL is applied (Eq.11.1).

To calculate the net annual amount of N mineralized (F_{SOM} , eq. 11.8) from the net carbon stock change (CSC) due to the land use change in the mineral soil, the CSC was divided by the country specific C/N ratios:

- for forest soils: 19 (source: BFW 1992)

Then the amount of N was multiplied by the default emission factor (EF_1) from Table 11.1 in the IPCC 2006 Gl. Then the result was converted from the amount of annual direct N_2O -N to N_2O emissions.

6.7.4.1.3 Indirect N_2O emissions from N leaching and runoff (4(IV))

In addition to the direct N_2O emissions from managed soils, also related indirect emissions occur. The IPCC 2006 Guidelines provide the following tier 2 methodology in Chapter 11:

$$N_2O-N = F_{SOM} * Frac_{LEACH} * EF_5 \text{ (eq. 11.10)}$$

Where

... N_2O-N = annual amount of N_2O -N produced from leaching and runoff of N additions to managed soils, $kg\ yr^{-1}$

... F_{SOM} = the net annual amount of N mineralized in mineral soil associated with loss of soil C from soil organic matter as a result of changes in land use or management $kg\ N\ yr^{-1}$

... $Frac_{LEACH}$ = fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff $kg\ N$ per kg of N additions

$Frac_{LEACH}$ is a country specific factor of 0.15154 (EDER et al., 2013) and EF_5 is provided in Table 11.3 of the IPCC 2006 Guidelines.

6.7.5 Uncertainty Assessment

The following uncertainties of the input data were used:

For the annual LUC area FL to OL see Chapter 6.2.5, Table 254.

The uncertainties of the emission factors and carbon stock change factors were given in the Chapter 6.2.5, Table 255.

The uncertainty of the totals of the emissions/removals of the for Other land ranges from ± 300 kt CO_2 to ± 632 kt CO_2 . Expressed in % of the total emissions of the other land category, the uncertainty lies between ± 70 and $\pm 123\%$.

6.7.6 Recalculations

GHG emissions and removals from Other land have not been revised since the 2023 submission. Substantial improvements in the Austrian system for land representation have led to revisions in the total Other land area; however, these improvements have not affected conversions from Forest land to Other land – the only subcategory causing carbon stock changes and GHG emissions in Other land.

6.7.7 Category-specific QA/QC

The calculation of the data for category 4.E is embedded in the overall QA/QC-system of the Austrian GHG inventory (see Chapter 6.1.4).

6.7.8 Planned improvements

See Chapter 6.1.8.

6.8 Harvested Wood Products (Category 4.G)

6.8.1 Category description

The category Harvested Wood Products (HWP) is the second largest sink in Austria. In 2022 this category contributed to net removals with -2 110 kt CO₂ equivalent. The largest contribution results from the product category sawn wood, followed by wood panels and paper/paper products. Due to the nature of the input data and subsequent calculations, HWPs produced and exported are included in the same category as HWPs produced and consumed domestically. Disposal of HWP as solid waste is not occurring in Austria due to the restrictive landfill legislation.

With regard to the trend it can be seen that after the low domestic production and consequently exceptionally low HWP sink in 2020 (due to a huge amount of salvage logged wood in Central Europe from disturbances in the years before, as well as low wood prices and Corona pandemic influences), the net sink of the HWP category has increased in 2022 the second year in a row after returning to pre-2020 levels in 2021.

Figure 46: Emissions/removals from Harvested wood products for the period 1990 to 2022 by product category in kt CO₂

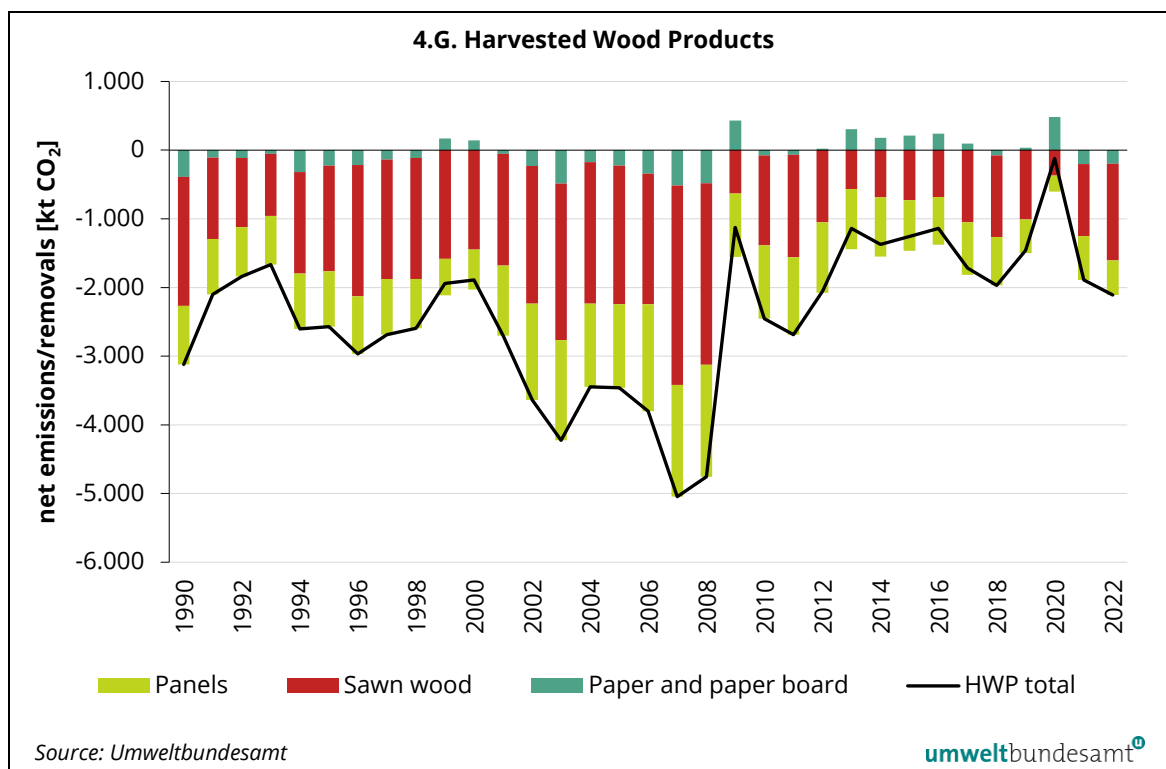


Table 278: Emissions/removals from Harvested wood products for the period 1990 to 2022 in kt CO₂.

	Harvested wood products (produced and consumed domestically)	Sawn wood	Panels	Paper and paper board	Harvested wood products (produced and exported)	HWP in SWDS
1990	-3 122	-1 877	-854	-391	IE	NO
1995	-2 569	-1 537	-806	-227	IE	NO
2000	-1 889	-1 448	-581	140	IE	NO
2005	-3 461	-2 020	-1 216	-226	IE	NO
2010	-2 452	-1 311	-1 064	-77	IE	NO
2011	-2 687	-1 491	-1 128	-68	IE	NO
2012	-2 055	-1 052	-1 023	20	IE	NO
2013	-1 138	-566	-876	305	IE	NO
2014	-1 372	-687	-864	179	IE	NO
2015	-1 254	-729	-737	212	IE	NO
2016	-1 137	-683	-692	238	IE	NO
2017	-1 719	-1 050	-765	96	IE	NO
2018	-1 969	-1 189	-704	-77	IE	NO
2019	-1 462	-1 011	-486	35	IE	NO
2020	-122	-373	-233	484	IE	NO
2021	-1 889	-1 048	-640	-201	IE	NO
2022	-2 110	-1 407	-506	-197	IE	NO

6.8.2 Methodological Issues

Emissions/removals from HWPs are based on calculation of the stocks derived from domestic harvest by applying the production approach (or approach B) of the 2006 IPCC Guidelines. Production data has been derived from the FAO Stat database on forestry production and trade statistics from 1961 to 2018. For the years from 2019 onwards the data from the Joint Forest Sector Questionnaire (JFSQ) is used, which is annually provided by the Federal Ministry of Agriculture, Forestry, Regions and Water Management (BML). It contains the latest forestry statistics which later enter into the FAO database and is therefore now obtained more directly which guarantees a timely submission. Table 279 shows the domestic production of sawn wood, wood panels and paper/paper board as calculated from production and trade data from the FAO Stat database and the JFSQ.

Table 279: Production of harvested wood products based on domestic harvest in Austria for the period 1990 to 2022 in cubic metres or tonnes calculated from FAO statistics and the JFSQ.

	Sawn wood [m³]	wood panels [m³]	Paper and paper board [t]
1990	5 615 705	1 325 979	1 701 371
1995	5 377 673	1 375 427	1 790 818
2000	5 496 399	1 251 063	1 638 620
2005	6 430 551	2 005 363	2 069 826
2010	5 811 867	2 048 785	2 201 453
2011	6 064 727	2 133 739	2 211 644
2012	5 561 243	2 018 614	2 162 515
2013	4 997 590	1 914 609	1 954 311
2014	5 161 458	1 930 385	1 980 232
2015	5 232 621	1 830 333	1 919 134
2016	5 188 675	1 815 209	1 856 156
2017	5 647 474	1 906 001	1 907 844
2018	5 841 881	1 865 734	2 011 693
2019	5 644 690	1 666 129	1 947 728
2020	4 906 193	1 443 147	1 618 298
2021	5 733 763	1 827 783	2 008 066
2022	6 175 692	1 725 090	2 047 159

As the original FAO production data does not differentiate the product categories between wood originating from domestic and imported harvest, the share for the domestic harvest needs to be obtained (equation 2.8.1 of chapter 2 of the IPCC (2014) KP supplement):

$$f_{IRW,i} = \frac{IRW_{p,i} - IRW_{ex,i}}{IRW_{p,i} + IRW_{im,i} - IRW_{ex,i}}$$

Where:

$f_{IRW,i}$ = share of wood from domestic harvest for year i , dimensionless

$IRW_{p,i}$ = Industrial roundwood production (wood in the rough) for year i , $m^3 a^{-1}$

$IRW_{ex,i}$ = Industrial roundwood – export quantity for year i , $m^3 a^{-1}$

$IRW_{im,i}$ = Industrial roundwood – import quantity for year i , $m^3 a^{-1}$

In addition, the paper production on basis of domestic harvest is further adjusted by equation 2.8.2 of chapter 2 of the IPCC (2014) KP supplement which corrects for the paper production on basis of imported pulp:

$$f_{PULP,i} = \frac{PULP_{p,i} - PULP_{ex,i}}{PULP_{p,i} + PULP_{im,i} - PULP_{ex,i}}$$

Where

$f_{PULP,i}$ = share of domestically produced pulp for the domestic production of paper and paperboard in year i

$PULP_{p,i}$ = production of wood pulp in year i , $t \text{ a}^{-1}$

$PULP_{ex,i}$ = export of wood pulp in year i , $t \text{ a}^{-1}$

$PULP_{im,i}$ = import of wood pulp in year i , $t \text{ a}^{-1}$

The original FAO production data for the diverse wood products are then multiplied by the relevant $f_{RW,i}$ and, in case of paper, additionally with the $f_{PULP,i}$ factors and aggregated to derive the production data on basis of domestic harvest presented in Table 279. For calculating the annual carbon stock inflow associated with the domestically produced wood products, the derived data are multiplied by the respective C conversion factors in $kt \text{ C m}^{-3}$ or $kt \text{ C t dm}^{-1}$ (Table 280).

Table 280: Applied carbon conversion factors for HWP commodities.

HWP commodity	conversion factors $t \text{ C/m}^3$ or $t \text{ C/ t paper}$	Source
Sawnwood coniferous	0.225	IPCC (2014) KP Supplement, Tab. 2.8.1
Sawnwood non-coniferous	0.335	Rüter, 2011
Veneer Sheets	0.295	IPCC (2003) GPG, Tab. 3a.1.1
Plywood	0.240	IPCC (2003) GPG, Tab. 3a.1.1
Particle Board	0.290	Rüter, 2011
Fibreboard, Compressed	0.350	Rüter, 2011
Hardboard	0.417	Rüter, 2011
MDF	0.319	Rüter, 2011
Insulating Board	0.115	Rüter, 2011
Paper and Paperboard	0.450	IPCC (2006) GL, Tab. 12.4

The production approach requires a time series of C stock in domestically produced wood starting with year 1900 in order to reflect current emissions from HWPs which were harvested many decades ago. As the FAO statistics start from 1961, the annual carbon stock inflow from domestic wood production needs to be extrapolated backwards to obtain a full time series from the 1901 onwards. This is done by applying equation 12.6 of Vol 4, chapter 12 of the 2006 IPCC Guidelines separately to the sawn wood, wood panels and paper time series:

$$inflow_t = inflow_{1961} * e^{[U*(t-1961)]}$$

Where

$inflow_t$ = annual C inflow from production on basis of domestic harvest of aggregated sawn wood, wood panels, or paper for year t (pre 1961), $kt \text{ C yr}^{-1}$

t	= year (pre 1961)
$inflow_{1961}$	= annual C inflow from production on basis of domestic harvest of aggregated sawn wood, wood panels, or paper for the year 1961, kt C yr ⁻¹
U	= estimated continuous rate of change in industrial roundwood consumption for the region that includes the reporting country between 1900 and 1961 (Table 12.3 of Vol 4, chapter 12 of the 2006 IPCC Guidelines), 0.0151

For each of the three wood product categories, an associated annual total C stock is calculated by starting in 1900, and applying the equation below (equation 12.1 of Vol 4, chapter 12 of the IPCC 2006 Guidelines) to each subsequent year up to the present:

$$C_i = e^{-k} * C_{i-1} + \left[\frac{(1 - e^{-k})}{k} \right] * inflow_i$$

Where:

C_i	= the carbon stock of the HWP pool for the year i , kt C
C_{i-1}	= the carbon stock of the HWP pool for the previous year i , kt C
k	= decay constant of first-order decay given in units, yr ⁻¹ ($k = \ln(2)/HL$, where HL is half-life of the HWP pool in years. Tier 2 half-lives are used for sawn wood, wood panels and paper according to Table 2.8.2 of the KP supplement.

Finally, emissions/removals from the HWPs for a given year are calculated from the annual carbon stock change in the HWP pool ($\Delta C_i = C_i - C_{i-1}$).

6.8.3 Uncertainty Assessment

The methods follow closely the IPCC 2006 GL, therefore the uncertainty of $\pm 50\%$ as listed in the IPCC 2006 GL for this category was applied. This leads to absolute uncertainties in the range of ± 60 to $\pm 2\,472$ kt CO₂.

6.8.4 Recalculations

There were no recalculations despite the update with the most recent JFSQ statistics.

6.8.5 Planned Improvements

See Chapter 6.1.8.

7 WASTE (CRF SECTOR 5)

7.1 Sector overview

This chapter includes information on methods for estimating greenhouse gas emissions as well as references of activity data and emission factors concerning waste management and treatment activities reported under CRF Category 5 *Waste: Solid Waste Disposal (5.A), Biological Treatment of Solid Waste (5.B), Incineration and Open Burning of Waste (5.C) and Waste Water Treatment and Discharge (5.D)*.

Waste management and treatment activities are sources of methane (CH₄), carbon dioxide (CO₂) and nitrous oxide (N₂O) emissions.

7.1.1 Emission Trend

Overall greenhouse gas emissions from waste management and treatment activities in the year 2022 amounted to 1 174 kt CO₂ equivalent (1990: 4 367 kt CO₂ equivalent). These are about 1.6% of total greenhouse gas emissions in Austria in 2022 and 5.5% in 1990. In 2022, greenhouse gas emissions from the waste sector were 73% below the level of 1990.

Figure 47: GHG emissions from CRF 5 Waste.

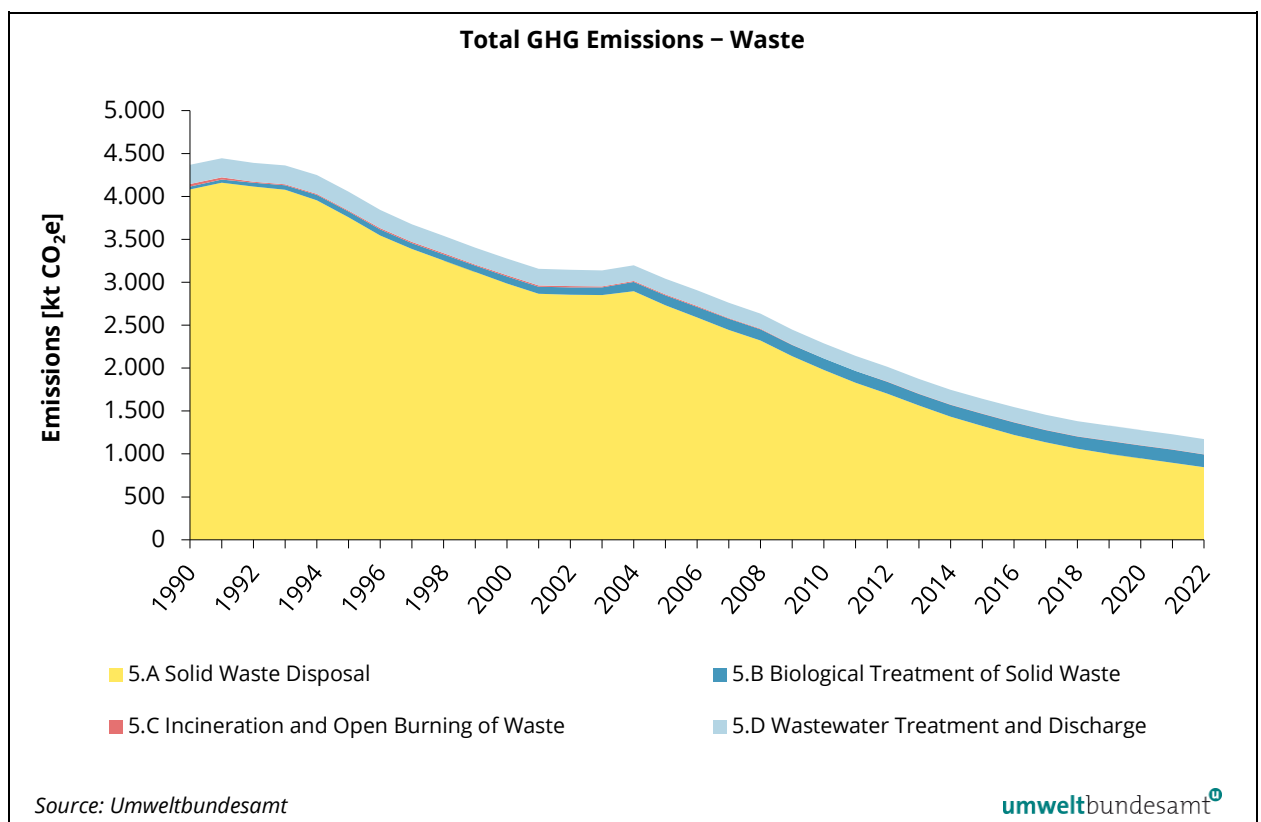


Table 281 presents the emission trend by gas. The major greenhouse gas emitted from this sector is CH₄, which represents 81% of all emissions from this sector in 2022, followed by N₂O (19%) and CO₂ (0.2%).

CH₄ emissions

CH₄ emissions from sector Waste amounted to 947 kt CO₂ equivalent in 2022; that is 78% below the level of 1990. CH₄ emissions originate from all sub-categories within this sector, but the largest source is *5.A Solid Waste Disposal*, contributing 89% to total CH₄ emissions from this sector.

The decrease of CH₄ emissions is a result of waste management policies. The amount of landfilled waste decreased significantly, the organic fraction within this waste decreased as well and methane recovery systems have increasingly been implemented during the period, reducing the amount of methane emitted. Furthermore, the decrease of inhabitants connected to septic tanks contributed to the reduction of CH₄ emissions.

N₂O emissions

N₂O emissions from sector Waste amounted to 225 kt CO₂ equivalent in 2022. Emissions increased by 111% since 1990.

68% of N₂O emissions originate from *5.D. Wastewater Treatment and Discharge*, 32% are from *5.B Biological Treatment of Solid Waste*. In both categories emissions are increasing; waste incineration (municipal solid waste and waste oil) is a minor source of N₂O emissions.

CO₂ emissions

CO₂ emissions from sector Waste amounted to 2.1 kt CO₂ equivalent in 2022 and decreased by 93% compared to 1990.

CO₂ emissions originate from waste incineration (municipal solid waste, waste oil and hospital waste). The only plant incinerating municipal waste without energy recovery was shut down in 1991, which resulted in a drop of CO₂ emissions from 1991–1992. The decrease in emissions since 2005 is due to the waste incineration regulation specifying more stringent emission limits for all facilities to be complied by 2005 and thus reducing the number of facilities and thus waste incinerated.

Table 281: Greenhouse gas emissions from Waste sector by gas.

Year	CO ₂ [kt]	CH ₄ [kt CO ₂ e]	N ₂ O [kt CO ₂ e]	Total CRF 5 [kt CO ₂ e]
1990	28	4 233	106	4 367
1995	11	3 906	137	4 055
2000	12	3 099	166	3 277
2005	12	2 835	194	3 041
2010	2.1	2 082	205	2 289
2011	2.1	1 935	206	2 143
2012	2.1	1 806	208	2 016
2013	2.1	1 666	205	1 873
2014	2.1	1 538	207	1 747
2015	2.1	1 433	210	1 644
2016	2.1	1 328	216	1 546
2017	2.1	1 238	217	1 457

Year	CO ₂ [kt]	CH ₄ [kt CO ₂ e]	N ₂ O [kt CO ₂ e]	Total CRF 5 [kt CO ₂ e]
2018	2.1	1 162	217	1 381
2019	2.1	1 107	221	1 329
2020	2.1	1 054	222	1 278
2021	2.1	1 002	225	1 230
2022	2.1	947	225	1 174
1990–2022	-93%	-78%	+111%	-73%

Table 282 presents the greenhouse gas emissions by sub-category. As can be seen, the dominant sub-category is *5.A Solid Waste Disposal*, contributing 72% (2022) to greenhouse gas emissions from sector Waste.

Table 282: Greenhouse gas emissions from Waste sector by subcategories.

Year	5.A	5.B	5.C	5.D	Total
	[kt CO ₂ e]				
1990	4 081	35	29	223	4 367
1995	3 758	67	12	218	4 055
2000	2 987	81	13	196	3 277
2005	2 730	116	13	182	3 041
2010	1 978	134	2.2	175	2 289
2011	1 831	136	2.2	174	2 143
2012	1 701	140	2.2	173	2 016
2013	1 566	132	2.2	172	1 873
2014	1 435	138	2.2	171	1 747
2015	1 328	141	2.2	173	1 644
2016	1 221	146	2.2	176	1 546
2017	1 135	144	2.2	176	1 457
2018	1 060	144	2.2	175	1 381
2019	1 003	148	2.2	176	1 329
2020	950	150	2.2	176	1 278
2021	898	153	2.2	176	1 230
2022	846	149	2.2	177	1 174
1990–2022	-79%	+328%	-92%	-21%	-73%

7.1.2 Key Categories

Methodology and results of the key category analysis is presented in Chapter 1.5.

7.1.3 Completeness

Table 283 gives an overview of the IPCC 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 283: Overview of subcategories of Category Waste: transformation into SNAP Codes and status of estimation.

IPCC Category	SNAP	CO ₂	CH ₄	N ₂ O
5.A solid waste disposal				
5.A.1 Managed waste disposal sites	090401 Solid Waste Disposal on Land	NA	✓	NA
5.A.2 Unmanaged waste disposal sites ^{*)}	090402 Unmanaged Waste Disposal	NO	NO	NO
5.A.3 Uncategorized waste disposal sites	090403 Other	NO	NO	NO
5.B Biological treatment of solid waste				
5.B.1 Composting	091005 Compost production	NA	✓	✓
5.B.2 Anaerobic digestion at biogas facilities – Municipal Solid Waste	091006 Biogas production	NA ^{**)}	✓	NA ^{***)}
5.C INCINERATION AND OPEN BURNING OF WASTE				
5.C.1 Waste incineration	090201 Incineration of domestic or municipal waste	✓	✓	✓
	090207 Incineration of hospital wastes	✓	✓	✓
	090208 Incineration of waste oil	✓	NA	✓
5.C.2 Open burning of waste		NA	✓	✓
5.D WASTE WATER treatment and discharge				
5.D.1 Domestic wastewater	091002 Wastewater treatment in residential/commercial sect.	NA	✓	✓
5.D.2 Industrial wastewater	091001 Wastewater treatment in industry	NA	✓	✓ ^{****)}
5.D.3 Other (please specify)		NO	NO	NO

^{*)} In Austria all waste disposal sites are managed.

^{**) CO₂: of biogenic origin and thus reported as an information item in the Energy sector}

^{***)} According to the 2006 IPCC GL emissions negligible (Vol. 5, p.4.4 and table 4.1); no EF provided in the IPCC GL

^{****)} covered: N₂O from (on-site) industrial wastewater treatment. N₂O from industrial wastewater treated together with domestic wastewater in wastewater treatment plants is included in 5.D.1

7.1.4 Methodological Issues

For the emissions calculation of *CRF 5.A Solid Waste Disposal* the First Order Decay (FOD) Tier 2 method is applied. Data on the amounts of waste disposed at solid waste disposal sites – including also waste from industrial sources – is available on a yearly basis. Table 287 summarises the parameters used, which are partly country specific, partly IPCC defaults.

The calculation for *CRF 5.B Biological Treatment of Solid Waste* is based on the 2006 IPCC GL, but country-specific emission factors are applied (Tier 2). Emissions from composting and mechanical-biological treatment are calculated by multiplying waste quantities by emission factors taken from national studies. For the calculation of emissions from biogas plants the IPCC 2006 default EF of 5% CH₄/biogas produced is applied (Tier 1) until 2015. Since then a linear decline until 1% in 2030 is assumed (see chapter 7.3.2.2).

For *CRF 5.C.1 Waste Incineration* the CORINAIR methodology is applied: the quantity of waste is multiplied by an emission factor for CO₂, CH₄ and N₂O. For *CRF 5.C.2 Open Burning of Waste* a simple country specific method with country specific emission factors is applied for CH₄ and N₂O.

N₂O emissions from *CRF 5.D.1 Domestic Wastewater* are calculated using a country specific method (CS), based on the 2006 IPCC Guidelines, applying CS EF (direct N₂O) and IPCC defaults (indirect N₂O). Main differences to the default methodology are described in Chapter 7.5.2. Calculation of CH₄ emissions from this category follows the methodology of the 2006 IPCC GL, but including a CS methane correction factor. N₂O and CH₄ emissions from *CRF 5.D.2 Industrial Wastewater* are determined based on a study conducted in 2019 (UMWELTBUNDESAMT 2019c), applying a CS emission factor for the calculation of direct N₂O emissions and the default value for indirect N₂O emissions. For methane it is assumed that 1% of the gas generated in the anaerobic pre-treatment of waste water is actually emitted.

7.1.5 Quality Assurance and Quality Control (QA/QC)

In addition to the general QC activities described in Chapter 1.3.3, the following QA/QC activities are done on a regular basis:

- 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 the Umweltbundesamt are contacted. After finalisation of the calculation but prior to submission, the respective section of the NIR is sent to relevant experts for a final check of descriptions and trend analysis.
- 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.
- In case of new or refined methods the calculation sheets are validated to ensure there are no transcription errors and are finally protected against accidental modification.

Further category-specific QA/QC steps and results are described in the respective subchapters.

7.2 Solid Waste Disposal (Category 5.A)

Emissions: CH₄

Key Source: Yes

7.2.1 Source category description

In 2022 emissions from *5.A Solid Waste Disposal* contributed 72% to greenhouse gas emissions from sector Waste and 1.2% to total greenhouse gas emissions in Austria. From 1990 to 2022 greenhouse gas emissions from this source decreased by 79% (see Table 282).

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 waste¹⁰¹ 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, sludge from wastewater treatment and waste from industrial sources.

It has to be noted that from 2009 on no waste is allowed to be deposited any more without being pre-treated (due to the Landfill Ordinance¹⁰²), so since 2009 no disposal of 'residual waste' is reported by landfill operators and therefore no new and additional amount of residual waste is taken into account in the inventory. Emissions from this subcategory are therefore only affected by waste deposited before 2009. Nevertheless 'residual waste' still has a notable contribution to total CH₄ generated (86% in 1990, 73% in 2005 and 45% in 2022). Waste from households and similar sources covered by the municipal waste collecting 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 incineration is a pre-treatment option too.

'Residual waste' corresponds to waste:

- originating from private households and similar sources (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

'Non residual waste':

- comprises pre-treated waste from households (e.g. sorting residues from mechanical-biological treatment) and waste with biodegradable lots from other sources, including industrial waste and sludge.
- is divided into the categories wood, construction waste, paper, green waste, sludge, sorting residues/stabilized material, textiles and fats.

Stabilized material and sorting residues remaining after mechanical, biological and mechanical-biological treatment and bulky waste are the main fraction deposited. Other fractions deposited are sludge and construction waste. Bio waste, paper and wood are mainly composted, recycled or reused (due to the implementation of the Waste Management Law), fat and textiles are not deposited any more (see Table 287). It has to be noted that from 2009 on no waste with high organic content is allowed to be deposited any more without being pre-treated (due to the Landfill Ordinance). Residues from MBT plants are exempted from this ordinance.

Table 284 presents a summary of all considered waste types and the corresponding identification numbers (list of waste).

¹⁰¹ 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).

¹⁰² Ordinance on Landfills (Landfill Ordinance 1996), Federal Law Gazette No 164/1996; Ordinance on Landfills (Landfill Ordinance 2008), Federal Law Gazette II No 39/2008

Table 284: Considered types of waste (list of waste¹⁰³ pursuant to Article 1 (a) of Directive 75/442/EEC on waste).

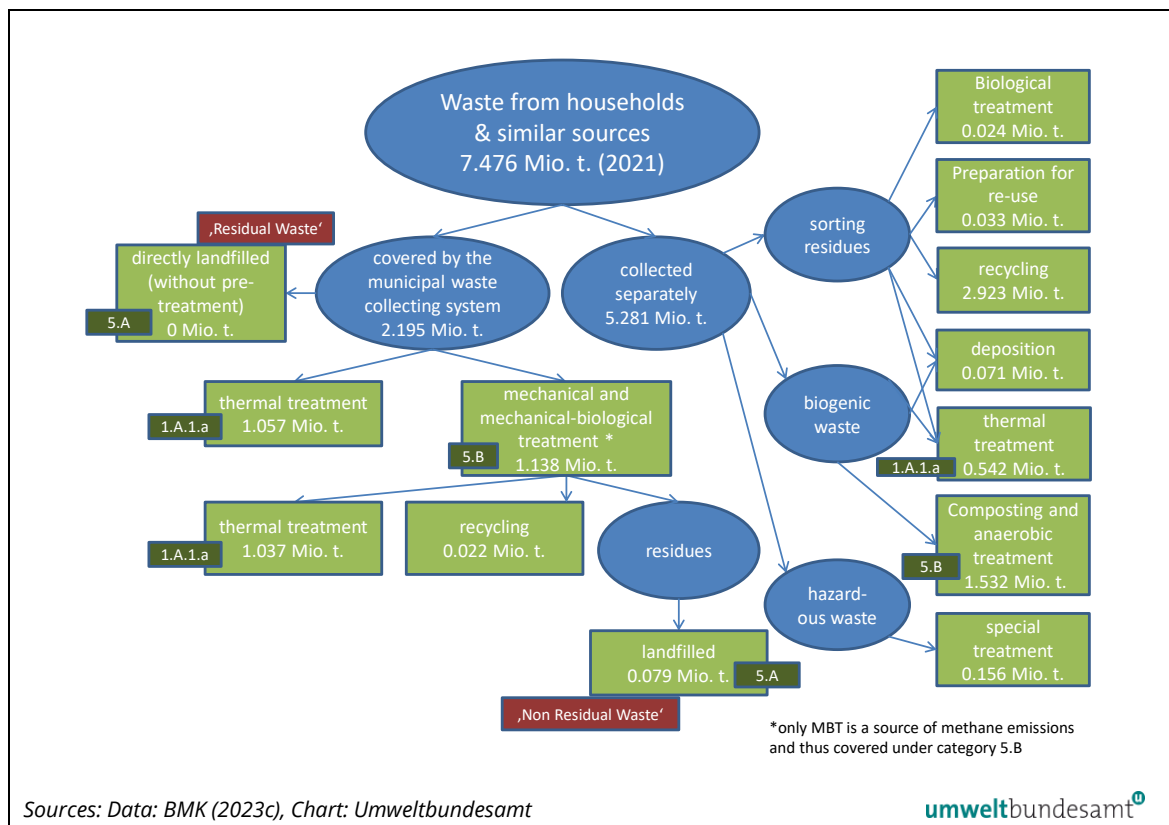
Waste Identification No	Type of Waste	Waste Identification No	Type of Waste
0303	wastes from pulp, paper and cardboard production and processing	170903	other construction and demolition wastes (including mixed wastes) containing dangerous substances
1905	wastes from aerobic treatment of solid waste	170904	mixed construction and demolition waste
1908	wastes from wastewater treatment plants not otherwise specified	190805	sludge from treatment of urban wastewater
1909	wastes from the preparation of water intended for human consumption or water for industrial use	190809	grease and oil mixture from oil/water separation containing only edible oil and fats
1912	wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified	200101/ 200102	paper and cardboard
20303	waste from solvent extraction	200108	biodegradable kitchen and canteen waste
30105	Sawdust, shavings, cuttings, wood, particle board and veneer	200111	textiles
30304	de-inking sludge from paper recycling	200201	Bio-degradable wastes
30307	mechanically separated rejects from pulping of waste paper and cardboard	200302	waste from markets
30310	fibre rejects, fibre-, filler-, and coating sludge from mechanical separation	200307	bulky waste
40106	Sludge, in particular from on-site effluent treatment containing chromium	190811–14	sludge from treatment of industrial wastewater
40109	waste from dressing and finishing	200125	edible oil and fat
40221	wastes from unprocessed textile fibres	170201	wood
150103	wooden packaging		

Figure 48 below is only to inform about the waste management practices in Austria, and data presented herein is not used for the calculation of GHG emissions. The main streams of treatment and disposal of waste from households and similar sources are shown in Figure 48. It also aims to transparently show the distinction between residual and non-residual waste (with regard to municipal solid waste¹⁰⁴) and to demonstrate that all relevant activity data are taken into account in the inventory.

¹⁰³ 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

¹⁰⁴ In fact non-residual waste also comprises waste from other (industrial) sources.

Figure 48: Waste from households and similar sources – treatment and disposal routes 2021.
Please note: This illustration only covers data from households and similar sources. Waste from industrial and similar sources (e.g. wastewater treatment plants) is not considered in this figure, but included in the inventory.



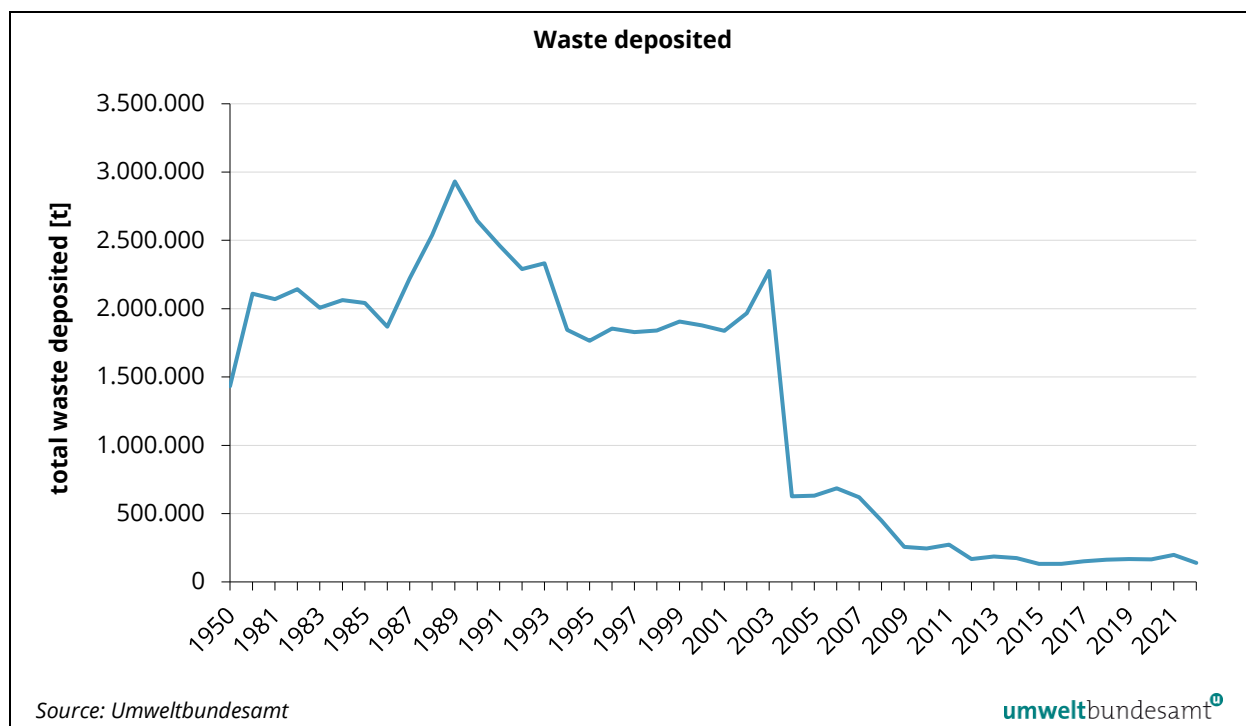
Almost 100% of waste from households and similar sources is incinerated, recycled or treated mechanical-biologically. Since 2009 only minor amounts of stabilized residues have been still directly deposited.

In Austria all waste disposal sites are managed sites. Only landfills for mass waste contain relevant organic material and are hence sources of CH₄ emissions. All other landfill types are not relevant for GHG emissions. According to the most recent information taken from the status report (BMK 2023f) of the latest Federal Waste Management Plan (BMK 2023e), 24 mass waste landfills were in operation in 2021, compared to 61 sites in 2002.

In the inventory waste amounts deposited from 1950 onwards are taken into account. From 1950 till the end of the 1980s waste amounts were increasing, with a peak in 1989. The decrease after 1989 is partly due to the introduction of a landfill levy. This levy originates from an Austrian Law for cleaning up contaminated sites¹⁰⁵ with the objective to finance cleaning up and securing activities for contaminated site.

¹⁰⁵ Law on the Remediation of Contaminated Sites (1989), Federal Law Gazette No 299/1989

Figure 49: Waste ('residual waste' and 'non-residual waste') with a relevant share of degradable organic carbon (deposited on mass waste landfills), period 1950–2022.



In 1990 waste management was for the first time regulated by law (Austrian Waste Management Law¹⁰⁶). As a result, waste separation, reuse and recycling activities increased and the amounts of deposited waste decreased significantly until 1994.

The amount of deposited waste peaked once more in 2003 due to the remediation of contaminated sites, and then dropped as from the beginning of 2004 generally only pre-treated waste was allowed to be deposited. This is due to the implementation of the Landfill Ordinance¹⁰⁷, which prohibits the disposal of untreated waste with relevant content of organic matter in Austria from 2004 on and therefore leads to reduced waste volumes as well as decreased carbon content in deposited waste. Under certain circumstances there were some exceptions to this pre-treatment-obligation granted to some Austrian provinces (regulated in § 76 Abs. 7 AWG 2002). In four of the nine Austrian provinces it was still allowed to deposit waste directly without any pre-treatment until the end of 2008.

Since the beginning of 2009 no waste with relevant content of organic matter is allowed to be deposited any more without being pre-treated due to the provisions of the Landfill Ordinance¹⁰⁷. Deposition of residual waste as well as paper, wood and green waste thus does no longer take place in Austria.

¹⁰⁶ Waste Management Act of 2002, Federal Law Gazette I No 102/2002

¹⁰⁷ Ordinance on Landfills 1996 ("Deponieverordnung" 1996), Federal Law Gazette No 164/1996, as amended by Federal Law Gazette II No 49/2004; Ordinance on Landfills 2008 ("Deponieverordnung" 2008), Federal Law Gazette II No 39/2008, as amended by Federal Law Gazette II No 144/2021)

7.2.2 Methodological Issues

For the emissions calculation the First Order Decay (FOD) method is applied, assuming that the degradable organic carbon (DOC) in waste decays throughout a few decades. Good quality activity data on historical and current waste amounts is available. Parameters used are partly country-specific (e.g. landfill gas collection), partly default values. The method has therefore been characterized as a Tier 2 method.

7.2.2.1 Activity data

The quantities of 'residual waste' have been taken from the following sources:

- Data for 2008–2022 have been taken from the EDM¹⁰⁸, an electronic database administered by the BMLFUW and delivering data as input to the national Federal Waste Management Plan. 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>;
- Data for 1998–2007 were taken from a database for solid waste disposals called „Deponie-datenbank“ ('Austrian landfill database'), a database administered and maintained by the Umweltbundesamt until the end of 2008;
- Data for 1950–1997 on the amounts of deposited residual waste were taken from national studies (HACKL & MAUSCHITZ 1999, UMWELTBUNDESAMT 2001b) and the respective Federal Waste Management Plans (BMLFUW 1995, BMLFUW 2001).

In the national study (HACKL & MAUSCHITZ 1999) as well as in the historical 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 as well as the EDM) and thus considered in the time series from 1998 onwards. To achieve a consistent time series, data of the two overlapping years¹⁰⁹ (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' of the years 1998–2007 were taken from the database for solid waste disposals ('Deponiedatenbank', 'Austrian landfill database'), data for 2008–2022 have been taken from the EDM (Electronic Data Management). Only the types of waste with biodegradable lots are considered. There are no data available for the years before 1998, thus extrapolation was done 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 used.

Table 285 presents activity data and CH₄ emissions from managed waste disposal on land for the period 1990–2022.

¹⁰⁸ Electronic Data Management

¹⁰⁹ Data available from the Federal Waste Management Plan (Bundesabfallwirtschaftsplan - BAWP) as well as from the Austrian landfill database.

Table 285: Activity data for 'residual waste' and 'non residual waste', greenhouse gas emissions and implied emission factors 1990–2022

Year	Non-Residual Waste	Residual Waste	Total Waste	CH ₄ emissions	IEF*
	[t/a]			[t/t]	
1990	648 702	1 995 747	2 644 448	145 756	0.06
1995	716 219	1 049 709	1 765 928	134 204	0.08
2000	826 874	1 052 061	1 878 935	106 674	0.07
2005	389 660	241 733	631 393	97 510	0.18
2010	244 969	0	244 969	70 637	0.33
2011	273 313	0	273 313	65 403	0.27
2012	166 263	0	166 263	60 766	0.41
2013	185 156	0	185 156	55 941	0.34
2014	174 500	0	174 500	51 251	0.33
2015	131 959	0	131 959	47 419	0.41
2016	132 182	0	132 182	43 618	0.37
2017	151 866	0	151 866	40 535	0.30
2018	163 663	0	163 663	37 863	0.26
2019	166 659	0	166 659	35 807	0.24
2020	165 576	0	165 576	33 927	0.23
2021	197 067	0	197 067	32 082	0.18
2022	138 940	0	138 940	30 208	0.24

* IEF calculated on basis of gross CH₄ emissions: (CH₄ emissions + CH₄ recovery) / MSW. The smaller the annual amount of waste deposited, the larger the IEF and vice versa. E.g. in 1990, 2 644 kt waste were deposited resulting in an IEF of 0.06 t CH₄/t waste, whereas in 2022 only 139 kt were landfilled resulting in an IEF of 0.24 t CH₄/t waste. Fluctuations of the IEF are thus due to inter-annual fluctuations of annually reported waste amounts deposited at quite steadily declining emissions.

Significant reductions of deposited waste volumes occurred 2003/2004 and 2008/2009, due to the restrictions pursuant to the Landfill Ordinance. The decrease 2011/2012 was caused by the shut-down of two bigger mechanical biological treatment plants resulting in lower depositions of residues from this pre-treatment. CH₄ emissions also declined, but quite steadily and not in the same extent as the volumes develop from year to year as these are also affected by historical DOC depositions (FOD). Since 1990, less than 10% of the annual emissions stem from the most recently deposited waste, and more than 90% from waste deposited in previous years.

Table 286: Mass of decomposable DOC deposited [kt], by waste type.

	Residual waste	Non-Residual waste							
	mixed MSW	wood	paper	sludges	sorting residues	bio-waste	textiles	construction waste	fats
Decomposable DOC (DDOCm) deposited [kt]									
1990	239	3.0	6.9	7.8	36.1	1.9	0.4	1.5	0.0
1995	94	3.3	7.6	8.6	39.9	2.1	0.5	1.6	0.0
2000	81	1.7	5.2	6.2	53.7	1.3	1.0	2.7	0.0
2005	24	0.4	0.1	0.5	31.8	0.1	0.0	0.8	0.0
2010	0	0.0	0.0	0.1	21.3	0.0	0.0	0.0	0.0
2011	0	0.0	0.0	0.1	23.8	0.0	0.0	0.0	0.0
2012	0	0.0	0.0	0.2	14.3	0.0	0.0	0.0	0.0
2013	0	0.0	0.0	0.5	15.5	0.0	0.0	0.0	0.0
2014	0	0.0	0.0	0.4	14.8	0.0	0.0	0.0	0.0

	Residual waste	Non-Residual waste							
	mixed MSW	wood	paper	sludges	sorting residues	bio-waste	textiles	construction waste	fats
2015	0	0.0	0.1	0.1	11.3	0.0	0.0	0.0	0.0
2016	0	0.0	0.0	0.3	11.1	0.0	0.0	0.0	0.0
2017	0	0.0	0.1	0.5	12.6	0.0	0.0	0.0	0.0
2018	0	0.0	0.1	0.4	13.7	0.0	0.0	0.0	0.0
2019	0	0.0	0.1	0.7	13.5	0.0	0.0	0.0	0.0
2020	0	0.0	0.1	0.8	13.4	0.0	0.0	0.0	0.0
2021	0	0.0	0.1	0.7	16.3	0.0	0.0	0.0	0.0
2022	0	0.0	0.0	0.4	11.6	0.0	0.0	0.0	0.0

7.2.2.2 Emission Parameters

Where available, country specific parameters are used after they have been checked if they are in the range of the IPCC guidelines. If country specific parameters were not available IPCC default values are taken. The following table summarises the parameters used plus the corresponding references.

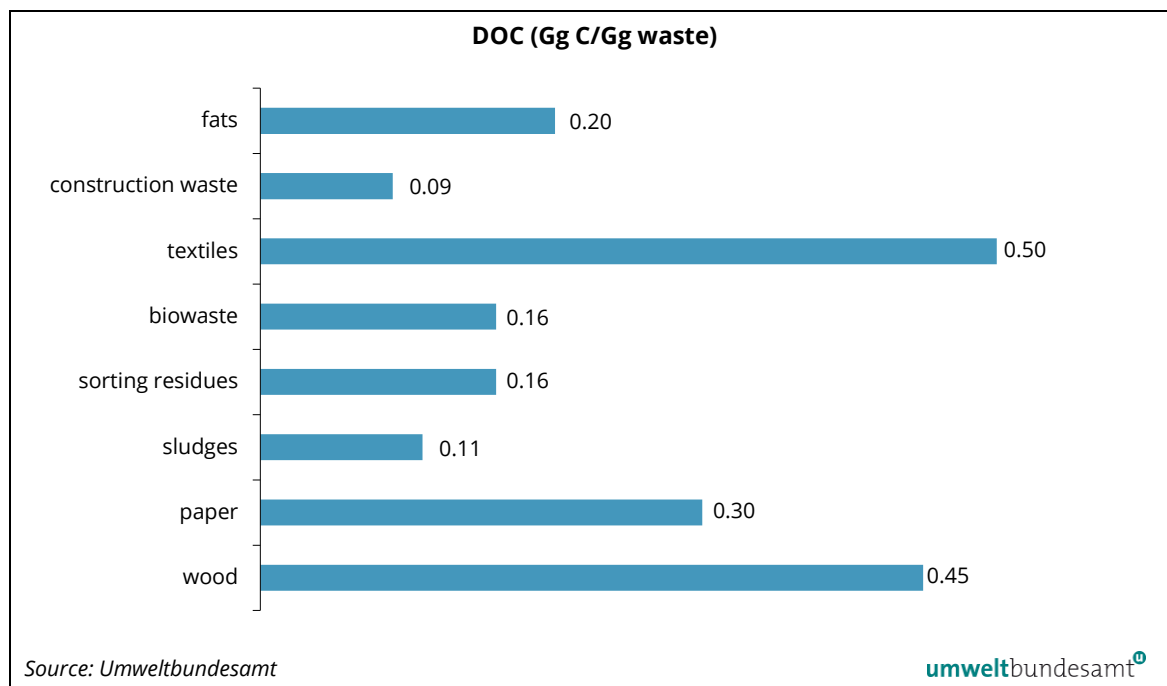
Table 287: Parameters for calculating CH₄ emissions from SWDS.

Waste category/ Parameters	residual waste	wood	paper	sludges	sorting residues	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 2005)								
DOC (kt C/kt waste)	See Table 288	0.45	0.3	0.11	0.16	0.16	0.5	0.09	0.2
	(BAUMELER et al. 1998), (UMWELTBUNDESAMT 2005)								
	7	25	15	7	20	10	15	20	4
Half life period (t_{1/2})	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 CH₄ in Landfill Gas (F)	From 2018 onwards: 0.5 (IPCC 2006) 2009-2018: linearly declining from 0.55 (2008) to 0.5 (2018) 1950-2008: 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 51 (UMWELTBUNDESAMT 2004b, 2008a, 2014b, 2019b, 2023b)								
Process start (M)	13 Delay time of 6 months, with an average residence time of 6 months (IPCC default)								

7.2.2.2.1 Biodegradable organic carbon (DOC)

Austria applies the waste composition modelling approach. The DOCs of the different waste categories under '**non residual waste**' are thus held constant for the entire time series, at the level shown in Table 287. These are clearly defined (wood, paper, sludge etc.) and quite 'homogenous'.

Figure 50: 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. have clearly influenced the trend of the DOC.

For the year 1990 a DOC content of 200 g/kg residual waste was taken (UMWELTBUNDESAMT 2003). 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 2003). 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.

Table 288: Bio-degradable organic carbon content of residual waste (mixed MSW, directly deposited).

Year	kg C/kg Residual Waste
1950–1990	0.20 ¹⁾
1995	0.15 ¹⁾
2000	0.13 ^{*)}
2005	0.17 ²⁾
2008	0.17 ³⁾
2009–2022	n.r. ^{**)}

¹⁾ based on (UMWELTBUNDESAMT 2003)

²⁾ based on (BMLFUW 2006a)

³⁾ calculated according to waste composition 2009 (annual update of BMLFUW 2006a)

^{*}) interpolated

^{**)} no deposition of residual waste any more

The intensified separate collection of organic and paper waste and the corresponding decreasing share of these materials in the residual waste fraction was the reason for the decrease of the DOC in residual waste during the 1990ies. The increase of the DOC of residual waste in 2000 and the following years is due to the increasing share of biogenic components especially of food waste in residual waste (as can be seen in Table 289).

Table 289: Composition of residual waste.

Residual waste	1990 ¹⁾	1993 ¹⁾	1996 ¹⁾	1999 ¹⁾	2004 ²⁾	2008 ³⁾
	[% of moist mass]	[% of moist mass]	[% of moist mass]	[% of moist mass]	[% of moist mass]	[% of moist mass]
Paper, cardboard	22	18	14	14	11	12
Glass	8	6	4	3	5	4
Metal	5	4	4.5	5	3	3
Plastic	10	9	11	15	10	10
Composite materials	11	11	14	–	8	10
Textiles	3	3	4	4	6	6
Hygiene materials	–	–	–	12	11	8
Biogenic components	30	34	30	18	37	40
Hazardous household waste	1	2	1	0.3	2	1
Mineral components	7	8	4	–	4	3
Wood, leather, rubber, other components	2	4	1	3	1	–
Residual fraction	–	–	14	27	2	2

¹⁾ (UMWELTBUNDESAMT 2003)

²⁾ (BMLFUW 2006a)

³⁾ Annual update (2009) of (BMLFUW 2006a)

7.2.2.2.2 DOCf

The DOCf values used for calculation are shown in Table 287.

Austria does not apply the bulk DOCf option of the IPCC 2006 GL as detailed information is available on the waste deposited (to be reported by landfill operators according to § 41 Landfill Ordinance). Based on this information the calculation is done separately for each waste fraction (wood, paper, sludges, sorting residues, bio waste, textiles, construction waste, fats, residual waste). The composition of the different landfilled waste fractions is well known, allowing for applying an appropriate DOCf accordingly (see UMWELTBUNDESAMT 2005). Higher DOCf values than the IPCC 2006 default (0.5) are applied for most of the waste types (except wood) as the composition data shows a low share of lignin in the waste deposited.

For 'residual waste', a calculation of the DOCf (0.6) was done based on waste analyses carried out in Austria in 2004¹¹⁰ (BMLFUW 2006a). Applying the default DOCf values presented in the 2019 Refinement to the 2006 IPCC GL, Table 3.0, our calculations for residual waste would result in a DOCf of 0.592. This value would be even slightly higher if the average value of 0.523 for moderately decomposable waste (indicated in the notes to Table 3.0) were used instead of the default value given of 0.5. The relatively high DOCf for Austria is mainly due to the high share of kitchen waste (about 37% of the total waste composition or almost 49% only regarding fractions with degradable organic substance).

A justification regarding the DOCf values of further waste fractions is given hereinafter:

- 'Sludges' do not contain lignin, therefore a slightly higher DOCf is in line with the GL.
- The default DOCf of green waste according to Table 3.0 of the 2019 Refinement to the 2006 IPCC GL is 0.7 and thus even higher than the value used in Austria. However in Austria the fraction 'biowaste' also includes branches, thus a slightly lower DOCf is appropriate.
- The waste category 'sorting residues' does not only include wood, but also compost like output from MBTs. Therefore a higher DOCf is justified.
- The decomposition of 'paper', even of newsprints, is higher than of 'wood' - again a higher DOCf is justified.

Also in (BAYARD et al 2018) the biodegradation of different waste streams was investigated showing typically higher DOCf values than the recommended DOCf of the IPCC GL 2006 of 0.5.

7.2.2.2.3 Fraction of CH₄ in generated landfill gas (F)

For the historical years **1950–2008** Austria uses a country-specific value of 0.55 for the fraction of CH₄ in generated landfill gas (F), based on various literature, among others RETTENBERGER G., MEZGER, H. (1992), FLÖGL, W. (2002), ÖWAV (2003), UMWELTBUNDESAMT (2008a). This fraction is slightly higher than the default from the IPCC 2006 Guidelines (0.5) and based on the following considerations:

- The methane concentration in the generated landfill gas changes over time. After a few months already before the so called "stable methane phase" begins, the methane concentration rises to about 55%. During the stable methane phase (this phase lasts several years/decades) the CH₄-concentration typically is about 55% (RETTENBERGER G., MEZGER, H. 1992).
- Further, the methane concentration in the landfill gas depends on the waste fractions deposited. Fats and proteins show substantially higher concentrations than carbohydrates (WEILAND, P. 2001). In biogas plants, fats and oils show very high methane concentrations (about 68%), legumes show concentrations between 52% and 65%, food waste about 60% (LFL 2017). Separately collected biowaste also contains proteins and fats, kitchen and canteen waste even higher proportions. In Austria it was allowed to landfill untreated waste until 2004, in some federal provinces until 2008, therefore a higher methane concentration in landfill gas is to be expected as not only cellulose and hemicellulose (with a theoretical methane concentration of about 50%) but also proteins and fats were deposited until 2008.

¹¹⁰ the analysis of 2004 is used as since 2004 a ban of landfilling of untreated residual waste came into force (with exemptions until 2008)

From 2018 onwards, a value of 0.5 is applied, based on the IPCC 2006 GL.

For the years **2008–2018** a linear decline from 0.55 to 0.5 is assumed as the change of the methane concentration does not occur within one year.

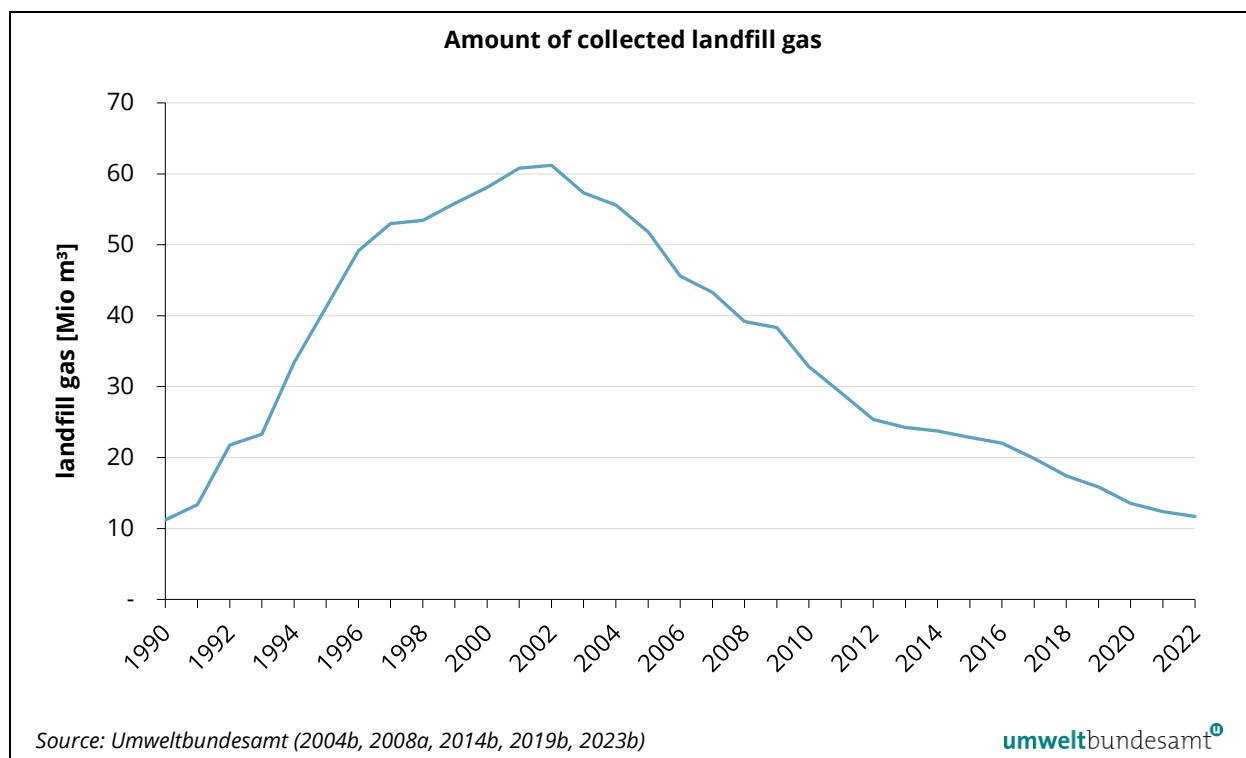
This approach is applied since the 2021 submission as, depending on the waste age, the amount of CO₂ absorbed in water increases (0.01% to 10% of CO₂ might be absorbed in water according to RETTENBERGER G., MEZGER, H. (1992)). This was not reflected in the historical submissions, and addressed during the 2020 comprehensive ESD-Review (EEA 2020).

7.2.2.2.4 Landfill gas recovery

In 2004, 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 nine landfills were equipped with landfill gas wells, whereas in 2001 at all operating mass landfills landfill gas was collected.

In 2008, 2013, 2018 and 2023 further surveys were conducted (UMWELTBUNDESAMT 2008a, UMWELTBUNDESAMT 2014b, UMWELTBUNDESAMT 2019b, UMWELTBUNDESAMT 2023b) to get new data on collected landfill gas as well as information on its use from landfill operators. Landfill gas volumes and their treatment are thus surveyed in a 5-year cycle. The most recent survey covers the period 2018 – 2022 and proves that the previous assumptions made (refer to UMWELTBUNDESAMT 2023f) overestimated the quantities of methane actually collected.

Figure 51: Amount of collected landfill gas 1990 to 2022.



From 2002 onwards, the amount of landfill gas collected decreased (despite a consistent recovery practice) as a consequence of:

- Reduced carbon content of deposited waste and consequently reduced landfill gas production
- Slightly decreasing methane concentration in recovered landfill gas – an effect that is due to the extensive capturing of landfill gas which can lead to the dilution of the landfill gas captured.

Compared to 2002 (maximum), the collected amount of landfill gas decreased by 81% by 2022.

7.2.3 Uncertainty Assessment

The Uncertainty Assessment is originally based on a national study (WINIWARTER & RYPDAL 2001) and was improved and revised by expert judgement for the submission 2005. These values were confirmed in the latest uncertainty 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 290: Uncertainty assessment for managed waste disposal on land.

	(WINIWARTER & RYPDAL 2000)	Expert judgement 2005 (WINIWARTER 2007)
Activity data	25%	12%
Emission factor	35%	25%

7.2.4 Category-specific QA/QC

Beginning from the year 1998 until the end of the year 2007, activity data on deposited waste was reported annually by landfill operators to the Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW, since 2020 the BMK – Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology). After a first check the reports were forwarded to the Umweltbundesamt, who in turn incorporated the reports into a landfill database. Landfill operators in default were prosecuted. In the course of the data collection and administration, a quality control of the incoming data was implemented: data was checked in terms of completeness and plausibility. To clarify any discrepancies landfill operators were contacted. Lists of landfill owners were sent to competent authorities of each province (responsible for licensing and controlling) in order to check if number and type of landfill facilities were correct. Last but not least, plausibility was gained by comparison of the data with previous reports.

Since the year 2008 landfill operators are obliged¹¹¹ to report their data directly and electronically at the portal of <http://edm.gv.at> (EDM: **E**lectronic **D**ata **M**anagement in environmental and waste

¹¹¹ According to § 41 (1) Landfill Ordinance

management). Every person or installation collecting and treating waste is obliged to register in EDM and submit annually reports of each waste input and output (yearly balance of type, quantity, origin and destination of waste). In various meetings and training courses especially landfill operators were educated in using this new reporting tool. Responsible institution for administration of the EDM is the Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK). The former landfill database is not maintained any more, but its data were used for checking accurately whether all landfill operators have registered in EDM. Analysis and quality control of the data is carried out on an on-going basis. Although the comparison with previous reports is an important tool, the advantage of having the landfill data embedded in the general input-output reports is obvious (counterchecking with the reports of partners).

In addition, supervisors appointed by the competent authority for each landfill are obliged to monitor regularly not only the landfill site itself but also each registration in EDM and the reporting of data. As there is a special tax on wastes being landfilled, another independent mechanism of control on landfills is realised by the ministry of finance (via former customs executives).

Input Data Audit 2014/2015

At the end of 2014/beginning 2015 a multi-step audit was conducted by the IBE sectoral waste experts at the BMLFUW (Department responsible for analysis and quality check of EDM data on landfilled waste) and the Umweltbundesamt (Expert Team responsible for data query on behalf of the BMLFUW). Aim was to get insight into collection, processing and quality control of data, i.e. waste amounts deposited, and clarify issues on transparency, accuracy, completeness, consistency, comparability and timely availability of data.

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.

7.2.5 Recalculations

Revisions are reported for the years 2018–2021 (2021: +20 kt CO₂e) as updated data on landfill gas recovery from a national study (UMWELTBUNDESAMT 2023b) was made available and incorporated into the inventory. In the previous submissions, results from the preceding study (UMWELTBUNDESAMT 2019b) were used to derive assumptions on recovered amounts for the years 2018–2021.

The whole time series of recalculations is included in Annex 8 to the NIR.

7.2.6 Planned improvements

The need and possibilities for methodological adjustments of the model due to the new specifications of the IPCC 2019 Refinement (e.g. on the consideration of active aeration of landfills) will be investigated.

7.3 Biological Treatment of Solid Waste (Category 5.B)

Emissions: CH₄, N₂O

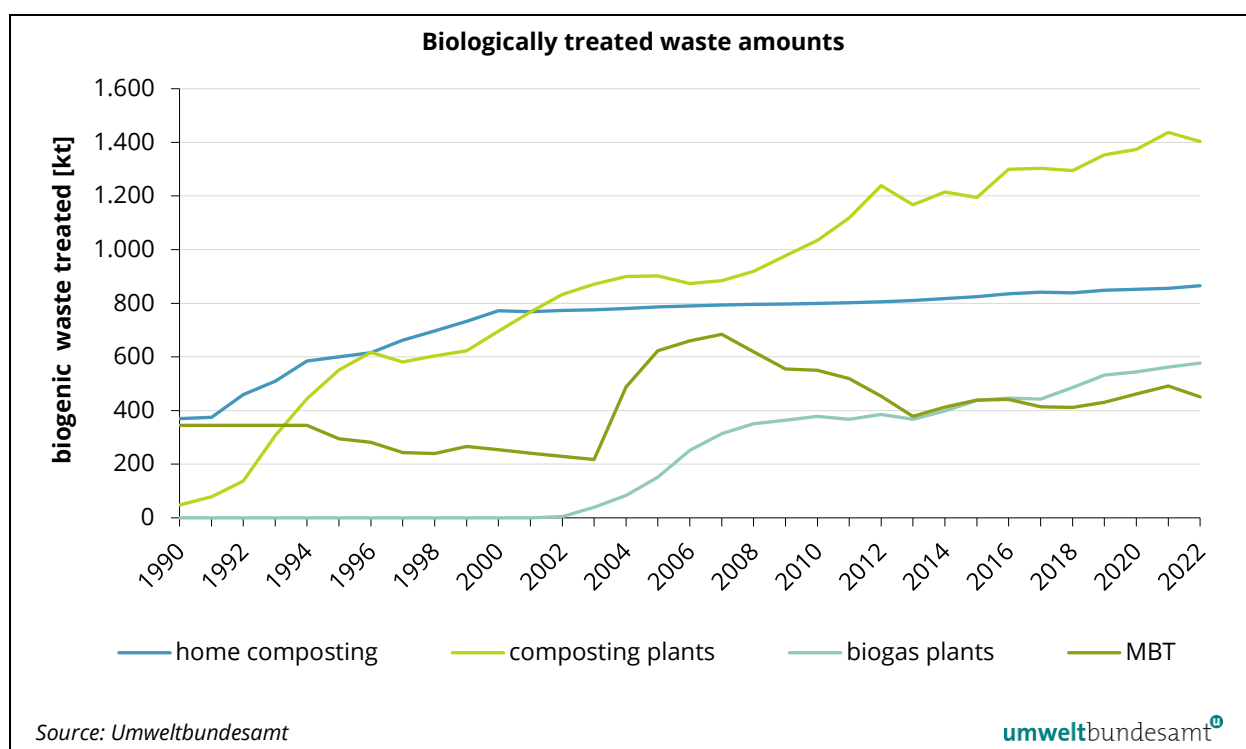
Key Source: no

7.3.1 Source category description

In this category biological treatment of solid waste is considered, including CH₄ and N₂O emissions from mechanical-biological treatment (MBT), composting and anaerobic digestion.

- 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, covering centralised composting plants and home composting
- biogenic waste treated in biogas plants (anaerobic treatment)

Figure 52: Amounts of waste treated (mechanical-) biologically.



Emissions increased by 328% since 1990 as the result of the increasing amount of composted waste, the construction of biogas plants and to a minor part to increased amounts of mechanical-biologically treated waste.

7.3.2 Methodological Issues

7.3.2.1 Composting (5.B.1)

Emissions from mechanical-biological treatment as well as composting are calculated by multiplying the quantity of waste by the corresponding emission factor, using Equation 4.1 respectively Equation 4.2 from the IPCC 2006 GL.

$$CH_4 \text{ emissions} = M_i * EF_i$$

$$N_2O \text{ emissions} = M_i * EF_i$$

Where

M_i ... mass of organic waste treated by biological treatment type i (composting, MBT)

EF_i ... emission factor for treatment i (MBT, composting)

7.3.2.2 Anaerobic digestion at biogas facilities (5.B.2)

Biogas plants became operational in Austria in 2002. For the years before (2001 and former years) 'NO' is reported as no anaerobic digestion of waste took place in Austria.

CH₄ emissions from biogas plants, i.e. emissions due to unintentional leakages during process disturbances or other unexpected events as well as from storage of fermentation residues, are calculated applying the IPCC 2006 default value of 5% CH₄ emissions of biogas produced¹¹². From 2015 to 2030 it is assumed that the leakage gradually decreases to stabilise at a leakage rate of 1%. The reasoning for this continuous decrease is that gas-tight storage tanks are required for new biogas plants to obtain approval. As the average lifetime of a biogas plant is estimated with 15 years, it can be assumed that by 2030 only gas-tight biogas plants are in operation. But still a leakage of 1% will be assumed, also after 2030.

$$CH_4 \text{ emissions} = M * L_0 * F * CH_4 \text{ density} * EF$$

Where:

M ... mass of organic waste treated by anaerobic treatment plants

L_0 ... CH₄ generation potential

F ... fraction of methane in biogas

EF ... emission factor (% of CH₄ generated)

N₂O emissions for category 5.B.2 – Municipal Solid Waste are reported as 'NA' in CRF table 5.B from 2002 onwards as the 2006 IPCC Guidelines (vol. 5) (1) do not include a default methodology and EF and (2) N₂O emissions from anaerobic digestion of organic waste are assumed to be negligible (vol. 5, p.4.4 and table 4.1).

¹¹² The remaining 95% of the total methane generated and not emitted is included in the "Amount of CH₄ for energy recovery", covering flaring as well.

7.3.2.3 Activity data

The 'Electronic Data Management' (EDM) is the main data source for this category. The EDM is an information network operated by Umweltbundesamt. It is a central *eGovernment* initiative by the Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (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.

Historical activity data were taken from national publications and regional sources.

- From 2009 onwards, data on **mechanical-biologically treated waste** is taken directly from the Electronic Data Management (EDM). For the years prior to 2009, several national studies provided the required activity data (BAUMELER et al 1998, ANGERER 1997, UMWELTBUNDESAMT 2008b).
- Data source for the waste amounts treated in **composting plants** is the EDM as well. Data for the first years of the time series were collected from the Austrian Federal Provinces (AMLINGER 2003), data in-between interpolated. Regarding EDM data on composting plants, research by waste experts from Umweltbundesamt (2015) 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 be further decreased. The 5% assumption is continued from 2014 and onwards.
- Current **home composted amounts** are taken from the latest Federal Waste Management Plan (BMK 2023e). Historical amounts (2000 and earlier years) are available from a national study (AMLINGER 2005). To create a time series, a per capita value was derived from both sources and an average per capita of 95 kg then applied to the population figures (STATISTIK AUSTRIA 2023i).

In submission 2023 the amounts of waste composted in private and community gardens have been entirely revised.¹¹³ The reason is a change of the estimation method done in the course of the preparation of the BAWP 2023 in view of an upcoming reporting obligation regarding home-composted quantities to the European Commission¹¹⁴. Based on an estimated total volume of biogenic waste produced (covering food waste as well as grass, leaves, branches from green urban areas) the biogenic waste collected via municipal waste management system (residual waste) and via separate collection was deducted to get a value of biogenic waste potentially be composted in home and community gardens.

- **Biogas plants:** EDM data on waste treated anaerobically is available since 2011. For the years prior to 2011 an increase of activity from 2002 onwards in line with the increasing

¹¹³ Until submission 2022 home composted amounts for the years 2010 ff were calculated based on a per-capita value of 215 kg/person/a, whereas for Vienna only 15% of the population was considered due to the lower number of gardens in this urban area. This approach was in line with the method applied for the BAWP (BMNT 2018a).

¹¹⁴ In the future home composting will be included in the AT recycling rate for municipal waste.

feeding-in of renewable energy from biogas plants into the national grid is assumed. Anaerobic digestion started to become a treatment option in 2002 in Austria when the Green Electricity Act (Ökostromgesetz 2002; Federal Law Gazette No 149/2002) entered into force.

Table 291: Activity data for MBT and composting (5.B.1) as well as anaerobic treatment (5.B.2).

Year	Mechanical-Biological Treatment (MBT)	Composting plants	Home composting	Anaerobic treatment
[kt]				
1990	345	48	370	NO
1995	295	551	600	NO
2000	254	695	772	NO
2005	623	903	786	152
2010	551	1 035	799	378
2011	519	1 118	802	367
2012	453	1 239	806	385
2013	379	1 168	811	367
2014	413	1 215	817	399
2015	439	1 194	825	438
2016	442	1 300	836	446
2017	414	1 303	841	443
2018	412	1 294	839	486
2019	430	1 353	849	532
2020	462	1 374	853	544
2021	492	1 437	856	563
2022	451	1 404	866	577

7.3.2.4 Emission factors

Different references provide emission factors for mechanical-biologically treated waste, thus an average value was used. The emission factor for composted waste is taken from a national study. The emission factors are within the IPCC default range as presented in Table 4.1 of the IPCC 2006 GL.

Table 292: Emission factors used for 'Composting' (5.B.1).

	CH ₄ [kg/t FS*]	N ₂ O [kg/t FS]	References
Mechanical-biological treatment (MBT)	0.6	0.1	(UBA BERLIN 1999) (AMLINGER 2003, AMLINGER et al. 2005) (ANGERER & FRÖHLICH 2002) (DOEDENS et al. 1999)
Composting (bio-waste, loppings, home composting)	0.75	0.1	(AMLINGER 2003, AMLINGER et al. 2005)

* 'Feuchtsubstanz' = 'Wet mass'

The EFs provided here refer to the wet mass ('FS'-Feuchtsubstanz), the EFs in the CRF however refer to the dry mass. For the input material a moisture content of 60% was assumed. Accordingly, the IEF refers to the AD in dry matter. Furthermore it should be noted that in the CRF the IEF is calculated for MBT and for composting together, which has an impact to the total IEF of CH₄. However, the input to MBT is much smaller than the input to composting (only about 17% of the total input in 5.B.1 in 2022) and therefore the emission factor is dominated by the EF for composting.

For CH₄ the IEFs based on dry matter are as follows: MBT: 1.5 kg CH₄/t dry matter; Composting: 1.9 kg CH₄/t dry matter. Taking into account the respective treated amounts, a combined IEF of 1.81 kg CH₄/t dry matter can be derived for 2022.

For N₂O from MBT and Composting the IEF related to dry matter is 0.25 kg N₂O/t dry matter.

Table 293: Emission parameters used for 'Anaerobic digestion at biogas plants' (5.B.2).

	Parameter		References
L ₀	CH ₄ generation potential	110 m ³ /t	UMWELTBUNDESAMT 2011b
F	Fraction of CH ₄ in biogas	0.6	UMWELTBUNDESAMT 2011b
EF _{until 2015}	EF (emitted CH ₄)	5%	(IPCC 2006)
EF _{2016 onwards}	EF (emitted CH ₄)	See below	Expert judgement

The emission factor for CH₄ emitted is gradually decreasing from 2016 to 2030, as Austrian approval authorities require 'zero' leakage from new biogas plants. For this reason, the leakage of 5% is gradually decreasing to 1% in 2030, considering the average lifetime of a biogas plant with 15 years.

A CH₄ density (D) of 0.65 kg/m³ is applied.

The 2006 IPCC GL do not provide an N₂O emission factor for 'anaerobic digestion', and emissions are assumed to be negligible (Volume 5, Chapter 4.1.3.1, Table 4.1). Hence Austria reports 'NA' for that source.¹¹⁵

7.3.3 Uncertainty Assessment

The following uncertainties are determined for that category:

Table 294: Uncertainty assessment for CRF 5.B Biological Treatment of Solid Waste.

	CH ₄	N ₂ O
Activity data	20%	20%
Emission factor	50%	50%

7.3.4 Recalculations

No recalculations were carried out in this years' submission.

¹¹⁵ The UNFCCC Reporting Guidelines (Dec. 24/CP.19) state in footnote 6 to article 37 b (page 12), that "the notation key 'NE' could also be used – i.e. does not have to be used (no 'shall requirement') – when an activity occurs in the Party but the 2006 IPCC Guidelines do not provide methodologies to estimate the emissions/removals". Based on this paragraph, our understanding in this matter is that reporting of "NA" is valid in the absence of an IPCC default methodology and emission factor.

7.3.5 Category-specific QA/QC

See Chapter 7.1.5.

All QA/QC steps have been undertaken for this category. A comparison of EF with the IPCC defaults proved that these are in the range of the IPCC 2006 GL. In addition, the input data audit described under the CRF 5.A *Solid Waste Disposal* to a large extent also considers this sub-category as the data basis (EDM) is the same.

7.3.5.1 Composted amounts

For the years 2011–2014 activity data on the input in **composting plants** reported via Electronic Data Management (EDM) were checked for accuracy and completeness. As according to current knowledge the EDM reporting obligation does not cover all potential composting plants in Austria, some waste amounts not reported via EDM have to be considered additionally to achieve time-series consistency, estimated to be 5% additionally to the reported waste amounts (Expert Judgement Umweltbundesamt).

Historical **home composted amounts of waste** in Austria are available from two different sources: The Federal Waste Management Plan (BMK 2023e), based on a calculation considering different national mass volumes, as well as a national study (AMLINGER 2005) surveyed at the level of the federal provinces. A comparison has shown that the results coincide very well (0.096 t per capita versus 0.095 t per capita).

7.3.5.2 Verification – CH₄ from biogas plants

An alternative approach for calculation was considered, using the EF included in chapter 4.1.3.1 of the IPCC 2006 GL – corrigendum of July 2015 (0.8 kg CH₄/t waste treated) leading to lower CH₄ emissions (20 vs 39 kg CO₂e/t waste treated) than applying the IPCC default for CH₄ in terms of emissions per gas produced (as actually applied and included in chapter 4.1 of the IPCC 2006 GL). Due to the higher gas generation potential of biogenic waste fermented (mainly municipal biogenic and kitchen waste) the more conservative option was chosen for the Austrian inventory.

7.3.6 Planned improvements

No improvements are currently planned.

7.4 Incineration and Open Burning of Waste (Category 5.C)

The Austrian Federal clean air act (Bundesluftreinhaltegesetz, BGBl. I Nr. 137/2002)¹¹⁶ prohibits the burning of waste outside stationary combustion facilities with the general exception of fire grills,

¹¹⁶ <https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20002155>

bonfires and barbecues as well as activities which need a specific permit (e.g. burning of agricultural residues).

7.4.1 Waste Incineration (5.C.1)

Source Category Description

Emissions: CO, CH₄, N₂O

Key source: No

In this category, emissions from incineration of waste oil are included as well as emissions from municipal waste incineration without energy recovery. All CO₂ emissions from waste are caused by waste incineration. The share of 5.C.1 in total emissions from waste is 0.6% for the year 1990 and 0.2% for the year 2022.

In Austria, waste oil has been incinerated in especially designed so called “USK-facilities” (**Umweltschutzkomponenten GmbH**). The emissions of waste oil combustion for energy recovery (e.g. in cement industry) are reported under fuel combustion. In 2002, the Austrian waste incineration regulation¹¹⁷ came into force, introducing ambitious emission limits (from 2005 on¹¹⁸) for air pollution for all kind of waste incineration plants without any limit of size. The number of facilities, which do have the allowance for incineration of waste oil other than cement plants and large waste incineration plants, was only five since the year 2010.

In general, municipal, industrial and hazardous waste are combusted for energy recovery in district heating plants or in industrial sites and therefore the emissions are reported under fuel combustion. There is only one waste incineration plant without energy recovery which has been operated until 1991 with a capacity of 22 000 tons of municipal waste per year. This plant has been rebuilt as a district heating plant, starting operation in 1996. Therefore, the emissions since the re-opening of this plant are reported under fuel combustion from 1996 onwards.

Table 295: Greenhouse gas emissions from Category 5.C.1.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	27.92	0.0009	0.0004	28.06
1995	11.11	0.0003	0.0001	11.15
2000	12.40	0.0003	0.0001	12.44
2005	12.40	0.0003	0.0001	12.44
2010 to 2022	2.05	0.0001	0.0000	2.06
1990–2022	-93%	-94%	-96%	-93%

Methodological Issues

A simple tier1 methodology is applied: the quantity of waste is multiplied by an emission factor for CO₂, CH₄ and N₂O.

¹¹⁷ Abfallverbrennungs-(Sammel-)Verordnung (AVV; BGBl. II Nr. 389/2002 i. d. g. F.): Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft und des Bundesministers für Wirtschaft und Arbeit über die Verbrennung von Abfällen.

¹¹⁸ Old facilities had to conform to the new regulation 2005 at the latest.

Emission factors

National emission factors for CH₄ are derived from residual fuel oil VOC emission factors (BMWA 1990, BMWA 1996, UMWELTBUNDESAMT 2001a). N₂O emission factors are taken from a national study (ORTHOFFER et al. 1995).

For municipal solid waste and clinical waste the CO₂ emission factor is calculated by means of IPCC GPG 2001 default assumptions for total carbon content and fossil carbon share. The selected calculation parameters are presented in Table 296. Because of the absence of plant specific data a combustion efficiency of 100% has been selected.

For waste oil, the same CO₂ emission factor (80 t CO₂/TJ) as for 1.A.1.a heavy oil is used and a heating value of 40.3 GJ/t (source: Energy balance-residual fuel oil) is used to convert the emission factors from [t/TJ] to [kg/t].

Table 296: Emission factors and parameters of IPCC Category 5.C.1 Waste Incineration.

Waste Type	Carbon content	Share in fossil carbon	Combustion efficiency	CO ₂ [kg/t]	CH ₄ [g/t]	N ₂ O [g/t]
Municipal Waste	40%	40%	100%	586.67	0.2 ⁽¹⁾	12.18
Clinical Waste	60%	40%	100%	880.00	100.00	12.00
Waste Oil	–	–	–	3 224.00	NA	24.18

⁽¹⁾ IPCC 2006 Guidelines table 5-3, technology 'continuous incineration/stoker'.

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 2001c) 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 ambitious emission 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

At current there is one facility which has the permit to incinerate hazardous waste (including hospital waste) in larger amounts which is allocated in 1.A.1.a. Additionally there is one hospital with a permit to incinerate waste (capacity < 2 t/h) but it is not known if and how the energy is used. As-

suming a capacity of 1 t/hour of plastics waste and 500 hours yearly operating time it was estimated to be 500 t/year. However, waste experts at the Umweltbundesamt doubt if this hospital makes use of the permit. Thus from the expert view this is rather an over- than an underestimate.

Under the new waste regulation 8 companies have the permit to incinerate waste oil although it is not known if they make use of their permit in reality. These companies are mostly road transport companies or car dealers which are considered not to use the energy. Each of the 8 companies is assumed to have installations with a capacity of 60.8 t waste oil/year (UMWELTBUNDESAMT 2001c). This is the same average capacity that has been used for estimating the waste oil quantity for 1990 to 2005. This results in a rounded value of 500 t waste oil/year. Activity data for the years 2006–2009 has been interpolated. Activity data for clinical waste and waste oil has been kept constant since the year 2010 because the number of facilities with a permit did not change.

Table 297: Activity data for IPCC Category 5.C Waste Incineration.

Year	Municipal Waste [Mg]	Clinical Waste [Mg]	Waste Oil [Mg]
1990	22 000	9 000	2 200
1991	22 000	7 525	1 500
1992	NO	6 050	1 800
1993	NO	4 575	2 100
1994	NO	3 100	2 500
1995	NO	3 100	2 600
1996	NO	3 100	2 700
1997	NO	3 100	2 800
1998	NO	3 100	2 900
1999–2005	NO	3 100	3 000
2006	NO	2 500	2 500
2007	NO	2 000	2 000
2008	NO	1 500	1 500
2009	NO	1 000	1 000
2010–2022	NO	500	500

The following table shows activity data of waste incineration with energy recovery.

Table 298: Activity data for waste incineration with energy recovery.

Year	1.A.1.a Public Electricity and Heat ¹⁾			1.A.2 Industrial waste		1.A.2 Manuf. Industries ³⁾
	MSW [t]	hazardous waste [t] ⁴⁾	sewage sludge [t]	Industrial waste [t]	of which waste oil [t]	Ind. Waste [TJ]
1990	299 256	80 000	55 000	59 422	11 716	3 220
1995	441 502	71 337	60 672	86 998	28 675	5 270
2000	528 365	70 513	80 406	169 888	27 794	6 250
2005	944 948	103 058	58 979	338 491	27 028	7 891
2010	1 418 176	109 772	57 002	359 589	21 911	11 210
2011	1 456 520	108 220	164 636	393 857	19 597	11 941
2012	1 438 921	98 227	176 809	388 235	12 662	11 401
2013	1 516 986	143 848	173 637	428 759	10 365	11 264
2014	1 774 538	168 985	177 894	462 892	11 963	11 022
2015	1 850 216	114 110	201 061	481 311	15 370	10 966

Year	1.A.1.a Public Electricity and Heat ¹⁾			1.A.2 Industrial waste		1.A.2 Manuf. Industries ³⁾
	MSW [t]	hazardous waste [t] ⁴⁾	sewage sludge [t]	Industrial waste [t]	of which waste oil [t]	Ind. Waste [TJ]
2016	1 783 095	399 848	197 201	478 954	20 396	11 928
2017	1 895 859	104 892	201 374	476 084	18 267	11 834
2018	1 842 933	101 684	182 822	513 896	19 782	12 140
2019	1 910 989	99 344	180 179	487 055	22 070	11 026
2020	2 077 348	86 853	168 996	470 651	18 756	11 644
2021	2 081 197	97 521	97 824	481 066	18 628	11 413
2022	2 023 033	101 177	94 853	480 875	18 411	13 088

¹⁾ Umweltbundesamt, IEA JQ 2023.

²⁾ (HACKL & MAUSCHITZ 1995, 1997, 2001, 2003, 2007, MAUSCHITZ 2004), From 2005 onwards ETS data is used

³⁾ 1.A.2.f other fuels – activity data

⁴⁾ including waste oil and clinical waste

Recalculations

No recalculations were carried out.

Planned improvements

No improvements are planned.

7.4.2 Open Burning of Waste (5.C.2)

Emissions from the open burning of wood residues from vineyards are calculated in the Agriculture sector but reported in the Waste sector under category 5.C.2.1.b *Open Burning of Waste* – Biogenic – Other. In response to the ESR Review 2023, biogenic CO₂ emissions were added to this source category.

A simple country specific method with country specific emission factors is applied for estimation of CH₄ and N₂O emissions. For the calculation of biogenic CO₂, the simple Tier 1 methodology of the 2006 IPCC GL (Volume 5, Chapter 5, equation 5.1) is used.

Activity data

For activity data, the planted vineyard area of the national vineyard surveys (Weingartengrunderhebungen) for the years 2009, 2015 and 2020 (STATISTIK AUSTRIA 2011, 2016, 2021) was used, as these explicitly comprise the vineyard area planted with vine stems. For time series consistency, the areas of vineyards between 2009, 2015 and 2020 were interpolated. For 2021 und 2022, the value of 2020 has been taken as no more recent data is currently available. According to the EU legislation, these surveys have to be carried out every 5 years. So, in 2025 the next survey will be conducted. Land use areas are harmonized with sector Land Use, Land Use Change and Forestry (LULUCF) of Austria's GHG inventory to be consistent within the Austrian Inventory and across all sectors. Further details are given in chapter 6.3 *Cropland (Category 4.B)*.

According to an expert judgement from the *Federal Association of Viniculture* (Bundesweinbauverband Österreich) in 2001 the amount of residual wood per hectare viniculture was 1.5 to 2.5 t residual wood and the part of it that is burnt was estimated to be 1 to 3%. For the calculations the

upper limits (3% of 2.5 t/ha) were used, resulting in a factor of 0.075 t burnt residual wood per hectare viticulture area. Based on recent information from the *Federal Association of Viniculture*, the area of vineyards with open burning activities has decreased over time and is assessed to be no more than 1% of the total vineyard areas for the years from 2010 onwards. The burning of vine is either prohibited or only permitted to a very limited extent in the relevant federal provinces. The areas of vineyards with open burning activities between 2001 and 2010 were determined by linear interpolation between the two, respective expert judgement estimates. The value of 2010 (1%) is used for the subsequent years.

Table 299: Activity data for the open burning of wood residues from vineyards 1990–2022.

Year	Viniculture Area [ha]	Burnt Residual Wood [t]
1990	58 364	4 377
1995	55 627	4 172
2000	50 304	3 773
2005	46 892	2 475
2010	45 517	1 138
2011	45 502	1 138
2012	45 486	1 137
2013	45 470	1 137
2014	45 454	1 136
2015	45 439	1 136
2016	45 584	1 140
2017	45 729	1 143
2018	45 874	1 147
2019	46 020	1 150
2020	46 165	1 154
2021	46 165	1 154
2022	46 165	1 154

Emissions factors

The emission factors (4 828 g CH₄/t and 49.7 g N₂O/t burnt wood) were calculated by multiplying the emission factors of 7 kg N₂O/TJ and 680 g CH₄/TJ (STANZEL et al. 1995) with a calorific value of 7.1 MJ/kg burnt wood which corresponds to burning wood logs in poor operation furnace systems.

For biogenic CO₂, the default parameters (fraction of carbon in the dry matter, oxidation factor) were taken from Table 2.4 and Table 5.2 (IPCC 2005, Volume 5, Chapter 2 and Chapter 5).

Recalculations

In previous inventories a constant share of 3% for Austria's areas of vineyards was used as activity data (Bundesweinbauverband Österreich 2001). According to updated information, this share was decreased to 1% for the years from 2010 onwards. This improvement resulted in revised emissions for the years 2002–2021 (–0.3 kt CO₂e).

Planned improvements

As the Austrian National Inventory requires a homogeneous allocation of activities and emission sources for both greenhouse gases and air pollutants and Austria is confronted with two contradictory recommendations in the reporting under the UNFCCC (ARR 2023) and under the UNECE / EU NEC Directive (NEC Review 2022), Austria decided not change its reporting in the submission 2024.

7.5 Wastewater Treatment and Discharge (Category 5.D)

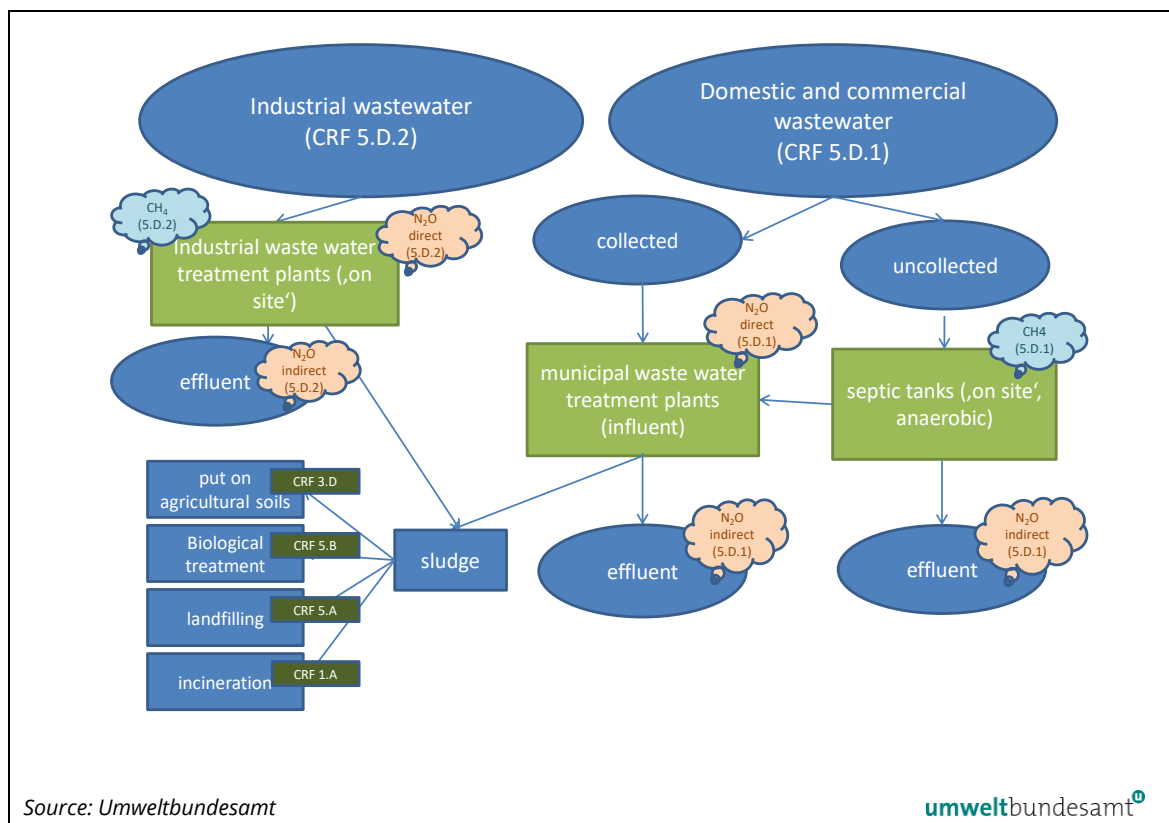
Emissions: CH₄, N₂O

Key Source: yes, 5.D.1 CH₄ (TA)

7.5.1 Source category description

This category covers CH₄ emissions from domestic and industrial wastewater as well as direct and indirect N₂O emissions from wastewater of domestic and industrial origin. CH₄ emissions stem from septic tanks as well as from anaerobically pre-treated industrial waste water. Direct N₂O emissions stem from wastewater treatment plants using aerobic procedures with nitrification and denitrification steps whereas indirect N₂O emissions stem from the discharge of treated wastewater (nitrogen effluent) into aquatic environments. N₂O emissions reported under *5.D.1 domestic wastewater* also include commercial and some industrial wastewater ('co-discharger'). N₂O and CH₄ emissions from the on-site treatment of industrial wastewater are reported under *5.D.2 industrial wastewater*.

Figure 53: Wastewater treatment systems and discharge pathways (schematic illustration).



In the year 2022, greenhouse gas emissions from *5.D Wastewater Treatment and Discharge* contributed 15% to greenhouse gas emissions from sector 5 *Waste* and 0.2% to total national greenhouse gas emissions in Austria. From 1990 to 2022, greenhouse gas emissions from this category decreased by 21%. This is due to the decrease of CH₄ emissions from domestic wastewater handling (-82%), affected by the declining number of people disposing their wastewater into septic systems. On the other hand, N₂O emissions from wastewater treatment plants strongly increased (+78%) in line with the growing number of inhabitants connected to modern centralized wastewater treatment plants. GHG emissions from 5.D.2 contribute only minor to GHG emissions from sub-category 5.D (2.7% in 2022).

Table 300: Greenhouse gas emissions from wastewater treatment (5.D) 1990–2022

Source	5.D.1 – domestic wastewater						5.D.2 – industrial wastewater				5.D
	CH ₄		N ₂ O				CH ₄		N ₂ O		GHG
	septic systems		indirect effluent plants	effluent population	direct plants	total	On-site		On-site		total
	[t CH ₄]	[t CO ₂ e]	[t N ₂ O]	[t N ₂ O]	[t N ₂ O]	[t CO ₂ e]	[t CH ₄]	[t CO ₂ e]	[t N ₂ O]*	[t CO ₂ e]	[t CO ₂ e]
1990	4 850	135 798	205	117	0	85 433	34	942	1.4	363	222 535
1995	4 205	117 753	215	79	77	98 421	42	1 180	1.6	419	217 773
2000	2 682	75 092	138	47	266	119 327	52	1 461	2.1	544	196 424
2005	1 641	45 941	101	34	363	131 986	105	2 944	2.4	637	181 509
2010	1 102	30 846	75	19	437	140 792	109	3 061	2.1	545	175 244
2011	1 051	29 425	74	18	440	140 960	105	2 950	2.2	570	173 904
2012	1 001	28 029	73	17	443	141 278	108	3 022	2.3	600	172 929
2013	961	26 917	70	17	447	141 478	110	3 069	2.8	745	172 209
2014	923	25 837	68	16	452	141 908	111	3 103	2.4	642	171 490
2015	913	25 574	70	16	457	143 901	109	3 055	2.4	643	173 172

	5.D.1 – domestic wastewater						5.D.2 – industrial wastewater				5.D	
	CH ₄		N ₂ O				GHG	CH ₄		N ₂ O	GHG	GHG
Source	septic systems		indirect effluent plants	effluent population	direct plants	total	total	On-site		On-site	total	total
	[t CH ₄]	[t CO ₂ e]	[t N ₂ O]	[t N ₂ O]	[t N ₂ O]	[t CO ₂ e]	[t CO ₂ e]	[t CH ₄]	[t CO ₂ e]	[t N ₂ O]*	[t CO ₂ e]	[t CO ₂ e]
2016	906	25 372	75	16	463	146 874	172 246	116	3 255	2.6	678	3 934
2017	841	23 549	77	15	468	148 114	171 662	124	3 479	2.7	728	4 207
2018	774	21 670	76	13	472	148 674	170 344	134	3 752	3.0	797	4 549
2019	768	21 508	78	13	474	149 970	171 478	134	3 751	3.3	875	4 626
2020	762	21 342	74	13	477	149 541	170 883	130	3 634	6.2	1 655	5 289
2021	747	20 913	74	13	479	150 056	170 969	131	3 663	5.9	1 567	5 230
2022	737	20 632	73	13	485	151 130	171 763	125	3 507	5.0	1 331	4 838
1990–2022	–85%		–65%	–89%	-	+77%	–22%	+272%		+267%	+271%	–21%
2021–2022	–1.3%		–2.2%	–1.3%	+1.2%	+0.7%	+0.5%	+4.3%		–15.1%	–7.5%	+0.2%

* covered: direct and indirect N₂O from industrial waste water treated on site

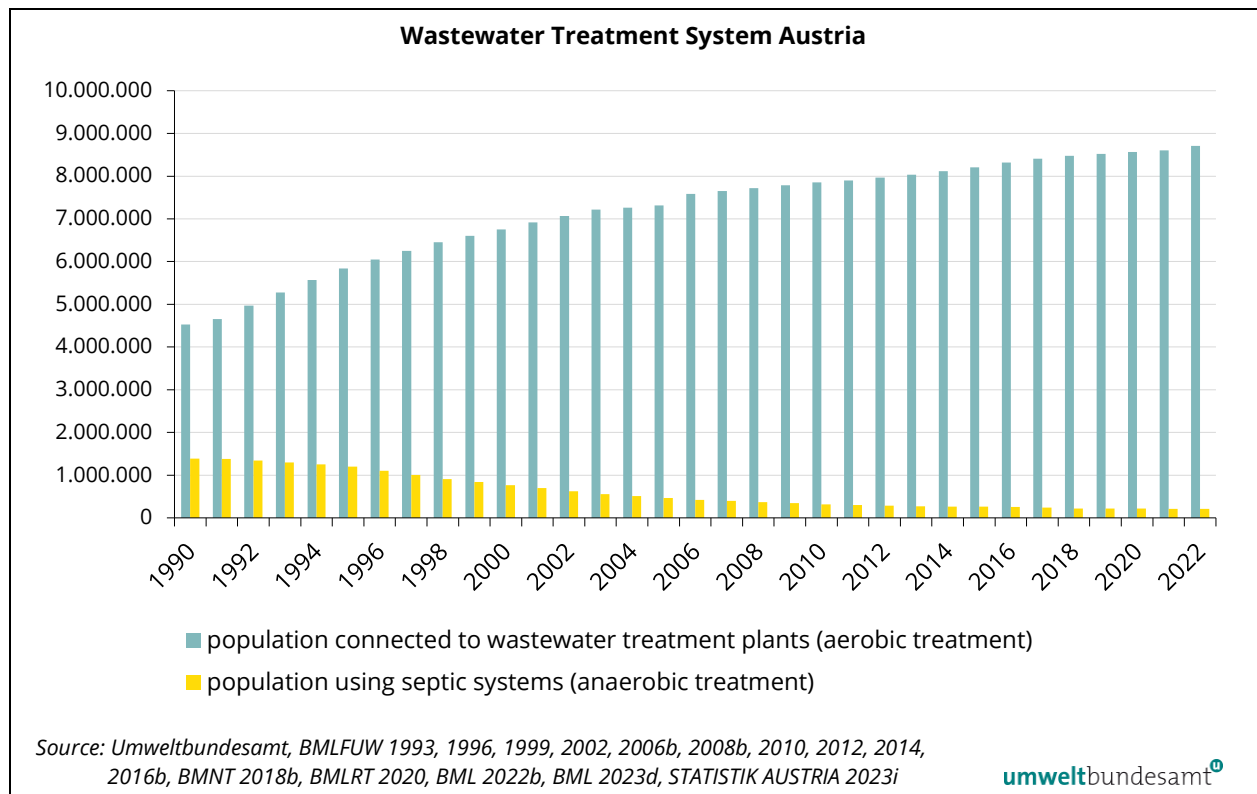
7.5.2 Methodological Issues

7.5.2.1 Domestic waste water treatment

CH₄ emissions from domestic wastewater disposed to septic tanks are calculated applying a Tier 2 method following the IPCC 2006 GL, using partly default values (B₀), partly country specific factors (MCF). For calculation of CH₄ emissions only the share of population disposing the wastewater to septic systems (anaerobic conditions) is considered.

N₂O emissions from the treatment and discharge of domestic and commercial wastewater (including industrial sources – ‘co-dischargers’) are calculated applying a country-specific method, as described in chapter 7.5.2.2.

For calculation of N₂O emissions the whole population is considered, in separate calculation steps. Most wastewater in Austria is treated in centralised wastewater treatment plants. There are only some sparsely populated areas that are not connected to the public sewage system, but where septic tanks have to be used. From 1990 to 2022 the connection rate to wastewater treatment plants increased from 59.0% to 96.2% (BML 2023d).

Figure 54: Domestic Wastewater Treatment in Austria¹¹⁹.

Data on the Austrian **population (P)** is taken from national statistics (STATISTIK AUSTRIA 2023i). Data on the **connection rates** to the public sewage system are available for the years 1971, 1981, 1991, 1995, 1998, 2001, 2003, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022 (missing data interpolated) and were taken from the Austrian reports on water pollution control (Gewässer-schutzberichte – BMLFUW 2002 and previous reports) and situation reports on municipal wastewater (BMLFUW 2006b, BMLFUW 2008, BMLFUW 2010, BMLFUW 2012, BMLFUW 2014, BMLFUW 2016b, BMNT 2018b, BMLRT 2020, BML 2022b, BML 2023d).

Sewage sludge

In order to prevent uncontrolled putrefaction, sewage sludge is stabilized. In smaller facilities such stabilization is usually carried out aerobically (open pool with oxygen input) and only a negligible amount of methane is produced. In bigger plants (typically > 30 000 pe) stabilization is carried out anaerobically in a digestion tower. The methane gas produced in the course of the anaerobic treatment is used for energy recovery in combined heat/power generation systems (CHP).¹²⁰ Related emissions are covered in CRF sector 1.A fuel combustion and are thus reported as 'IE' in CRF Table 5.D. The 'NA' additionally reported in CRF table 5.D only refers to the emissions source 'septic tanks', where no recovery and no flaring takes place.

In 2022 about 45% of the sewage sludge was incinerated (included in 1.A), 26 % was applied on agricultural soils (included in 3.D). The remaining part was treated another way, in Austria mainly in composting and to a minor part in mechanical-biological treatment plants (included in 5.B).

¹¹⁹ Note that direct discharge of sludge on landfill is prohibited since 2004 resp. 2009

¹²⁰ Only if technical disruptions or overloads occur, the methane gas is flared off.

7.5.2.1.1 CH₄ emissions

CH₄ emissions reported under *CRF 5.D.1 Wastewater Treatment and Discharge* originate from the disposal of domestic wastewater to septic tanks and are calculated following the method of the IPCC 2006 GL. Emissions are a function of the amount of Total Organics in Wastewater (TOW = P x BOD x 365) disposed to septic systems and an emission factor.

$$CH_4 (\text{domestic wastewater}) = P \times T_{[\text{septic tanks}]} \times BOD \times 365 \times EF$$

Where:

P = country population

T_[septic tanks] = degree of utilisation of septic tanks for wastewater discharge

BOD = per capita BOD value (IPCC 2006 default: 60 g BOD₅/person/day)

EF = emission factor: $B_0 \times MCF = 0.16$

B₀ = methane producing capacity (IPCC 2006 default: 0.6 kg CH₄/kg BOD)

MCF = methane correction factor (country specific: 0.27)

For calculation, the share of population disposing their wastewater to septic tanks is taken into account:

Table 301: Share of population using septic tanks (1991–2022).

1991	2001	2003	2006	2008	2010	2012	2014	2016	2018	2020	2022
17.8%	8.6%	6.8%	5.1%	4.4%	3.8%	3.4%	3.1%	3.0%	2.5%	2.4%	2.3%

Data on the Austrian **population (P)** is provided by STATISTIK AUSTRIA (2023i). Information on the **connection rate** to the public sewage system are regularly updated and published in the Austrian reports on water pollution control (see chapter 7.5.2.1)

In the year 2022, 96.2% of the Austrian population is connected to municipal wastewater treatment plants. The remaining wastewater is treated either in septic tanks (2.3%), domestic wastewater handling systems (1.3%), or disposed otherwise ('unspecified disposal routes': 0.2%).

Until 1998, detailed statistics on waste water disposal routes were available: in addition to wastewater treated in municipal plants, also domestic wastewater handling systems, septic tanks and 'unspecified disposal routes' were covered. However, data availability has changed in the early 2000s and since then only the share of 'population connected' and the share of 'population not connected' to waste water treatment plants is provided, but no further split. For this reason, a derived mean value based on historical data is used for determining the share of the not connected population using septic tanks for the years from 2001 onwards. BOD and *B₀* are default values from the IPCC 2006 GL. For determining the Methane Correction Factor (MCF) a country specific approach was chosen, taking into account that the MCF is temperature dependent. The MCF defines the share of methane producing capacity (*B₀*) that degrades anaerobically and may vary between 0.0 (completely aerobic) to 1.0 (completely anaerobic).

(GIBBS & WOODBURY 1993) identify a MCF of 100% at 30–40°C, a MCF of 35% at 20°C and a MCF of 10% at 10°C. Taking into account the temperature conditions in Austria (average temperature of 20°C for 8 months and 10°C for 4 months the year) the mean value for the whole year (0.27) has been calculated by (STEINLECHNER et al. 1994) as follows:

$$MCF (\text{mean value for whole year}) = 0.35 \times 2/3 + 0.10 \times 1/3 = 0.27$$

7.5.2.1.2 N₂O emissions

N₂O emissions from CRF 5.D.1. *Wastewater Treatment and Discharge* are calculated using a country specific method. Emissions are calculated separately for N₂O from effluent (indirect emissions) and N₂O from advanced centralized wastewater treatment plants, hereinafter referred to as 'plants', (direct emissions), and are then summed up.

$$N_2O \text{ emissions} = N_2O_{PLANTS} + N_2O_{EFFLUENT}$$

$N_2O \text{ emissions}$ = total N₂O emissions from wastewater handling and discharge

N_2O_{PLANTS} = N₂O from advanced wastewater treatment plants

$N_2O_{EFFLUENT}$ = N₂O from plant effluent + N₂O from effluent of the population not connected to plants

The main differences to the default methodology of the IPCC 2006 GL are as follows:

- In the Austrian approach the different nitrogen flows (nitrogen influent to plants, nitrogen effluent from plants and nitrogen effluent from wastewater of the population not connected to plants) are considered separately and related emissions are then summed up. The different paths considered are illustrated in Figure 53.
- Instead of estimating $N_{EFFLUENT}$ based on protein consumption and co-discharged fractions (IPCC 2006 GL), measured/reported values (country-specific N) are used, based on EMREG ($N_{EFFLUENT PLANTS}$) and ZESSNER & LINDTNER 2005 ($N_{EFFLUENT POPULATION}$).
- For the calculation of direct emissions from wastewater treatment plants a country-specific EF, based on measurements at Austrian wastewater treatment plants (2013/2014) is used. Only the population connected to plants with controlled nitrification and denitrification ('modern/advanced plants') is considered.

Direct N₂O emissions from plants (N_2O_{PLANTS})

N₂O emissions from wastewater treatment plants are based on a national measurement programme delivering results (EF) for 2013 (BMLFUW 2015). Emissions for the whole time series (except for 2013) are calculated based on the EF derived and applying Equation 6.9 of the IPCC 2006 GL:

$$N_2O_{PLANTS} = P * T_{CND-PLANTS} * F_{IND-COM} * EF_{PLANT}$$

N_2O_{PLANTS} = N₂O emissions from modern wastewater treatment plants

P = Austrian population

$T_{CND-PLANTS}$ = connection rate to modern, centralized wastewater treatment plants (CS)

$F_{IND-COM}$ = fraction of industrial and commercial co-discharge (CS)

EF_{PLANT} = emission factor for Austrian wastewater treatment plants (CS)

Activity data

Data on the Austrian **population (P)** is provided by STATISTIK AUSTRIA (2023i). Information on the **connection rate** to the public sewage system are regularly updated and published in the Austrian reports on water pollution control (see chapter 7.5.2.1).

As only modern wastewater treatment plants with controlled nitrification and denitrification steps are relevant for N₂O emissions, only these so-called 'CND-plants' are considered in the calculation. Since 2010 all municipal wastewater treatment plants are classified as CND-plants, due to the high overall denitrification rate in Austria (80% in 2010). In 2022 the denitrification rate reached a level

of 81.2%. Minor fluctuations are mainly due to the changing waste water temperature. On the contrary, until 1994 there was almost no plant with nitrification and denitrification in Austria and nitrogen removal has largely taken place as sludge removal (10%). It is assumed that between 1994 and 2010 their share was rising, in line with the N-removal. The $T_{\text{CND-PLANTS}}$ was calculated on basis of connection rates to the public sewage system (national statistics) and the assessed share of CND-plants in Austria.

Table 302: Activity data for calculation of direct N_2O emissions (plants).

	Population	$T_{\text{CND-PLANTS}}$		Denitrification rate
		connection rate plants	share CND-plants	
	no.	[%]	[%]	[%]
1990	7 677 850	59.0%	0.0%	10.0%
1995	7 948 278	73.5%	23.8%	26.7%
2000	8 011 566	84.3%	70.7%	59.5%
2005	8 225 278	88.9%	89.3%	72.5%
2010	8 361 069	93.9%	100.0%	80.0%
2011	8 388 534	94.2%	100.0%	80.0%
2012	8 426 311	94.5%	100.0%	80.0%
2013	8 477 230	94.8%	100.0%	80.8%
2014	8 543 932	95.0%	100.0%	81.5%
2015	8 629 519	95.1%	100.0%	81.1%
2016	8 739 806	95.2%	100.0%	80.6%
2017	8 795 073	95.6%	100.0%	80.3%
2018	8 837 707	95.9%	100.0%	80.9%
2019	8 877 637	96.0%	100.0%	80.5%
2020	8 916 845	96.0%	100.0%	81.0%
2021	8 951 520	96.1%	100.0%	81.0%
2022	9 052 856	96.2%	100.0%	81.2%

F_{IND-COM}: It is assumed that 30% of total nitrogen influent to wastewater treatment plants is attributable to commercial and industrial sources (ORTHOFFER et al 1995).

Emission Factor (EF_{PLANT})

The country specific EF used for modern wastewater treatment plants (EF_{PLANT}) is 43 g N_2O /population equivalent/year and is derived from a national measuring programme 2013/2014, measuring and analyzing N_2O emissions from 24 field measurements at 8 representative wastewater treatment plants in Austria (BMLFUW 2015). The EF considers current operational conditions, in particular nitrogen removal (denitrification) at Austrian wastewater treatment plants. The waste water emission ordinance for municipal wastewater treatment plants with an organic design capacity larger than 5 000 population equivalents forces a minimum reduction rate of 70% of total nitrogen. The objective of N-removal is to reduce the risk of eutrophication of surface waters.

Indirect N₂O emissions from wastewater effluent (N₂O_{EFFLUENT})

For the calculation of indirect N₂O emissions Equation 6.7 from the IPCC 2006 GL is applied:

$$N_2O_{EFFLUENT} = N_{EFFLUENT} * EF_{EFFLUENT} * 44/28$$

$N_2O_{EFFLUENT}$ = N₂O emissions from effluent to surface water bodies

$N_{EFFLUENT}$ = $N_{EFFLUENT\ PLANTS}$ + $N_{EFFLUENT\ POPULATION\ (CS)}$

$EF_{EFFLUENT}$ = emission factor for wastewater discharge (IPCC 2006)

Activity data

$N_{EFFLUENT}$ includes nitrogen effluent from the population not connected to the public sewage system ($N_{EFFLUENT\ POPULATION}$) as well as nitrogen effluent from wastewater treatment plants ($N_{EFFLUENT\ PLANTS}$). Both are country specific values and thus did not need to be calculated based on protein intake statistics (as provided for Equation 6.8 of the IPCC 2006 GL).

Data on $N_{EFFLUENT\ PLANTS}$ are retrieved from the Electronic Emission Register of Surface Water Bodies ('Emissionsregister – Oberflächenwasserkörper', abbreviated 'EMREG-OW'¹²¹), an electronic register of material emissions to surface water bodies from point sources, especially municipal sewage treatment plants. It is administered by the Federal Ministry of Agriculture, Forestry, Regions and Water Management and serves the collection of information for the National Water Management Plan and for management plans for international river catchment areas. Data is so far available for the years 2001, 2004, 2006, 2008, 2010, 2012, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021 and 2022 (UMWELTBUNDESAMT 2023c). Data for the years in between had to be interpolated. For the years before 2001 the $N_{effluent}$ plants were derived taking the population as well as the denitrification rate into account.

$N_{EFFLUENT\ POPULATION}$ is based on investigations made by ZESSNER & LINDTNER (2005), assessing specific N loads from households in Austria to be within the range 11–13 g N/inhabitant/d. Based on the higher value of this range (13 g) and the Austrian statistics on population the $N_{EFFLUENT\ POPULATION}$ was calculated.

Table 303: Activity data for calculation of N₂O from wastewater effluent.

	N _{EFFLUENT PLANTS}	N _{EFFLUENT POPULATION}	N _{EFFLUENT TOTAL}
	[t N/yr]	[t N/yr]	[t N/yr]
1990	26 094	14 937	41 031
1995	27 420	9 994	37 415
2000	17 507	5 968	23 475
2005	12 804	4 332	17 136
2010	9 578	2 420	11 998
2011	9 409	2 309	11 718
2012	9 240	2 199	11 440
2013	8 933	2 112	11 045
2014	8 625	2 027	10 652
2015	8 966	2 006	10 972
2016	9 604	1 991	11 595

¹²¹ 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)

	N_{EFFLUENT PLANTS}	N_{EFFLUENT POPULATION}	N_{EFFLUENT TOTAL}
	[t N/yr]	[t N/yr]	[t N/yr]
2017	9 738	1 848	11 585
2018	9 632	1 700	11 332
2019	9 965	1 687	11 653
2020	9 475	1 674	11 150
2021	9 460	1 641	11 101
2022	9 247	1 619	10 866

Emission Factor (EF_{EFFLUENT})

The default emission factor for N₂O emissions from domestic wastewater nitrogen effluent of the IPCC 2006 GL is applied: 0.005 kg N₂O-N/kg N.

7.5.2.2 Industrial waste water treatment (on site)

CH₄ and N₂O emissions from sub-category 5.D.2 (see Table 300) are estimated on the basis of a study conducted in 2019 (UMWELTBUNDESAMT 2019c), investigating the practice of wastewater handling in industrial plants in Austria, covering the following industrial branches:

- Paper and pulp
- Food and beverages, covering
 - dairy processing
 - breweries
 - fruit juice production
 - starch production
 - sugar production
 - meat production
 - vegetable oils
 - pet food production
 - rendering

CH₄ emissions

The IPCC 2006 GL state that only industrial wastewater with significant carbon loading that is treated under intended or unintended anaerobic conditions will produce CH₄. Accordingly, all relevant industrial plants in Austria in the area of food production and pulp and paper – i.e. with significant carbon loading – were contacted in the framework of a national study (UMWELTBUNDESAMT 2019c), to get information on:

- their wastewater treatment practice (on-site treatment/indirect discharge, aerob/anaerob treatment, sludge digestion, gas recovery, etc.)
- bottom-up data on gas generated in the pre-treatment of waste water and methane concentration (based on measurements).

It turned out that anaerobic wastewater pre-treatment only partially takes place in individual industrial sectors – such as the paper industry, breweries, starch, sugar and fruit juice production. All plants with anaerobic pre-treatment have gas collection with subsequent energy recovery. For industrial wastewater treatment plants practicing no anaerobic wastewater pre-treatment on-site –

e.g. in the milk and meat production – a MCF of zero is assumed in accordance with the IPCC 2006 Guidelines as they are well managed in Austria.

In addition most of the industrial plants do not have anaerobic treatment of the sludge. The sludge is incinerated on-site or off-site or transferred to external treaters (biogas plants, domestic waste water treatment plants). The few plants with an anaerobic treatment of sludge use the biogas produced for energy production.

Nevertheless, emission of methane can occur as diffuse emissions e.g. during the subsequent aerobic treatment of the anaerobic pre-treated waste water (partly stripping of methane if methane is included in the pre-treated waste water). For this reason, an EF of 1% of the methane generated was applied for all plants with an anaerobic pre-treatment.

The assumption of 1% fugitive methane emission is also supported in (IFEU 2008), where a fugitive emission of 1% is assumed for biogas plants.

Emissions data for 1990 – 2018 were taken directly from the study (UMWELTBUNDESAMT 2019c), data for subsequent years were extrapolated mainly using production data for primary and secondary pulp (AUSTROPAPIER 2023), as the paper industry is the main source of CH₄ emissions from this sub-category (share of 82% in 5.D.2).

N₂O emissions

N₂O is produced, if modern waste water treatment is applied (N-removal by nitrification/ denitrification). However, industrial waste water often shows only small nitrogen concentrations and therefore direct N₂O emissions are low. Furthermore indirect N₂O emissions are caused by the N-load in the effluent emitted to the receiving waters.

Indirect N₂O emissions are calculated by using measured N-loads from industrial direct discharges reported annually within the EMREG (UMWELTBUNDESAMT 2023c) and the emission factor for wastewater discharge of 0.005 kg N₂O-N/kg N (IPCC 2006).

7.5.3 Uncertainty Assessment

The uncertainty, originally based on ORTHOFER et al (1995), was re-evaluated and adapted for the N₂O EF based on an expert judgement by Umweltbundesamt (2015). The compared to the previous estimate higher EF uncertainty is due to the relatively low uncertainty assessment of previous submissions, the very large uncertainty associated with the default EF for indirect N₂O emissions (IPCC 2006 GL) as well as the wide dispersion of the individual measurement results influencing the EF for wastewater treatment plants (Expert judgement by Umweltbundesamt (2015)). Also fluctuating nitrogen flows and removals affects the uncertainty of the applied CS EF.

Uncertainties for CH₄ remain unchanged compared to previous estimations.

Table 304: Uncertainty assessment for CRF 5.D.1 Wastewater Treatment and Discharge.

	CH ₄	N ₂ O
Activity data	20%	20%
Emission factor	50%	100%

Up to now no uncertainty assessment for waste water treatment at industrial sites was carried out.

7.5.4 Category-specific QA/QC

7.5.4.1 CH₄ from septic tanks (5.D.1)

The country specific **MCF** used – 0.27 based on (STEINLECHNER et al. 1994), which is lower than the IPCC 2006 default for septic systems (0.5) – has been validated during the In-Country Review 2013 by comparison with a study on 'Evaluation of Greenhouse Gas Emissions from Septic Systems' of the Water Environment Research Foundation (WERF 2010), on emission rates (measurements) of methane from septic tanks in California. According to the study, a MCF value of about 0.22 would be applicable for septic systems¹²². As the measurements have been carried out under conditions (air temperatures) similar to the average temperature of Austria the results can directly be compared and the use of 0.27 be supported. Using a MCF of 0.22 is also supported by an article on 'Methane, carbon dioxide, and nitrous oxide emissions from septic tank systems' (ENVIRONMENTAL SCIENCE & TECHNOLOGY 2011).

7.5.4.2 N₂O from domestic wastewater treatment (5.D.1)

An extensive QA/QC on the methodology has been conducted in 2014/2015 to best adapt the method for estimating N₂O emissions from wastewater to the IPCC 2006 GL. In this context different options were considered and discussed with other wastewater experts. Results for the year 2013 range from 122 t N₂O to 757 t N₂O (using no country-specific data at all). The currently applied option was chosen as it delivers the most accurate emissions result, considering actual nitrogen flows and a CS emission factor reflecting up-to-date operating conditions at Austrian wastewater treatment plants.

Results of the measurement program (RelaKO) were presented to a wide range of national stakeholders at two events organised by the Austrian Water and Waste Management Association ('ÖWAV'; PARRAVICINI & SVARDAL 2015) and published as a scientific article in Energy Procedia (PARRAVICINI ET AL 2016) as well as in the JOURNAL OF ENVIRONMENTAL MANAGEMENT 279 (2021).

Verification EF_{PLANTS}

As a QA and verification measure Austria regularly evaluates plant specific N flows (influent to and effluent from wastewater treatment plants) and take this data for extrapolation of plant specific N₂O emissions – as determined by the national measuring programme 2013/2014 RelaKO (BMLFUW 2015) – to national N₂O emissions from wastewater treatment plants on basis of the regression equation of the RelaKO project. This way, changing operating conditions at wastewater treatment plants can be considered and emissions (or the EF_{PLANT}) adjusted accordingly, if necessary.

¹²² A MCF value of 0.22 was calculated using the mean methane emission value measured for the septic tanks from this project.

7.5.5 Recalculations

For 5.D.1 domestic wastewater, recalculations were carried out as new information on the connection rate for 2022 became available, which has an impact on 2021 (–0.4 kt CO₂e) due to interpolation between 2020 and 2022.

7.5.6 Planned improvements

The specifications of the IPCC 2019 Refinement, in particular regarding CH₄ from municipal wastewater treatment plants, will be investigated and the national GHG inventory for category 5.D will be adapted accordingly for the 2025 submission.

8 OTHER (CRF SECTOR 6)

Austria does not report any emissions under CRF Sector 6.

9 INDIRECT CO₂ AND NITROUS OXIDE EMISSIONS

Austria does not separately report any indirect CO₂ emissions from the atmospheric oxidation of CH₄, CO and NMVOCs in CRF Table 6, but has partly covered these emissions in categories 1.A and 2.D.3 as described below.

Table 305: Indirect emissions as reported in CRF Table 6 for the year 2022

Greenhouse Gas Source and Sink Categories	Indirect Emissions	
	CO ₂	N ₂ O
1. Energy	IE,NE	NE
2. Industrial Processes and Product Use	IE	NE
3. Agriculture	NO	NO
4. LULUCF	NO	NO
5. Waste	NA	NA
6. Other (please specify)	NO	NO

The reasons for the notation keys reported in CRF Table 6 are:

1. Energy

CO₂ emissions reported in category 1.A consider total carbon of fossil fuels and thus also covers all potential indirect CO₂ emissions (reported as “IE” in CRF Table 6)

CO₂ emissions from carbon included in fugitive CH₄ emissions reported in category 1.B are not estimated (reported as “NE” in CRF Table 6)

2. Industrial processes and product use:

Indirect CO₂ emissions from solvent use (from NMVOC) are reported under 2.D.3 Solvent Use in CRF table Table2(I).A-Hs2 (“IE”)

10 RECALCULATIONS AND IMPROVEMENTS

Recalculations of previously submitted inventory data are performed with the purpose to improve the GHG inventory. This chapter quantifies the changes in emissions for all greenhouse gases compared to the previous submission. Recalculations are quantified for total GHG emissions for all years.

10.1 Explanations and justifications for recalculations, including in response to the review process

Compiling an emission inventory includes data collecting, data transfer and data processing. Data has to be collected from different sources, for instance national statistics, plant operators, studies, personal information or other publications. The provided data must be transferred from different data formats and units into a unique electronic format to be processed further. The calculation of emissions by applying methodologies on the collected data and the final computing of time series into a predefined format (CRF) 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 minimized it is sometimes necessary to make some revisions (called recalculations) under the following circumstances:

- An emission source was not considered in the previous inventory.
- A source/data supplier has delivered new data. The causes might be: Previous data were preliminary data only (by estimation, extrapolation), improvements in methodology.
- 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 obligations caused by 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.

Detailed information on recalculations and their justifications can be found in the following sub-chapters as well as the corresponding Sector-specific Chapters 3 *Energy* – 7 *Waste*, in which all methodological changes and activity data updates that led to recalculations of emissions with respect to the previous submission are listed.

10.1.1 Energy (Sector 1)

10.1.1.1 Stationary sources

Update/Improvement of activity data

Revision of the energy balance

The federal statistics office “Statistik Austria” revised the energy balance (mainly for the year 2021) with the following **main implications** for energy consumption as used in the inventory and the corresponding CO₂ emissions:

- Natural gas 2021: Gross inland consumption has not been revised. Transformation input has been revised by +0.6 PJ (+33 kt CO₂ for 1.A.1.a). Own use of the energy sector has been revised by +0.4 PJ (+21 kt CO₂ for 1.A.1.c). -1.8 PJ (-97 kt CO₂) of final energy consumption has been subtracted from 1.A.4 and +0.8 PJ (+43 kt CO₂) has been shifted to 1.A.2.
- Gasoil 2021: Gross inland consumption has been revised by -2.2 PJ (-166 kt CO₂), of which -1.1 PJ final energy consumption for 1.A.2 (-84 kt CO₂) and -1.1 PJ for 1.A.4 (-82 kt CO₂).
- LPG 2021: Minor shifts (0.1 PJ) from 1.A.4 and *Transport* to ‘non energy use’.
- Residual fuel oil: 0.7 PJ (59 kt CO₂) has been shifted from 1.A.4 to 1.A.2.
- Coal 2021: Final energy consumption has been revised by -0.1 PJ which results in -16 kt CO₂ for 1.A.4 and + 6 kt CO₂ for 1.A.2.
- Solid biomass 2021: Final energy consumption has been revised by +6.9 PJ, which has been mostly allocated to the residential sector (1.A.4b).

1.A.2.g.7 Off-road Industry

Revision 2021: +11.2 kt CO₂e

Energy consumption for non-road mobile machinery in the industrial sector has been revised for 2021 due to an update of the industrial production index.

Methodological changes

For 1990 to 2021, minor changes in greenhouse gas emissions (CH₄ emissions) of sub-categories 1.A.4.a *commercial/institutional* and 1.A.4.b *residential* occur because of updated heating stock data and newly allocated shares of combustion technologies per energy carrier (updated energy demand model for space heating).

10.1.1.2 Mobile sources

Update/Improvement of activity data

1.A.3.b Road transport

Revision 2021: -10.2 kt CO₂e

Revision of real fuel consumption for PC and LDV PHEV

The energy consumption in vehicle concepts with fuel combustion and electric motor is subject to high uncertainties. The fact is that in reality there are use cases with a high proportion of kilometres driven electrically, but also with the almost exclusive use of the combustion engine (ITNA,

2023¹²³, p.9). For this reason, a more pessimistic charging behaviour for PHEV vehicles has been assumed, which increased the real fuel consumption of PHEV cars (petrol) and LDV (petrol), especially in 2021.

Correction factor for real-world fuel consumption for LDV

The real-world consumption correction factor – when switching from NEDC (New European Driving Cycle) to WLTP (Worldwide harmonized Light vehicles Test Procedure) standard values – has been reduced in the NEMO emissions calculation model for LDV according to the latest CO₂ monitoring.

Update of specific vehicle mileage per year

Improvement of data evaluation in the central vehicle assessment database (ZBD - annual “sticker check” in accordance with §57a KFG). An update of the relevant input data made it possible to evaluate half-years for 2021 and 2022 and thus define the specific annual mileage of vehicles more precisely. This has led to an increase for LDV and 2-wheelers for 2021 compared to last year's inventory.

In general, data from the ZBD is used to evaluate the specific yearly mileage for vehicle categories PC, LDV, buses and 2-wheelers.

Update of NEMO fleet model

Due to an adjustment of the age distribution in the fleet model, the proportion of more efficient EURO V and EURO VI trucks in total HDV mileage has increased slightly towards the end of the time series. This results in a reduction of fuel consumption in category HDV (domestic trucks/trailers) and consequently in a GHG reduction.

As a result of the retrospective reduction of fuel consumption for domestic HDV (*1.A.3.b.iii*) and the increase in *1.A.3.g.7 off-road industry* and in *1.A.3.b road transport (domestic)* - due to methodological reasons - the energy use in fuel exports must be reduced, as the total amount of fuel sold in 2021 has remained unchanged and may not be changed. It is simply a shift from fuel exports to fuel used in inland. This is irrelevant for total GHG emissions from road transport given the established “fuel sold” principle in accordance with international reporting requirements.

1.A.4.c.2 Mobile combustion in agriculture and forestry

Revision 2021: +0.08 kt CO₂e

The CH₄ proportions of HC have been updated to exact proportions of 7%, 3.4% and 2.4% per device group according to the EMEP/EEA Guidebook 2023 [1-a-4-non-road Table 3-6, page 37ff]. The overall CH₄ proportions of HC have been revised slightly upwards.

1.A.5 Military

Revision 2021: -2.1 kt CO₂e

Confidential data (fuel consumption) became available from a survey for military off-road vehicles for the year 2021. The evaluation for 2021 and a separate expert assessment helped to refine the

¹²³ SCHWINGSHACKL, M. & REXEIS, M. (2023): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2022. ITNA – Institut für Nachhaltige Antriebe und Thermodynamik. Erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2023.

trend from 1990 to 2022. Consequently, the entire time series has been recalculated, which led to a reduction of GHG emissions for military non-road mobile machinery by 0.38 kt.

Military air traffic continues to be subject to great uncertainty due to a lack of actual data. The extrapolated value 2021 from the previous inventory has been revised based on an update of the inventory of helicopters and aircraft in the Austrian military available for 2022. This resulted in a reduction of GHG emissions for military aviation by 1.76 kt.

Memo Item International Bunkers - Navigation

Revision 2021: -23.8 kt CO₂e

Due to a linking error in the GEORG “Danube Shipping” module, the value for 2021 was incorrect and has been corrected.

10.1.1.3 Fugitive Emissions

No recalculations are reported for sector *1.B.* in this years' submission.

10.1.2 Industrial Processes and Other Product Use (Sector 2)

Consideration of additional sources/processes

2.A.2 Lime Production

For three processes in pulp and paper production reported in the ETS related to limestone production or lime use and PCC production respectively, time series were prepared and emissions and removals were considered in category *2.A.2 Lime Production* (recalculation difference 2021: - 9.41 kt CO₂).

2.F.1.e Mobile Air Conditioning

Following the recommendation of the 2022 UNFCCC review, an estimate for emissions from air conditioning stock for construction site vehicles was included (recalculation difference 2021+12.44 kt CO₂e).

Allocation of emissions between subcategories

2.B.1 Ammonia Production / 2.D.3.ii Other: Urea used as a catalyst

Updated urea amounts used in road traffic for 2005 onwards led to a redistribution of minor amounts between these two categories (-0.02 kt CO₂ 2021). Additionally, for the years 1990 – 2019, the recalculation of the time series of CH₄ emissions from *2.B.10.ii Urea Production* described below affected the reported CO₂ emissions from *2.B.1 Ammonia Production*.

Methodological improvements

2.B.10.ii Urea Production

An inconsistency in the time series was corrected: values reported by the company for methane emissions until 2019 were based on an assumed raw gas methane content, whereas from 2020 onwards measured data were used. The measured data showed that the methane content for the

years until 2019 had been assumed too low. For this submission, emissions until 2019 are calculated using the average IEF of the years 2020-2022 for which measured raw gas composition is available (recalculation difference 2019: +2.09 kt CO₂e).

2.D.3.i Solvent Use

Data on facility level that is prepared by the operators according to the VOC directive were collected and incorporated. During intensive QC of the data, which included comparison with the data of 2015 and 2019, some corrections of the data for 2015 and 2019 were made, leading to a recalculation for most sub-categories from 2015 onwards. Also, corrections on the top down data were made: besides correction of minor transcription errors for the years 2016ff, non-solvent use of a new company became available which was considered for 2021, leading to a decrease of total solvent use in Austria. As bottom up data is extrapolated to this value, this resulted in lower activity data and thus lower emissions for 2021. Overall, the recalculation difference 2021 in this subcategory is -2.95 kt CO₂e.

2.F.1.a Commercial Refrigeration and 2.F.1.d Industrial Refrigeration

A previous double-counting error was identified and corrected. During extensive QA/QC it became obvious that amounts of F-gases placed on the Austrian market reported as import were not imported by the company itself, but bought from an importer. The amounts were therefore already included in the reported amounts for F-gas import of the selling company. This led to a reduction of import data for the years 2011 onwards, affecting the two residual sub-categories *2.F.1.a Commercial Refrigeration* and *2.F.1.d Industrial Refrigeration*.

Also, for supermarkets, which are considered separately in the calculation, an allocation error for one specific refrigerant was corrected, which also affected activity data and emissions from these two sub categories.

Overall, the recalculations led to a reduction of emissions of 68.48 kt CO₂e in 2021.

2.F.1.e Mobile Air Conditioning

For trains, refill data has become available for the years 2014ff and was used instead of calculation of emissions assuming a leakage of 5%. As data showed that the leakage factor was higher than the previously assumed value, the average leakage factor of 2014-2022 was applied for the years before 2014 (recalculation difference 2021: +3.97 kt CO₂e).

2.F.2.a Foam Blowing

The emission factor for 2020 and 2021 was corrected, it was a software generated artefact of extrapolating the methodology to the next year (recalculation difference 2021: -3.47 kt CO₂e).

Update of activity or emissions data

2.C.1.b Steel

CH₄ emissions for 2021 that previously were extrapolated have been updated (recalculation difference 2021: - 0.11 kt CO₂e).

2.F.1.d Transport refrigeration

Data for 2021 were updated (recalculation difference 2021: - 0.11 kt CO₂e).

2.F.3 Fire protection

Previously, emissions from stock in fire protection units was extrapolated for 2021, now the actual value is used (recalculation difference 2021: + 1.04 kt CO₂e).

2.G.2 Other uses of SF₆ - particle accelerators.

Data for (medical) particle accelerators from 2012 onwards were updated (recalculation difference 2021: + 0.14 kt CO₂e).

10.1.3 Agriculture (Sector 3)

Update of activity data

3.A Enteric Fermentation, 3.B Manure Management, 3.D Agricultural Soils

Livestock data – cattle < 1 year

The livestock category cattle < 1 year comprises slaughtering calves < 1 year, other male calves and cattle < 1 year, and other female calves and cattle < 1 year according to the official statistics (Statistics Austria). The breakdown by type of use is determined by Statistics Austria using model calculations. Methodological improvements resulted in shifts between the cattle < 1 year sub-categories in the years 2003-2021 and thus lead to revised average values for gross energy intake, N_{excretion} and V_{S_{excretion}} for cattle < 1 year.

Background data for feeding and nutrition of dairy and suckling cows

New figures for the protein and fat content of milk for the year 2021 became available (AMA 2023a). This update resulted in minor revisions of the values for gross energy intake, N_{excretion} and V_{S_{excretion}} of dairy and suckling cows.

Biogas plants

New data on input materials for Austria's biogas plants became available from the compost and biogas association (Kompost- und Biogasverband 2023). The update resulted in slightly revised CH₄ and N₂O emissions with an impact on the source categories *3.B Manure Management, 3.D.a.2.a Animal manure applied to soils* and *3.D.a.2.c Other organic fertilizers applied to soils* for 2020 and 2021.

3.A Enteric Fermentation (CH₄)

This category has been revised due to updated activity and nutrition data (GE-intake; revision in category cattle <1 year – see above). The improvements resulted in updated emission amounts for the years 2003-2021 (+2.8 kt CH₄ for 2021).

3.B Manure Management (CH₄, direct and indirect N₂O)

Methane and N₂O emissions have been revised for the years 2003-2021 (+0.3 kt CH₄ for 2021, +0.004 kt N₂O for 2021), because of updated activity and nutrition data (see above).

3.D.a.2.a Animal Manure Applied to Soils

Updates and improvements as described above resulted in revised emissions from animal manure application for the years 2003-2021 (+0.01 kt N₂O for 2021).

3.D.a.2.c Other organic fertilisers

As a result of updated activity data on input materials for biogas plants, N₂O emissions have been revised for the years 2020 and 2021 (-0.003 kt N₂O for 2021).

3.D.a.3 Urine and dung deposited by Grazing Animals

Livestock related updates as already described before, led to recalculated N₂O emissions for the years 2003-2021 (+0.002 kt N₂O for 2021).

3.D.a.5 Mineral Soils (N₂O)

Revisions of activity data (perennial cropland remaining perennial cropland, perennial cropland converted to annual cropland, annual cropland remaining annual cropland; for more information see chapter 6.4.7 on LULUCF) resulted in slightly revised N₂O emissions for the entire time series (-0.00001 kt N₂O for 2021).

Improvements of methodologies and emission factors

3.D Agricultural Soils (N₂O)

3.D.b Agricultural Soils (indirect soil emissions – N₂O)

Atmospheric deposition: the main reasons for revised emissions are the application of updated Tier 2 NH₃ EF for mineral fertilisers and the update of the NH₃ EF for grazed sheep and deer according to the EMEP/EEA GB 2023 in the ammonia inventory as well as the adjusted activity data (N_{excretion} values for cattle and biogas). As a result, the indirect N₂O emissions from atmospheric deposition have been revised upwards for the entire time series (+0.04 kt N₂O for 2021).

N leaching and run-off: reasons for the minor recalculations are the revised amounts of animal manure applied to soils (+0.001 kt N₂O for 2021).

10.1.4 LULUCF (Sector 4)

4.A Forest land

The soil carbon stocks of land-use changes from/to settlement were updated on basis of an updated sealing ratio, which caused minor changes for the land-use change subcategory *Settlement to Forest land* for the whole time series in the range of -4.0 and 3.5 kt CO₂e per year compared to the last submission in 2023. The *Forest land* results for the years 2020 to 2022 are extrapolated using the results of the last NFI 2016/21 and relative harvest indices based on the harvest statistics for these years. By introduction of a new reported year, the relative harvest indices for the years since 2020 and the biomass losses due to harvest changed accordingly. Therefore, the *Forest land* results for the years 2020 and 2021 of this submission differ from those of the 2023 submission by -941 kt CO₂e (2020) and -1 031 kt CO₂e (2021).

4.B Cropland

The land-use and land-use change assessment for the *Settlement* and *Wetland* subcategories for this submission was improved by integrating various geographically specific data sources, specifically for the years 2016 to 2022, but also consistently backwards to 1990. For area consistency reasons this improvement caused changes in the areas of the *Cropland* and *Grassland* categories and related land-use changes. These area improvements caused changes of the annual net emissions

for the whole time series of the *Cropland* category in the range of 14 to 25 kt CO₂e per year compared to the last submission in 2023.

4.C Grassland

The land-use and land-use change assessment for the *Settlement* and *Wetland* subcategories for this submission was improved by integrating various geographically specific data sources, specifically for the years 2016 to 2022, but also consistently backwards to 1990. For area consistency reasons this improvement caused changes in the areas of the *Cropland* and *Grassland* categories and related land-use changes. In addition, wildfires at *Grassland* (and *Cropland* included in the *Grassland* figures) were estimated for the first time for submission 2024. On the basis of a comprehensive new study on *Grassland* mineral soils, the previous Tier 2 default estimate method for the mineral soil carbon stock changes of the *Grassland remaining Grassland* subcategory was removed from the category inventory model and exchanged by the Tier 1 assumption of no carbon stock changes for the whole time series. These improvements caused changes of the annual net emissions for the whole time series of the *Grassland* category in the range of 11 to 13 kt CO₂e per year compared to the last submission in 2023.

4.D Wetlands

The land-use and land-use change assessment for the *Settlement* and *Wetland* subcategories for this submission was improved by integrating various geographically specific data sources, specifically for the years 2016 to 2022, but also consistently backwards to 1990. In addition, updated activity data on wildfires at *Wetlands* (reeds) were included in the inventory for the 2024 submission. These improvements caused changes of the annual net emissions for the whole time series of the *Wetland* category in the range of -10 to 1 kt CO₂e per year compared to the last submission in 2023.

4.E Settlements

The land-use and land-use change assessment for the *Settlement* and *Wetland* subcategories for this submission was improved by integrating various geographically specific data sources, specifically for the years 2016 to 2022, but also consistently backwards to 1990. Furthermore, the results of a new comprehensive study on biomass stocks and growth rates of settlement trees and shrubs were included in the inventory for the 2024 submission. Cadastral data on urban trees of several Austrian towns and new nationwide results of an assessment of the (crown) cover of trees, shrubs, low vegetation and sealing in settlement using GIS layers were used for improved estimates of the biomass and soil carbon stock changes of the *Settlement* category. These improvements caused changes of the annual net emissions for the whole time series of the *Settlement* category in the range of 275 to 498 kt CO₂e per year compared to the last submission in 2023.

4.F Other land

No changes

4.G HWPs

No changes

10.1.5 Waste (Sector 5)

Update of activity data

5.A Solid Waste Disposal

Revisions are reported for the years 2018-2021 (2021: +20 kt CO₂e) as updated data on landfill gas recovery from a national study were made available (UMWELTBUNDESAMT 2023). In the previous submissions, results from the preceding study (UMWELTBUNDESAMT 2019) were used to derive assumptions on recovered amounts for the years 2018-2021.

5.C Incineration and Open Burning of Waste

In previous inventories, a share of 3% was assumed for the area of vineyards burnt for the entire time series according to an expert judgement from the Federal Association of Viniculture in 2001 (Bundesweinbauverband Österreich). According to current information from the Federal Association of Viniculture, the area of vineyards burnt has decreased over time and is assessed to be no more than 1 % of the total vineyard areas for the years 2010 onwards. The burning of vine is either prohibited or only permitted to a very limited extent in the relevant federal provinces. The area of vineyards burnt between 2001 and 2010 were determined by linear interpolation between the two, respective expert judgement estimates. This improvement resulted in revised emissions for the years 2002-2021 (-0.3 kt CO₂e).

5.D Wastewater Treatment and Discharge

For 5.D.1 domestic wastewater recalculations were carried out for 2021 (-0.4 kt CO₂e) as information on the connection rate for 2022 became available, affecting 2021 due to interpolation between 2020 and 2022.

10.2 Implication for emission levels and trends

As a result of the continuous improvement of Austria's GHG inventory, emissions of some sources have been recalculated on the basis of updated data or revised methodologies. Thus emission data for 1990 to 2021 which are submitted this year differ slightly from data reported previously.

Austria's GHG emissions reported this year in sum differ only slightly from the data submitted last year. The national total (excl. LULUCF) for the base year is 0.04% (+35 kt CO₂e) higher than reported last year. The national total (excl. LULUCF) for 2021 is 0.22% (-173 kt CO₂e) lower than the value submitted last year.

Table 306 presents the recalculation differences of national total GHG emissions for all years.

Table 306: Recalculations of Austria's GHG emissions compared to the previous submission.

	National Total GHG emissions without LULUCF			
	OLI 2023	OLI 2022	Recalculation Difference	
	[kt CO ₂ e]	[kt CO ₂ e]	[kt CO ₂ e]	[%]
1990	79 083	79 047	+35	0.04%
1995	79 986	79 953	+33	0.04%
2000	80 640	80 619	+21	0.03%

	National Total GHG emissions without LULUCF			
	OLI 2023	OLI 2022	Recalculation Difference	
	[kt CO ₂ e]	[kt CO ₂ e]	[kt CO ₂ e]	[%]
2005	92 605	92 589	+16	0.02%
2010	84 793	84 693	+100	0.12%
2011	82 607	82 506	+101	0.12%
2012	79 889	79 788	+101	0.13%
2013	80 310	80 229	+81	0.10%
2014	76 721	76 663	+59	0.08%
2015	78 935	78 884	+50	0.06%
2016	79 863	79 821	+42	0.05%
2017	82 195	82 132	+63	0.08%
2018	78 903	78 854	+49	0.06%
2019	80 058	79 994	+64	0.08%
2020	74 030	73 911	+119	0.16%
2021	77 360	77 532	-173	-0.22%

The following tables present the recalculation difference with respect to last years' submission for each sector (positive values indicate that this years' estimate is higher).

Table 307: Recalculation difference of Austria's greenhouse gas emissions compared to the previous submission by sector

THG	OLI 2023		OLI 2022		Recalculation Difference	
	1990	2021	1990	2021	1990	2021
	[kt CO ₂ e]		[kt CO ₂ e]		[kt CO ₂ e]	
Total*	79 083	77 360	79 047	77 532	+35	-173
1. Energy	52 666	51 916	52 665	52 142	+0.9	-225
2. IPPU	13 633	16 892	13 615	16 959	+18	-67
3. Agriculture	8 416	7 322	8 400	7 221	+17	+101
4. LULUCF	-11 682	-11 076	-12 207	-10 402	+526	-674
5. Waste	4 367	1 230	4 367	1 211	-	+19

* without LULUCF

National total emissions (excluding LULUCF) for **1990** were revised upwards since last years' submission (+ 35 kt CO₂e), mainly due to revised estimates reported for sectors **2 IPPU** and **3 Agriculture**. Under **2 IPPU**, additional processes in pulp and paper production related to limestone or lime use and PCC production were considered in this submission, changing the emissions of **2.A.2 Lime Production** over the entire time series. **Indirect N₂O emissions from Managed Soils (3.D.2)** were revised as updated emission factors from the new EMEP/EEA GB 2023 were applied in the ammonia inventory affecting the indirect N₂O emissions from atmospheric deposition as well.

Emissions for **2021** (without LULUCF) are lower (-173 kt CO₂e) than reported in the previous submission, mainly due to revised estimates in Sector **1 Energy**, particularly the category **1.A.4 Other Sectors** following revisions of the energy balance. Further revisions were reported for **1.A.2.c Chemicals** due to revisions of the energy balance, **1.A.3.b Road transport** (in particular for *heavy duty trucks*

and busses) due to model (fuel consumption) updates and 2.F.1 Refrigeration and Air Conditioning due to QA/QC measures.

In addition, revised values are also reported in categories 3.A Enteric Fermentation and 5.A Solid Waste Disposal due to updated activity data.

The following tables present the recalculation difference with respect to last years' submission for each gas (positive values indicate that this years' estimate is higher).

Table 308: Recalculation difference of Austria's greenhouse gas emissions compared to the previous submission by gas.

	1990 (Base year)	2021
	Recalculation Difference [kt CO ₂ e]	
Total	+35	-173
CO ₂	+17	-261
CH ₄	+2.0	+123
N ₂ O	+17	+21
HFC, PFC, SF ₆ , NF ₃	0	-54

without LULUCF

1990 emissions of CO₂, CH₄ and N₂O were revised upwards (+35 kt CO₂e in total), whereas no recalculations were reported for F-gases.

For **2021**, CO₂ and F-gas emissions were revised downwards (-261 kt CO₂e and -54 kt CO₂e resp.), whereas CH₄ and N₂O emissions were revised upwards (+ 123 kt CO₂e and + 21 kt CO₂e resp.). Recalculations of CH₄ and N₂O are largely attributable to revisions in sector 3 Agriculture. Recalculations of CO₂ mainly occur in sector 1 Energy, in particular in sub-category 1.A.4.b Other sources – Residential (stationary combustion), following the revisions of the energy balance.

A description of all recalculations by each sector is given in Chapter 10.1 as well as the relevant sectoral methodological chapters. Recalculation differences at sub-category level for the time-series 1990-2021 are provided in Annex 8.

10.3 Improvements made and planned improvements, including in response to the review process

The Umweltbundesamt is responsible for the management of the improvement programme. It is supported by the QA/QC programme based on the international standard EN ISO/IEC 17020:2012.

The overall goal is to produce emission inventories which are fully consistent with the UNFCCC reporting guidelines and the IPCC 2006 Guidelines and achieve the quality objectives set. To meet this goal, an improvement programme has been established that is driven by the results of various review processes, as e.g. internal reviews and audits (see chapter 1.2.3), the review under the UNFCCC and/or under the Kyoto Protocol as well as other international and European reviews, e.g. under the European Union Monitoring Mechanism ("Effort Sharing Decision Review") or under

CLRTAP. The Improvement programme requires the establishment of improvement plans set up and maintained for each sector as well as for general issues (incl. improvement of the Quality Management System), that are updated every year after the results from the UNFCCC review process become available and are carefully monitored.

10.3.1 Planned improvements

Source specific planned improvements are presented in the respective subchapters of Chapters 3–7. Planned improvements attributable to the previous UNFCCC Review 2020 are summarized below:

Table 309: *Planned improvements made in response to the UNFCCC Review*

Finding	Reference*	Improvement planned
Other (Comparability) Present the national totals with and without indirect CO ₂ in the CRF tables and in the NIR, in accordance with paragraph 29 of the UNFCCC Annex I inventory reporting guidelines.	ARR 2023 G.2	It is planned to report indirect CO ₂ from 2.D.3 separately in the 2025 submission.
1.A.5.b Mobile – liquid fuels – CO₂, CH₄ and N₂O (E.3, 2022) (E.7, 2020) Accuracy The ERT considers that the recommendation has not yet been fully addressed because the Party has not acquired the relevant data from the Austrian Ministry of Defence, and linear extrapolation is still being used for some parts of the time series without demonstrating the validity of the extrapolation in the NIR.	ARR 2023 E.1	The issue has been partly considered with the submission 2024: Fuel consumption data for military ground operations have been submitted by the Austrian Ministry of Defence in autumn 2023. Military aviation data have not been submitted yet by the Austrian Ministry of Defence. We are currently working on an inter-ministerial data exchange to obtain the data.
1.B.2 Oil, natural gas and other emissions from energy production – oil and natural gas – CH₄ – Transparency Make efforts to report the emissions for category 1.B.2 disaggregated into categories 1.B.2.a.i and 1.B.2.b.i.	ARR 2023 E.2	The requirement to report information on 1.B.2 separately for gas and oil has been discussed with Austrian representatives from the oil and gas industry in 2022 and again 2023. Nevertheless more time is needed to separate activity data, especially with regard to oil gas, so implementation needs to be postponed for submission 2025.
Comparison with international data – liquid biomass – CO₂, CH₄ and N₂O The ERT encourages the Party to follow up with Statistics Austria to explore the differences between the liquid biomass consumption data used for the national energy balance and the data submitted to IEA, and report any findings and recalculations in the NIR.	ARR 2023 E.5	Implementation needs further clarification from Statistics Austria why biofuels are reported differently in the IEA/EEA Joint Questionnaires and national statistics.

Finding	Reference*	Improvement planned
1.A Fuel combustion – sectoral approach – liquid, solid, gaseous, biomass, other fossil fuels – CO₂ The ERT recommends that the Party, for those EU ETS operators that do not report CO ₂ emissions based on direct measurements, collect AD and subsequently apply default or country-specific EFs to the relevant fuel consumption, thereby mitigating potential discrepancies resulting from use of different carbon conversion factors under the EU ETS (3.664 t CO ₂ /t C) and the 2006 IPCC Guidelines (vol. 2, chap. 1, table 1.4, p.23), which require converting the carbon EF to a CO ₂ EF using a factor of 44/12 = 3.667 t CO ₂ /t C).	ARR 2023 E.6	This issue is planned to be addressed in submission 2025.
3 General (agriculture) – CH₄ and N₂O The ERT recommends that the Party collect data on its annual horse population since 2017 to improve the accuracy of the estimation of CH ₄ emissions from enteric fermentation and CH ₄ and N ₂ O emissions from manure management.	ARR 2023 A.2	Submission 2024 is still based on the official estimate from the Austrian Horse Breeding Association. However, the finding has been included in Austria's inventory improvement programme. Additional information is provided in the NIR 2024. Refer to Chapter 5.1.8
3.F.5 Other (field burning of agricultural residues) – CH₄ and NO₂ The ERT recommends that the Party report CH ₄ and N ₂ O emissions from burning of woody perennial crops, including biomass from viticulture, under burning of agricultural residues and provide in the NIR a detailed explanation for the recalculation, including information on the impact of the recalculations on the trend in emissions at the category, sector and national level, as appropriate.	ARR 2023 A.5	Emissions from the open burning of biogenic waste have not yet been reallocated to the agricultural sector. However, additional information is included in the NIR 2024. Since the national inventory requires a homogeneous allocation of activities and emission sources for greenhouse gases and air pollutants (UNFCCC and UNECE reporting) to ensure consistency, further analyses of this finding is planned. Refer to Chapter 7.4.2

10.3.2 Improvements made in response to the review process

In 2023, Austria was reviewed by the UNFCCC. Results of this review – conducted as a desk review – are published in an Annual Review Report (ARR, UNFCCC 2024).

Table 310: Improvements made in response to the UNFCCC Review.

Finding	Reference*	Improvement made	Chapter
General			
CRF tables – N₂O The ERT recommends that the Party correct the reporting of indirect N ₂ O emissions for the LULUCF sector in CRF table 6 (i.e. by reporting those emissions as “NO”), ensuring consistency with the reporting of NO _x emissions.	ARR 2023 G.3	Indirect N ₂ O emissions for the LULUCF sector are now correctly reported as ‘NO’ in CRF Table 6 of the 2024 submission.	Chapter 9 CRF Table 6

Finding	Reference*	Improvement made	Chapter
Energy			
1.A.5.b Mobile – liquid fuels – CO₂, CH₄ and N₂O (Accuracy) Make efforts to improve the accuracy of the estimates by developing more efficient cooperation with the Austrian Ministry of Defence to resolve confidentiality issues. If linear extrapolation continues to be used for the estimates, demonstrate the validity of the trend in the NIR.	ARR 2023 E.1	The issue has been partly resolved with the submission 2024. Fuel consumption data for military ground operations have been submitted by the Austrian Ministry of Defence in autumn 2023. Military aviation data have not been submitted yet by the Austrian Ministry of Defence. We are currently working on an inter-ministerial data exchange to obtain the data.	Chapter 3.2.15
Fuel combustion – reference approach – liquid fuels – CO₂ The ERT recommends that the Party update CRF table 1.A(c) with the recalculated value for total apparent consumption (excluding NEU, reductants and feedstocks) for liquid fuels by subtracting the NEU value for naphtha, and explain the reason for, and impact of, the recalculation in the NIR.	ARR 2023 E.4	In the 2024 submission, total apparent consumption (excluding NEU, reductants and feedstocks) for liquid fuels has been revised by subtracting the non energy use of naphtha, which is about 37 PJ for 2022.	Chapter 3.2.1.2
1.A.1.a Public electricity and heat production – other fossil fuels – CO₂ The ERT recommends that the Party correctly allocate the non-fossil share of AD for MSW under public electricity and heat production (biomass) (category 1.A.1.a). The ERT encourages the Party to include additional information on waste incineration with energy recovery included as biomass and fossil fuels under the information item on MSW fossil and non-fossil shares in CRF table 1.A(a).	ARR 2023 E.7	The non renewable part of MSW has been allocated to 1.A.1.a other fossil fuels and the renewable part to 1.A.1.a biomass in this 2024 submission.	Chapter 3.2.9.2
1.A.1.a Public electricity and heat production – other fossil fuels – CO₂, CH₄ and N₂O The ERT recommends that the Party provide a detailed explanation in the NIR regarding how calorific values for MSW non-biomass and biomass fractions are derived for the GHG inventory and specify which carbon EFs are used to calculate CO ₂ emissions for each fraction. The ERT also recommends that the Party review the methodology for determining MSW non-biomass and biomass fractions to assess whether using a weighted or normal average could enhance the accuracy of estimates and, if revisions are deemed necessary, recalculate emissions accordingly and describe the recalculations in the NIR.	ARR 2023 E.8	This issue is addressed in the NIR 2024.	Chapter 3.2.9.2

Finding	Reference*	Improvement made	Chapter
1.A.1.a Public electricity and heat production – biomass – CO₂, CH₄ and N₂O The ERT recommends that Austria include in the NIR a clear explanation of the biomass fuel mix (AD and CO ₂ , CH ₄ and N ₂ O EFs for the different biomass types) in public electricity and heat production to allow a better understanding of the difference in trends before 2004 and after 2005.	ARR 2023 E.9	The fluctuations in the trends of 1.A.1.a biomass CO ₂ , CH ₄ and N ₂ O implied emission factors are explained in ANNEX 3.1.	Chapter 3.2.10.1 NIR ANNEX 3.1
1.A.3.b.iii Heavy-duty trucks and buses – gaseous fuels – CO₂, CH₄ and N₂O The ERT recommends that the Party provide in the NIR a detailed explanation for any recalculations performed for road transportation, including information on the impact of the recalculations on the trend in emissions at the category, sector and national total level, as appropriate.	ARR 2023 E.10	Austria added detailed explanations for the recalculations performed for road transportation in the 2024 submission, including a discussion on the impact of the recalculations on the trend in emissions at the category, sector and national total level, as appropriate	Chapter 3.2.13.2
1.A.3.c Railways – liquid and other fossil fuels, biomass – CO₂, CH₄ and N₂O The ERT recommends that the Party report the reasons for any recalculations for CO ₂ , CH ₄ and N ₂ O emissions from railways and the impact of these recalculations in the NIR, including on the trend in emissions at the category, sector and national total level, as appropriate.	ARR 2023 E.11	Austria added detailed explanations for the recalculations performed for road transportation in the 2024 submission, including a discussion on the impact of the recalculations on the trend in emissions at the category, sector and national total level, as appropriate	Chapter 3.2.13.3
IPPU			
2.C.1 Iron and steel production – CO₂ – Transparency Review and, if necessary, revise the title of NIR table 138 (section 4.4.1.2, p.246) to make it consistent with the table's content.	ARR 2023 I.7	Title of table is corrected in the NIR 2024 (CH ₄ added).	Chapter 4.4.1.2, Table 141
2.C.1 Iron and steel production – CO₂ – Transparency Provide accurate information and data (e.g. detailed carbon balances and carbon contents) in the NIR (section 4.4.1) to enhance the transparency of the reporting on carbon flows for iron and steel production activities related to the IPPU and energy sectors.	ARR 2023 I.8	Information on the confidentiality of detailed carbon balances is included in the NIR 2024	Chapter 4.4.1.2
2.F.1 Refrigeration and air conditioning – HFC-134a (Accuracy) Revise the estimate of HFC-134a emissions from manufacturing, stocks and disposal for the bus and construction vehicle classes of category 2.F.1.e (mobile air conditioning), using appropriate default EFs provided in the 2006 IPCC Guidelines (vol. 3, chap. 7, p.7.52) for the estimations if more accurate EFs are not available.	ARR 2023 I.11	Emissions from stocks for construction vehicles are estimated and reported in the 2024 submission.	Chapter 4.7.2.1 Chapter 4.7.5

Finding	Reference*	Improvement made	Chapter
2.F.1 Refrigeration and air conditioning – HFC-134a (Transparency) Transparently document any assumptions about vehicle AD.	ARR 2023 I.12	This information is included in the NIR 2024 chapter on MAC.	Chapter 4.7.2.1
2.C.1 Iron and steel production – CH₄ The ERT recommends that the Party include in CRF table 9 the explanation for the use of “IE” for reporting of CH ₄ emissions from sinter.	ARR 2023 I.13	The notation key ‘IE’ is explained in CRF Table 9 of the 2024 submission.	CRF Table 9
2.F.3 Fire protection, 2.F.4 Aerosols – HFCs The ERT recommends that Austria correct NIR table 167 to ensure that the emission data presented therein are consistent with the data reported in CRF table 2(II)B-H.	ARR 2023 I.14	The table has been corrected for the NIR 2024 submission.	Chapter 4.7.1, Table 148
2.G.3 N₂O from product uses – N₂O The ERT recommends that Austria include in the NIR the relevant explanations and justification regarding the use of a single value for AD and N ₂ O emissions for the whole time series.	ARR 2023 I.15	Information has been included in the NIR 2024.	Chapter 4.8.2.3
Agriculture			
3 General (agriculture) – CH₄ and N₂O The ERT recommends that Austria increase transparency in the NIR by including additional information on mules and asses, including the data source references, the assumptions used and the related uncertainty of emissions estimated using the different data sources available.	ARR 2023 A.1	Information has been included in the NIR 2024.	Chapter 5.1.7
3.B Manure management – CH₄ The ERT recommends that the Party provide in the NIR relevant information to demonstrate that the MCF values for liquid manure management for the full time series are not biased, taking into account the annual temperature variation and the trend from 1990 to the present.	ARR 2023 A.3	Information has been included in the NIR 2024.	Chapter 5.3.2.1
3.D.a.5 Mineralization/immobilization associated with loss/gain of soil organic matter – N₂O The ERT recommends that the Party include in the agriculture section of the NIR transparent documentation of the respective contribution of all subdivisions of cropland remaining cropland (category 4.B.1) (for example perennial converted to annual, annual remaining annual and perennial remaining perennial) that are losing soil carbon and hence contributing to the emissions under category 3.D.a.5.	ARR 2023 A.4	Information has been included in the NIR 2024.	Chapter 5.4.2.1.5

Finding	Reference*	Improvement made	Chapter
LULUCF			
4 General (LULUCF) – CO₂ The ERT recommends that the Party explain in the NIR how consistency is ensured in estimates for all land-use categories when applying SOC values from different soil depths (e.g. 0–50 cm carbon stock changes for all land-use conversions but 0–30 cm stock depths for cropland remaining cropland and grassland remaining grassland).	ARR 2023 L.3	The consistency of using soil carbon stocks of the same soil depth in single land-use change categories is more transparently described.	Chapter 6.1.3.2
4 General (LULUCF) – CO₂ The ERT recommends that the Party include in the NIR a description of the methodology used to identify organic soils.	ARR 2023 L.4	The methodology to identify organic soils is described.	Chapter 6.4.4.1.3
4 General (LULUCF) – CO₂ The ERT recommends that the Party provide transparent information in the NIR to demonstrate the accuracy of the estimates of soil carbon stock changes in cropland and grassland remaining in the same land-use categories, taking into consideration the SOC gains and losses due to changes in management practices.	ARR 2023 L.5	The accuracy of the estimates of soil carbon stock changes in the remaining cropland and grassland subcategories is more transparently described.	Chapters 6.3.4.1.4, 6.4.4.1.2
4.A.1 Forest land remaining forest land – CO₂ The ERT encourages the Party to continue collecting data to enable carbon stock changes in mineral soils for forests not in yield to be estimated in the future. The ERT also encourages the Party to include in the NIR the justification for applying a tier 1 methodology for carbon stock changes in mineral soils for forests not in yield.	ARR 2023 L.6	A justification for applying a tier 1 methodology for the mineral soils of forests not in yield is provided.	Chapter 6.2.4.1.3
4.A.1 Forest land remaining forest land – CO₂ The ERT recommends that the Party provide in CRF table 4.A estimates of the carbon stock change in biomass losses for forests not in yield or provide an explanation for the reporting of biomass losses as “IE” in CRF table 9 and in the NIR.	ARR 2023 L.7	An explanation for reporting biomass losses in forests not in yield as “IE” is provided.	Chapter 6.2.4.1.1
4.B Cropland – CO₂ The ERT recommends that the Party explain in the NIR where all perennial cropland types (including areas with a rotation period of up to 30 years, forest arboretums, forest seed orchards, Christmas tree plantations and plantations of woody plants for the purpose of obtaining fruits such as walnut or sweet chestnut) are accounted for in the GHG inventory.	ARR 2023 L.8	Perennial cropland was more precise and complete defined.	Chapters 6.3.3, 6.3.4.1.1

Finding	Reference*	Improvement made	Chapter
4.B.1 Cropland remaining cropland – CO₂ The ERT recommends that the Party explain in its NIR how it developed the weighted average biomass carbon stock change factor for the living biomass pool and demonstrate that basing the factor for conversions to and from perennial cropland only on vineyards and orchards allows for accurate estimates of emissions and removals from living biomass.	ARR 2023 L.9	The rationale for the use of weighted means of the vineyard and orchard biomass representative for perennial cropland biomass at related conversion areas was given.	Chapter 6.3.4.1.1
4.C.1 Grassland remaining grassland – CO₂ The ERT recommends that the Party explain, in the NIR, the correction applied to the areas of grassland remaining grassland from the original source data (the national statistics) and for use in the inventory. The ERT encourages the Party to report in the NIR on the progress of the project that aims to improve the quantification of the total grassland area with spatially explicit data sets.	ARR 2023 L.10	The derivation of the grassland area data was described in detail.	Chapters 6.4.2, 6.1.3.1
4.C.1 Grassland remaining grassland – CO₂ The ERT recommends that the Party report the soil carbon stock, management factors, assumptions and data sources and corresponding areas for grassland remaining grassland in the NIR., referring to the current or the potential update based on the national research project on management measures to maintain and enhance SOC stocks in grassland mineral soils.	ARR 2023 L.11	The rationale for changing the approach of estimating mineral soil carbon stock changes in grassland remaining grassland was explained.	Chapter 6.4.4.1.2
4.D Wetlands The ERT recommends that the Party demonstrate in the NIR that the current assumption that the area of drained peatlands has remained constant since 1990 accurately reflects the national circumstances, or if this is not possible, revise the areas using the best available information or a splicing technique from the 2006 IPCC Guidelines (vol.1, chap. 5) and explain any recalculation in the NIR.	ARR 2023 L.12	The finalisation of a project on the distribution and management of organic soils has been described. This project will be finalised in 2024 and used for submission 2025 and will improve the estimates for organic soils.	Chapter 6.1.8
4.D.1 Wetlands remaining wetlands – CO₂ The ERT recommends that Austria provide an explanation for the reporting of “NE” for CO ₂ emissions from other wetlands remaining other wetlands and flooded land remaining flooded land in CRF table 9 and in the NIR.	ARR 2023 L.13	An explanation was provided in the NIR and in CRF table 9.	Chapter 6.5.4.1, CRF Table 9
4.G HWP – CO₂ The ERT encourages the Party to report the factors used to convert from product units to carbon in the NIR. Further, the ERT encourages the Party to report these factors in CRF table 4.G and/or include a reference to the NIR in the documentation box.	ARR 2023 L.14	These factors are reported in the NIR.	Chapter 6.8.2, Table 280

Finding	Reference*	Improvement made	Chapter
WASTE			
5.D.1 Domestic wastewater – CH₄ (Convention reporting adherence) Provide consistent information in CRF table 5.D and the NIR (either estimates or the correct notation key for the recovered and flared CH ₄ from domestic wastewater).	ARR 2023 W.2	The notation key 'IE' for 5.D.1 is added in CRF Table 5.D and the NIR text adapted accordingly.	Chapter 7.5.2.1, CRF Table 5.D
5 General (waste) – CH₄ The ERT recommends that the Party demonstrate clearly in the NIR that deposition of paper, wood and green waste has not taken place since 2009, for example by citing the relevant legislation. The ERT encourages the Party to report the notation key "NO" for the annual change in total long-term carbon storage in HWP waste for the years in which this activity does not occur, in the memo item in CRF table 5.	ARR 2023 W.3	Reference to the Landfill Ordinance (Federal Law Gazette II No 39/2008) is included and information that due to that deposition of paper, wood and green waste no longer takes place in Austria is now more clearly stated in the NIR. 'NO' for the annual change in total long-term carbon storage in HWP waste reported in CRF Table 5.	Chapter 7.2.1, CRF Table 5
5.A Solid waste disposal on land – CH₄ The ERT recommends that Austria review the assumptions regarding landfill gas collection for 2018 onward, taking into consideration, as appropriate, the results of the survey conducted among the landfill operators on the landfill gas recovered and utilized in 2023 and covering 2018–2022, to ensure its reporting is consistent with the 2006 IPCC Guidelines (vol. 5, chap. 3, p.3.19).	ARR 2023 W.4	The results of the most recent survey on landfill gas recovery and utilization (UMWELTBUNDESAMT 2023b) were considered in this years' submission.	Chapter 7.2.2.4
5.B.2 Anaerobic digestion at biogas facilities – CH₄ The ERT recommends that the Party report separately CH ₄ flared and CH ₄ recovered for MSW combustion. It also recommends that, if the Party cannot report these emissions separately and continues to report CH ₄ flared as "IE", including those emissions under the amount of CH ₄ for energy recovery, the Party provide an explanation in CRF table 9 and in the NIR to clarify where the CH ₄ flared is reported.	ARR 2023 W.5	An explanation on where 'CH ₄ flared' is included is now provided in the NIR as well as in CRF Table 9.	Chapter 7.3.2.2 (see footnote) CRF Table 9

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11 ABBREVIATIONS

General

AMA.....	Agrarmarkt Austria
AECM	Agri-environment-climate Measures
BAWP	Bundes-Abfallwirtschaftsplan Federal Waste Management Plan
BFW.....	Bundesamt und Forschungszentrum für Wald Austrian Federal Office and Research Centre for Forest
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 of Agriculture, Forestry, Environment and Water Management
BMLRT.....	Bundesministerium für Landwirtschaft, Regionen und Tourismus; Federal Ministry of Agriculture, Regions and Tourism (formerly BMNT)
BML.....	Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft. Federal Ministry of Agriculture, Forestry, Regions and Water Management (formerly BMLRT)
BMNT	Bundesministerium für Nachhaltigkeit und Tourismus; Federal Ministry for Sustainability and Tourism (formerly BMLFUW)
BMUJF	Bundesministerium für Umwelt, Jugend und Familie; Federal Ministry for Environment, Youth and Family (before 2000)
BMWA	Bundesministerium für Wirtschaft und Arbeit Federal Ministry for Economic Affairs and Labour (renamed as BMWFJ)
BMWFJ	Bundesministerium für Wirtschaft, Familie und Jugend Federal Ministry of Economy, Family and Youth (formerly BMWA)
BUWAL.....	Bundesamt für Umwelt, Wald und Landschaft, Bern The Swiss Agency for the Environment, Forests and Landscape (SAEFL), Bern
CAN	Calcium Ammonium Nitrate (Fertilizer)
COP	Conference of the Parties
CORINAIR	Core Inventory Air
CORINE	Coordination d'information Environmentale

CRF	Common Reporting Format
DKDB.....	Dampfkesseldatenbank Austrian annual steam boiler inventory
DOC.....	Degradable Organic Carbon
EC	European Community
EDM.....	Electronic Data Management
EEA	European Environment Agency
EF.....	Emission Factor
EFTA	European Free Trade Association
EIONET.....	European Environment Information and Observation NETwork
EMEP	Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe
EMREG	Electronic Emission Register of Surface Water Bodies
EN.....	European Norm
EPER.....	European Pollutant Emission Register
ETC/AE	European Topic Centre on Air Emissions
EU	European Union
ERT	Expert Review Team (in context of the UNFCCC review process)
EZG.....	Emissionszertifikategesetz
FAME.....	Fatty Acid Methyl Ester (Fettsäuremethylester, Biodiesel)
FAO	Food and Agricultural Organisation of the United Nations
GHG	Greenhouse Gas
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
GWP	Global Warming Potential
HDV	Heavy Duty Vehicle
IPCC.....	Intergovernmental Panel on Climate Change
ICR.....	In-Country Review (by the UNFCCC)
IEA	International Energy Agency

ISO.....	International Standards Organisation
LDV.....	Light Duty Vehicle
LTO.....	Landing/Take-Off cycle
LULUCF.....	Land Use, Land-Use Change and Forestry – IPCC-CRF Category 4
MMS.....	Manure Management System
NACE.....	Nomenclature des activites economiques de la Communaute Euro- peenne
NAPFUE.....	Nomenclature for Air Pollution Fuels
ND.....	Natural Disturbances
NEMO.....	Network Emission Model
NFI.....	National Forest Inventory
NFR.....	Nomenclature for Reporting (Format of Reporting under the UNECE/CLRTAP Convention)
NISA.....	National Inventory System Austria
NPK.....	Nitrogen (N) Phosphorus (P) and Potassium (K) (Fertilizer)
NRMM.....	Non-Road Mobile Machinery
OECD.....	Organisation for Economic Co-operation and Development
OLI.....	Österreichische Luftschadstoff Inventur / Austrian Air Emission Inventory
OMV.....	Österreichische Mineralölverwaltung / Austrian Mineraloil Company
PC.....	Passenger cars
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
SWDS.....	Solid Waste Disposal Sites
TERT.....	Technical Expert Review Team (under the EU Monitoring Mechanism)
UNECE/CLRTAP.....	United Nations Economic Commission for Europe, Convention on Long-range Transboundary Air Pollution
UNFCCC.....	United Nations Framework Convention on Climate Change

Notation Keys

According to the revised UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (FCCC/CP/2013/10/Add.32002/8, Decision 24/CP.19)

"NO" (not occurring)	for categories or processes, including recovery, under a particular source or sink category that do not occur within a Party;
"NE" (not estimated)	for AD and/or emissions by sources and removals by sinks of GHGs 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 or removals of CO ₂ , N ₂ O, CH ₄ , HFCs, PFCs, SF ₆ and NF ₃ the Party shall indicate in both the NIR and the CRF completeness table why emissions or removals have not been estimated. Furthermore the Party should provide justifications for exclusion in terms of the likely level of emissions
"NA" (not applicable)	for activities under a given source/sink category that do occur within the Party but do not result in emissions or removals of a specific gas. If the cells for categories in the CRF tables for which "NA" is applicable are shaded, they do not need to be filled in.
"IE" (included elsewhere)	for emissions by sources and removals by sinks of GHGs estimated but included elsewhere in the inventory instead of the expected source/sink category. Where "IE" is used in an inventory, the Annex I Party should indicate, in the CRF completeness table, where in the inventory the emissions or removals from the displaced source/sink category have been included, and the Annex I Party should explain such a deviation from the inclusion under the expected category, especially if it is due to confidentiality.
"C" (confidential)	for emissions by sources and removals by sinks of GHGs which the reporting could lead to the disclosure of confidential information, given the provisions of paragraph 27 of above

Chemical Symbols

Greenhouse gases

CH ₄	Methane
CO ₂	Carbon Dioxide
N ₂ O	Nitrous Oxide
HFCs	Hydrofluorocarbons
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
NM VOC.....	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 Kt
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

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AUSTRIA'S NATIONAL INVENTORY REPORT 2024 – ANNEX

Submission under Regulation (EU) No 2018/1999

ANNEX
REP-0909

VIENNA 2024

Since 23 December 2005 the Umweltbundesamt has been accredited as Inspection Body for emission inventories, Type A (ID No. 241), 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: 2006 IPCC GL for National Greenhouse Gas Inventories, 2006 GL Revised Supplementary KP and 2006 GL Supplement Wetlands (akkreditierung-austria.gv.at/overview)



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ANNEX 1: KEY CATEGORIES

Annex 1.1 – Description of methodology for identification of key categories

The method used to identify key source categories follows the Approach 1 method – quantitative approach described in the IPCC 2006 GL (Volume 1), Chapter 4 *Methodological Choice and Identification of Key Categories*. In addition, the Approach 2 method was applied.

The analysis includes all greenhouse gases reported under the UNFCCC: CO₂, CH₄, N₂O, HFC, PFC, SF₆ and NF₃. All IPCC categories are included.

Key categories were first identified for the inventory excluding LULUCF and then the key category analysis was repeated for the full inventory including LULUCF categories.

The identification of key categories consists of six steps:

- Identifying categories
- Level Assessment excluding LULUCF (Approach 1 and Approach 2)
- Trend Assessment excluding LULUCF (Approach 1 and Approach 2)
- Level Assessment including LULUCF (Approach 1 and Approach 2)
- Trend Assessment including LULUCF (Approach 1 and Approach 2)
- Qualitative considerations

Annex 1.2 – Information on the level of disaggregation

Level of disaggregation and identification of key categories

To identify key categories total emissions were split into those categories that have been estimated using the same methodology and the same emission factor. Table A 17 presents the 313 source/sink categories (incl. LULUCF) considered in the Austrian key category analysis, and their greenhouse gas emissions expressed in CO₂ equivalent emissions for the years 1990 to 2022.

Further details and a list of the source/sink categories and key categories for each sector are given in the corresponding subchapters 3 *Energy* – 8 *Waste* in the NIR.

Level Assessment excluding LULUCF

For the Level Assessment the contribution of GHG emissions (expressed in CO₂ equivalent emissions) of each category to national total emissions was calculated. The calculation was performed for the years 1990 and 2022 according to Equation 4.1 of the IPCC 2006 GL. Then the sources were ranked in descending order of magnitude according to the results of the level assessment and finally a cumulative total was calculated.

For the year 2022 42 source categories comprised > 95% of the cumulative total and were thus rated as key categories. For the year 1990 49 source categories were identified as key categories in

the level assessment (Approach 1). The result of each level assessment is presented in Tables A 1 and A 2.

Trend Assessment excluding LULUCF

The Trend Assessment identifies source categories that have a different trend from the trend of the overall inventory. As differences in trends are more significant at the overall inventory level for larger source categories, the result of the trend difference (i.e. the source category trend minus total trend) is weighted according to the sources' level assessment.

For the Trend Assessment, emissions of the year 2022 were compared with 1990.

The calculation was performed according to Equation 4.2 of the IPCC 2006 GL. For sources with zero current year emissions Equation 4.3 of the IPCC 2006 GL was used to calculate the trend. The results were ranked in descending order of magnitude and a cumulative total was calculated. Those sources that make up > 95% of the total trend were rated key categories. 48 sources were identified as key categories in the trend assessment according to Approach 1. Results are presented in Table A 3.

Level Assessment including LULUCF

The level assessment was repeated for the full inventory including the LULUCF categories for the years 1990 and 2022 according to Equation 5.4.1 of the GPG-LULUCF. The result of each level assessment is presented in Tables A 4 and A 5.

Trend Assessment including LULUCF

Also the trend assessment was repeated for the full inventory including the LULUCF categories for the years 1990 and 2022 according to Equation 5.4.2 of the GPG-LULUCF (Equation 5.4.3 for zero current year emissions). The result of the trend assessment Approach 1 is presented in Table A 6.

Qualitative criteria

Qualitative criteria considered were:

- categories that are close to the 95% criteria, but are not included in all years, e.g. due to fluctuating emissions/removals
- mitigation techniques,
- high expected growth of emissions/removals
- unexpected low or high emissions/removals.

No additional key source categories were identified applying these qualitative criteria.

Identification of key categories

Any category meeting the 95% (Approach 1) respectively 90% (Approach 2) threshold in any year of the Level Assessment or in the Trend Assessment and meeting the qualitative criteria as described above is considered a key category. The key categories are presented in descending order of magnitude of contribution to total national GHG emissions.

Consequences of key category selection

Whenever a method used for the estimation of emissions/removals of a key category is not consistent with the requirements of the IPCC 2006 Guidelines, the method will have to be improved

in order to reduce uncertainty, which is considered in the emission inventory improvement programme.

Annex 1.3 – Results of the Key Category Analysis

Results are presented for the level assessments for the years 1990 and 2022, and for the trend assessment 1990-2022, both for the key category analysis excluding and including LULUCF. Furthermore, key categories identified including their ranking in the level and trend assessments and emission sources and removal sinks in the level of aggregation as used for the key category analysis together with emissions/removals from 1990 to 2022 for these categories are included.

Table A 1: Approach 1 – Level Assessment of the KCA excluding LULUCF for 1990.

IPCC Category Code	IPCC Category	GHG	Year 1990 Estimate $E_{x,t}$ [t CO ₂ -e units]	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 3 b gasoline	Road Transportation	CO ₂	7 896	10.0%	10.0%
2 C 1	Iron and Steel Production	CO ₂	6 840	8.6%	18.6%
1 A 1 a solid	Public Electricity and Heat Production	CO ₂	6 247	7.9%	26.5%
1 A 4 b liquid	Residential	CO ₂	5 633	7.1%	33.7%
1 A 3 b diesel oil	Road Transportation	CO ₂	5 358	6.8%	40.4%
3 A 1	Cattle	CH ₄	4 854	6.1%	46.6%
5 A	Solid Waste Disposal	CH ₄	4 081	5.2%	51.7%
1 A 1 a gaseous	Public Electricity and Heat Production	CO ₂	3 294	4.2%	55.9%
1 A 4 b solid	Residential	CO ₂	2 511	3.2%	59.1%
2 A 1	Cement Production	CO ₂	2 033	2.6%	61.6%
1 A 1 b liquid	Petroleum Refining	CO ₂	1 958	2.5%	64.1%
1 A 4 b gaseous	Residential	CO ₂	1 856	2.3%	66.5%
3 D 1	Direct N ₂ O Emissions from Managed Soils	N ₂ O	1 776	2.2%	68.7%
1 A 4 a liquid	Commercial/Institutional	CO ₂	1 420	1.8%	70.5%
1 A 1 a liquid	Public Electricity and Heat Production	CO ₂	1 229	1.6%	72.1%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO ₂	1 180	1.5%	73.6%
1 A 2 a solid	Iron and Steel	CO ₂	1 107	1.4%	74.9%
2 C 3	Aluminium Production	PFC	1 032	1.3%	76.3%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO ₂	1 014	1.3%	77.5%
1 A 2 d gaseous	Pulp, Paper and Print	CO ₂	943	1.2%	78.7%
1 A 2 d liquid	Pulp, Paper and Print	CO ₂	853	1.1%	79.8%
2 B 2	Nitric Acid Production	N ₂ O	780	1.0%	80.8%
1 A 4 a gaseous	Commercial/Institutional	CO ₂	698	0.9%	81.7%
1 A 2 a gaseous	Iron and Steel	CO ₂	650	0.8%	82.5%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO ₂	610	0.8%	83.3%
1 A 2 f gaseous	Non-Metallic Minerals	CO ₂	559	0.7%	84.0%
1 A 2 f solid	Non-Metallic Minerals	CO ₂	535	0.7%	84.7%
1 A 2 c gaseous	Chemicals	CO ₂	519	0.7%	85.3%
1 A 2 f liquid	Non-Metallic Minerals	CO ₂	508	0.6%	86.0%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO ₂	507	0.6%	86.6%
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO ₂	506	0.6%	87.2%
2 A 4 c	Non-metallurgical Magnesium	CO ₂	481	0.6%	87.8%
3 B 1 1	Cattle	CH ₄	467	0.6%	88.4%

IPCC Category Code	IPCC Category	GHG	Year 1990 Estimate Ex,t [t CO ₂ -e units]	Level Assessment L _{x,t}	Cumulative Total of L _{x,t}
2 B 1	Ammonia Production	CO ₂	467	0.6%	89.0%
2 A 2	Lime Production	CO ₂	456	0.6%	89.6%
1 A 1 b gaseous	Petroleum Refining	CO ₂	437	0.6%	90.2%
1 A 2 d solid	Pulp, Paper and Print	CO ₂	398	0.5%	90.7%
1 B 1 a	Coal Mining and Handling	CH ₄	373	0.5%	91.1%
3 D 2	Indirect N ₂ O emissions from Managed Soils	N ₂ O	357	0.5%	91.6%
2 D	Non-Energy Products from Fuels and Solvent Use	CO ₂	349	0.4%	92.0%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO ₂	345	0.4%	92.5%
3 B 1 1	Cattle	N ₂ O	294	0.4%	92.8%
1 B 2 b	Natural Gas	CH ₄	290	0.4%	93.2%
1 A 1 a other	Public Electricity and Heat Production	CO ₂	286	0.4%	93.6%
1 A 4 b biomass	Residential	CH ₄	264	0.3%	93.9%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO ₂	256	0.3%	94.2%
2 C 4	Magnesium Production – Mg Foundries	SF ₆	235	0.3%	94.5%
1 A 3 e gaseous	Other Transportation	CO ₂	224	0.3%	94.8%
1 A 4 b solid	Residential	CH ₄	224	0.3%	95.1%

Table A 2: Approach 1 – Level Assessment of the KCA excluding LULUCF for 2022

IPCC Category Code	IPCC Category	GHG	Year 2022 Estimate Ex,t [t CO ₂ -e units]	Level Assessment L _{x,t}	Cumulative Total of L _{x,t}
1 A 3 b diesel oil	Road Transportation	CO ₂	15 639	21.5%	21.5%
2 C 1	Iron and Steel Production	CO ₂	10 280	14.1%	35.6%
1 A 1 a gaseous	Public Electricity and Heat Production	CO ₂	4 500	6.2%	41.8%
1 A 3 b gasoline	Road Transportation	CO ₂	4 389	6.0%	47.8%
3 A 1	Cattle	CH ₄	4 035	5.5%	53.3%
1 A 4 b gaseous	Residential	CO ₂	3 032	4.2%	57.5%
1 A 4 b liquid	Residential	CO ₂	2 791	3.8%	61.3%
1 A 1 b liquid	Petroleum Refining	CO ₂	1 955	2.7%	64.0%
2 A 1	Cement Production	CO ₂	1 832	2.5%	66.5%
3 D 1	Direct N ₂ O Emissions from Managed Soils	N ₂ O	1 455	2.0%	68.5%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO ₂	1 453	2.0%	70.5%
1 A 2 d gaseous	Pulp, Paper and Print	CO ₂	1 372	1.9%	72.4%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 355	1.9%	74.2%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO ₂	1 272	1.7%	76.0%
1 A 2 a gaseous	Iron and Steel	CO ₂	1 049	1.4%	77.4%
1 A 1 a other	Public Electricity and Heat Production	CO ₂	1 028	1.4%	78.8%
1 A 2 c gaseous	Chemicals	CO ₂	991	1.4%	80.2%
5 A	Solid Waste Disposal	CH ₄	846	1.2%	81.4%
1 A 2 a solid	Iron and Steel	CO ₂	843	1.2%	82.5%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO ₂	800	1.1%	83.6%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO ₂	776	1.1%	84.7%
1 A 4 a gaseous	Commercial/Institutional	CO ₂	718	1.0%	85.7%
2 A 2	Lime Production	CO ₂	624	0.9%	86.5%
1 A 2 f other	Non-Metallic Minerals	CO ₂	616	0.8%	87.4%
1 A 2 f gaseous	Non-Metallic Minerals	CO ₂	593	0.8%	88.2%
3 B 1 1	Cattle	CH ₄	522	0.7%	88.9%
1 A 4 a liquid	Commercial/Institutional	CO ₂	495	0.7%	89.6%
2 B 1	Ammonia Production	CO ₂	418	0.6%	90.2%

IPCC Category Code	IPCC Category	GHG	Year 2022 Estimate Ex,t [t CO ₂ -e units]	Level Assessment L _{x,t}	Cumulative Total of L _{x,t}
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO ₂	344	0.5%	90.6%
2 A 4 c	Non-metallurgical Magnesium	CO ₂	317	0.4%	91.1%
1 A 2 c other	Chemicals	CO ₂	308	0.4%	91.5%
2 G 2	Other product manufacture and use - SF ₆ and PFCs from other product use	SF ₆	301	0.4%	91.9%
1 A 1 b gaseous	Petroleum Refining	CO ₂	300	0.4%	92.3%
3 D 2	Indirect N ₂ O emissions from Managed Soils	N ₂ O	288	0.4%	92.7%
3 B 1 1	Cattle	N ₂ O	281	0.4%	93.1%
1 A 2 b gaseous	Non-Ferrous Metals	CO ₂	279	0.4%	93.5%
1 A 1 a liquid	Public Electricity and Heat Production	CO ₂	236	0.3%	93.8%
1 B 2 b	Natural Gas	CH ₄	225	0.3%	94.1%
1 A 2 f solid	Non-Metallic Minerals	CO ₂	209	0.3%	94.4%
1 A 4 b biomass	Residential	CH ₄	200	0.3%	94.7%
1 A 3 b diesel oil	Road Transportation	N ₂ O	190	0.3%	94.9%
2 D	Non-Energy Products from Fuels and Solvent Use	CO ₂	172	0.2%	95.2%

Table A 3: Approach 1 – Trend Assessment of the KCA excluding LULUCF for the trend 1990–2022.

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate Ex,t	Trend Assessment T _{x,t}	% Contributi on to Trend	Cumulative Total of L _{x,t}
1 A 3 b diesel oil	Road Transportation	CO ₂	5 358	15 639	0.135	24.0%	24.0%
2 C 1	Iron and Steel Production	CO ₂	6 840	10 280	0.050	8.9%	33.0%
5 A	Solid Waste Disposal	CH ₄	4 081	846	0.037	6.5%	39.5%
1 A 3 b gasoline	Road Transportation	CO ₂	7 896	4 389	0.036	6.5%	46.0%
1 A 4 b liquid	Residential	CO ₂	5 633	2 791	0.030	5.4%	51.4%
1 A 4 b solid	Residential	CO ₂	2 511	34	0.029	5.1%	56.5%
1 A 1 a gaseous	Public Electricity and Heat Production	CO ₂	3 294	4 500	0.019	3.3%	59.8%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	0	1 355	0.017	3.0%	62.8%
1 A 4 b gaseous	Residential	CO ₂	1 856	3 032	0.017	3.0%	65.8%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO ₂	256	1 453	0.015	2.7%	68.5%
1 A 1 a liquid	Public Electricity and Heat Production	CO ₂	1 229	236	0.011	2.0%	70.6%
1 A 4 a liquid	Commercial/Institutional	CO ₂	1 420	495	0.010	1.8%	72.4%
1 A 1 a other	Public Electricity and Heat Production	CO ₂	286	1 028	0.010	1.7%	74.1%
1 A 2 d liquid	Pulp, Paper and Print	CO ₂	853	24	0.010	1.7%	75.8%
2 B 2	Nitric Acid Production	N ₂ O	780	23	0.009	1.6%	77.4%
1 A 2 f other	Non-Metallic Minerals	CO ₂	67	616	0.007	1.2%	78.6%
1 A 2 c gaseous	Chemicals	CO ₂	519	991	0.006	1.2%	79.8%
1 A 2 d gaseous	Pulp, Paper and Print	CO ₂	943	1 372	0.006	1.1%	80.9%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO ₂	610	107	0.006	1.0%	81.9%
1 A 2 a gaseous	Iron and Steel	CO ₂	650	1 049	0.006	1.0%	82.9%
3 A 1	Cattle	CH ₄	4 854	4 035	0.006	1.0%	83.9%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO ₂	1 014	1 272	0.004	0.8%	84.7%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO ₂	507	776	0.004	0.7%	85.4%
1 A 2 f liquid	Non-Metallic Minerals	CO ₂	508	160	0.004	0.7%	86.0%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO ₂	1 180	800	0.004	0.6%	86.7%
1 A 2 f solid	Non-Metallic Minerals	CO ₂	535	209	0.004	0.6%	87.3%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO ₂	345	73	0.003	0.6%	87.9%
1 A 2 d solid	Pulp, Paper and Print	CO ₂	398	130	0.003	0.5%	88.4%

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}	Trend Assessment T _{x,t}	% Contribution to Trend	Cumulative Total of L _{x,t}
2 C 4	Magnesium Production – Mg Foundries	SF6	235	2	0.003	0.5%	88.9%
1 A 2 b gaseous	Non-Ferrous Metals	CO2	75	279	0.003	0.5%	89.4%
2 A 2	Lime Production	CO2	456	624	0.003	0.5%	89.8%
1 A 4 b solid	Residential	CH4	224	3	0.003	0.5%	90.3%
1 A 2 c other	Chemicals	CO2	125	308	0.002	0.4%	90.7%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6	124	301	0.002	0.4%	91.1%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 776	1 455	0.002	0.4%	91.5%
1 A 3 b diesel oil	Road Transportation	N2O	11	190	0.002	0.4%	91.9%
1 A 2 a solid	Iron and Steel	CO2	1 107	843	0.002	0.4%	92.3%
1 A 1 b liquid	Petroleum Refining	CO2	1 958	1 955	0.002	0.3%	92.7%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	349	172	0.002	0.3%	93.0%
2 C 3	Aluminium Production	CO2	150	5	0.002	0.3%	93.3%
2 A 4 c	Non-metallurgical Magnesium	CO2	481	317	0.002	0.3%	93.6%
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO2	506	344	0.002	0.3%	93.9%
5 D	Waste Water Treatment and Discharge	CH4	137	24	0.001	0.2%	94.1%
1 A 1 b gaseous	Petroleum Refining	CO2	437	300	0.001	0.2%	94.3%
3 B 1 1	Cattle	CH4	467	522	0.001	0.2%	94.5%
1 A 2 g 8 solid	Other Manufacturing Industries	CO2	91	2	0.001	0.2%	94.7%
2 E	Electronics Industry	SF6	100	13	0.001	0.2%	94.9%

Table A 4: Approach 1 – Level Assessment of the KCA including LULUCF for 1990.

IPCC Category Code	IPCC Category	GHG	Year 1990 Estimate E _{x,t} [t CO ₂ -e units]	Absolute Value of Year 1990 Estimate E _{x,t}	Level Assessment L _{x,t}	Cumulative Total of L _{x,t}
4A1	Forest land remaining forest land	CO2	-8 122	8 122	8.5%	8.5%
1 A 3 b gasoline	Road Transportation	CO2	7 896	7 896	8.2%	16.7%
2 C 1	Iron and Steel Production	CO2	6 840	6 840	7.1%	23.9%
1 A 1 a solid	Public Electricity and Heat Production	CO2	6 247	6 247	6.5%	30.4%
1 A 4 b liquid	Residential	CO2	5 633	5 633	5.9%	36.2%
1 A 3 b diesel oil	Road Transportation	CO2	5 358	5 358	5.6%	41.8%
3 A 1	Cattle	CH4	4 854	4 854	5.1%	46.9%
5 A	Solid Waste Disposal	CH4	4 081	4 081	4.3%	51.2%
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	3 294	3 294	3.4%	54.6%
4G	HWP	CO2	-3 122	3 122	3.3%	57.9%
4A2	Land converted to forest land	CO2	-2 955	2 955	3.1%	60.9%
1 A 4 b solid	Residential	CO2	2 511	2 511	2.6%	63.6%
2 A 1	Cement Production	CO2	2 033	2 033	2.1%	65.7%
1 A 1 b liquid	Petroleum Refining	CO2	1 958	1 958	2.0%	67.7%
1 A 4 b gaseous	Residential	CO2	1 856	1 856	1.9%	69.7%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 776	1 776	1.9%	71.5%
1 A 4 a liquid	Commercial/Institutional	CO2	1 420	1 420	1.5%	73.0%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	1 229	1 229	1.3%	74.3%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO2	1 180	1 180	1.2%	75.5%
1 A 2 a solid	Iron and Steel	CO2	1 107	1 107	1.2%	76.7%
2 C 3	Aluminium Production	PFC	1 032	1 032	1.1%	77.7%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1 014	1 014	1.1%	78.8%

IPCC Category Code	IPCC Category	GHG	Year 1990 Estimate $E_{x,t}$ [t CO ₂ -e units]	Absolute Value of Year 1990 Estimate $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 2 d gaseous	Pulp, Paper and Print	CO ₂	943	943	1.0%	79.8%
4 E 2	Land converted to Settlements	CO ₂	917	917	1.0%	80.7%
1 A 2 d liquid	Pulp, Paper and Print	CO ₂	853	853	0.9%	81.6%
2 B 2	Nitric Acid Production	N ₂ O	780	780	0.8%	82.4%
1 A 4 a gaseous	Commercial/Institutional	CO ₂	698	698	0.7%	83.2%
1 A 2 a gaseous	Iron and Steel	CO ₂	650	650	0.7%	83.8%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO ₂	610	610	0.6%	84.5%
1 A 2 f gaseous	Non-Metallic Minerals	CO ₂	559	559	0.6%	85.1%
1 A 2 f solid	Non-Metallic Minerals	CO ₂	535	535	0.6%	85.6%
1 A 2 c gaseous	Chemicals	CO ₂	519	519	0.5%	86.2%
1 A 2 f liquid	Non-Metallic Minerals	CO ₂	508	508	0.5%	86.7%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO ₂	507	507	0.5%	87.2%
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO ₂	506	506	0.5%	87.8%
4 F 2	Land converted to Other land	CO ₂	502	502	0.5%	88.3%
2 A 4 c	Non-metallurgical Magnesium	CO ₂	481	481	0.5%	88.8%
3 B 1 1	Cattle	CH ₄	467	467	0.5%	89.3%
2 B 1	Ammonia Production	CO ₂	467	467	0.5%	89.8%
2 A 2	Lime Production	CO ₂	456	456	0.5%	90.2%
1 A 1 b gaseous	Petroleum Refining	CO ₂	437	437	0.5%	90.7%
1 A 2 d solid	Pulp, Paper and Print	CO ₂	398	398	0.4%	91.1%
4 C 2	Land converted to grassland	CO ₂	393	393	0.4%	91.5%
1 B 1 a	Coal Mining and Handling	CH ₄	373	373	0.4%	91.9%
3 D 2	Indirect N ₂ O emissions from Managed Soils	N ₂ O	357	357	0.4%	92.3%
2 D	Non-Energy Products from Fuels and Solvent Use	CO ₂	349	349	0.4%	92.6%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO ₂	345	345	0.4%	93.0%
4 C 1	Grassland remaining grassland	CO ₂	304	304	0.3%	93.3%
3 B 1 1	Cattle	N ₂ O	294	294	0.3%	93.6%
1 B 2 b	Natural Gas	CH ₄	290	290	0.3%	93.9%
1 A 1 a other	Public Electricity and Heat Production	CO ₂	286	286	0.3%	94.2%
1 A 4 b biomass	Residential	CH ₄	264	264	0.3%	94.5%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO ₂	256	256	0.3%	94.8%
2 C 4	Magnesium Production – Mg Foundries	SF ₆	235	235	0.2%	95.0%

Table A 5: Approach 1 – Level Assessment of the KCA including LULUCF for 2022.

IPCC Category Code	IPCC Category	GHG	Year 2022 Estimate $E_{x,t}$ [t CO ₂ -e units]	Absolute Value of Year 2022 Estimate $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 3 b diesel oil	Road Transportation	CO ₂	15 639	15 639	19.1%	19.1%
2 C 1	Iron and Steel Production	CO ₂	10 280	10 280	12.6%	31.7%
1 A 1 a gaseous	Public Electricity and Heat Production	CO ₂	4 500	4 500	5.5%	37.2%
1 A 3 b gasoline	Road Transportation	CO ₂	4 389	4 389	5.4%	42.5%
3 A 1	Cattle	CH ₄	4 035	4 035	4.9%	47.5%
4 A 1	Forest land remaining forest land	CO ₂	-3 192	3 192	3.9%	51.4%
1 A 4 b gaseous	Residential	CO ₂	3 032	3 032	3.7%	55.1%
1 A 4 b liquid	Residential	CO ₂	2 791	2 791	3.4%	58.5%
4 G	HWP	CO ₂	-2 110	2 110	2.6%	61.1%
1 A 1 b liquid	Petroleum Refining	CO ₂	1 955	1 955	2.4%	63.5%

IPCC Category Code	IPCC Category	GHG	Year 2022 Estimate Ex,t [t CO ₂ -e units]	Absolute Value of Year 2022 Estimate Ex,t	Level Assessment L _{x,t}	Cumulative Total of L _{x,t}
2 A 1	Cement Production	CO ₂	1 832	1 832	2.2%	65.7%
3 D 1	Direct N ₂ O Emissions from Managed Soils	N ₂ O	1 455	1 455	1.8%	67.5%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO ₂	1 453	1 453	1.8%	69.3%
4 A 2	Land converted to forest land	CO ₂	-1 420	1 420	1.7%	71.0%
1 A 2 d gaseous	Pulp, Paper and Print	CO ₂	1 372	1 372	1.7%	72.7%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 355	1 355	1.7%	74.3%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO ₂	1 272	1 272	1.6%	75.9%
1 A 2 a gaseous	Iron and Steel	CO ₂	1 049	1 049	1.3%	77.2%
1 A 1 a other	Public Electricity and Heat Production	CO ₂	1 028	1 028	1.3%	78.4%
1 A 2 c gaseous	Chemicals	CO ₂	991	991	1.2%	79.6%
5 A	Solid Waste Disposal	CH ₄	846	846	1.0%	80.7%
1 A 2 a solid	Iron and Steel	CO ₂	843	843	1.0%	81.7%
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO ₂	800	800	1.0%	82.7%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO ₂	776	776	0.9%	83.6%
4 E 2	Land converted to Settlements	CO ₂	746	746	0.9%	84.5%
1 A 4 a gaseous	Commercial/Institutional	CO ₂	718	718	0.9%	85.4%
2 A 2	Lime Production	CO ₂	624	624	0.8%	86.2%
1 A 2 f other	Non-Metallic Minerals	CO ₂	616	616	0.8%	86.9%
1 A 2 f gaseous	Non-Metallic Minerals	CO ₂	593	593	0.7%	87.6%
3 B 1 1	Cattle	CH ₄	522	522	0.6%	88.3%
4 F 2	Land converted to Other land	CO ₂	517	517	0.6%	88.9%
1 A 4 a liquid	Commercial/Institutional	CO ₂	495	495	0.6%	89.5%
2 B 1	Ammonia Production	CO ₂	418	418	0.5%	90.0%
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO ₂	344	344	0.4%	90.5%
2 A 4 c	Non-metallurgical Magnesium	CO ₂	317	317	0.4%	90.8%
1 A 2 c other	Chemicals	CO ₂	308	308	0.4%	91.2%
4 C 1	Grassland remaining grassland	CO ₂	304	304	0.4%	91.6%
2 G 2	Other product manufacture and use - SF ₆ and PFCs from other product use	SF ₆	301	301	0.4%	92.0%
1 A 1 b gaseous	Petroleum Refining	CO ₂	300	300	0.4%	92.3%
3 D 2	Indirect N ₂ O emissions from Managed Soils	N ₂ O	288	288	0.4%	92.7%
3 B 1 1	Cattle	N ₂ O	281	281	0.3%	93.0%
1 A 2 b gaseous	Non-Ferrous Metals	CO ₂	279	279	0.3%	93.4%
1 A 1 a liquid	Public Electricity and Heat Production	CO ₂	236	236	0.3%	93.7%
4 B 2	Land converted to cropland	CO ₂	233	233	0.3%	93.9%
1 B 2 b	Natural Gas	CH ₄	225	225	0.3%	94.2%
1 A 2 f solid	Non-Metallic Minerals	CO ₂	209	209	0.3%	94.5%
1 A 4 b biomass	Residential	CH ₄	200	200	0.2%	94.7%
1 A 3 b diesel oil	Road Transportation	N ₂ O	190	190	0.2%	94.9%
2 D	Non-Energy Products from Fuels and Solvent Use	CO ₂	172	172	0.2%	95.2%

Table A 6: Approach 1 – Trend Assessment of the KCA including LULUCF for the trend 1990–2022.

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate Ex,t	Trend Assessment T _{x,t}	% Contribution to Trend	Cumulative Total of L _{x,t}
1 A 3 b diesel oil	Road Transportation	CO ₂	5 358	15 639	0.119	23.5%	23.5%
2 C 1	Iron and Steel Production	CO ₂	6 840	10 280	0.051	10.0%	33.5%

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}	Trend Assessment T _{x,t}	% Contribution to Trend	Cumulative Total of L _{x,t}
4A1	Forest land remaining forest land	CO2	8 122	3 192	0.034	6.7%	40.2%
5 A	Solid Waste Disposal	CH4	4 081	846	0.025	4.9%	45.1%
1 A 4 b solid	Residential	CO2	2 511	34	0.020	4.0%	49.1%
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	3 294	4 500	0.020	3.9%	53.0%
1 A 3 b gasoline	Road Transportation	CO2	7 896	4 389	0.019	3.8%	56.9%
1 A 4 b liquid	Residential	CO2	5 633	2 791	0.017	3.4%	60.3%
1 A 4 b gaseous	Residential	CO2	1 856	3 032	0.016	3.2%	63.5%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	0	1 355	0.014	2.8%	66.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	256	1 453	0.013	2.6%	68.9%
4 A 2	Land converted to forest land	CO2	2 955	1 420	0.010	1.9%	70.8%
1 A 1 a other	Public Electricity and Heat Production	CO2	286	1 028	0.008	1.7%	72.5%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	1 229	236	0.008	1.5%	74.0%
1 A 2 d liquid	Pulp, Paper and Print	CO2	853	24	0.007	1.3%	75.3%
1 A 4 a liquid	Commercial/Institutional	CO2	1 420	495	0.007	1.3%	76.6%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	943	1 372	0.007	1.3%	77.9%
2 B 2	Nitric Acid Production	N2O	780	23	0.006	1.2%	79.1%
1 A 2 c gaseous	Chemicals	CO2	519	991	0.006	1.2%	80.3%
1 A 2 f other	Non-Metallic Minerals	CO2	67	616	0.006	1.2%	81.5%
1 A 2 a gaseous	Iron and Steel	CO2	650	1 049	0.006	1.1%	82.6%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1 014	1 272	0.005	1.0%	83.6%
1 A 1 b liquid	Petroleum Refining	CO2	1 958	1 955	0.004	0.8%	84.4%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	610	107	0.004	0.8%	85.2%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	507	776	0.004	0.8%	85.9%
4 G	HWP	CO2	3 122	2 110	0.004	0.7%	86.7%
2 A 2	Lime Production	CO2	456	624	0.003	0.5%	87.2%
1 A 2 f liquid	Non-Metallic Minerals	CO2	508	160	0.003	0.5%	87.7%
2 A 1	Cement Production	CO2	2 033	1 832	0.002	0.5%	88.2%
1 A 2 b gaseous	Non-Ferrous Metals	CO2	75	279	0.002	0.5%	88.6%
1 A 2 f solid	Non-Metallic Minerals	CO2	535	209	0.002	0.4%	89.1%
1 A 2 c other	Chemicals	CO2	125	308	0.002	0.4%	89.5%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6	124	301	0.002	0.4%	89.9%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	345	73	0.002	0.4%	90.3%
3 A 1	Cattle	CH4	4 854	4 035	0.002	0.4%	90.7%
1 A 2 d solid	Pulp, Paper and Print	CO2	398	130	0.002	0.4%	91.1%
2 C 4	Magnesium Production – Mg Foundries	SF6	235	2	0.002	0.4%	91.5%

Table A 7: Approach 1 – Key categories identified including their ranking in the level and trend assessment for the KCA excluding LULUCF.

IPCC Category Code	IPCC Category	GHG	Approach 1			Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}	Share Latest Year (2022)
			Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022			
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	8	3	7	3 294	4 500	6.2%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	15	37	11	1 229	236	0.3%

		Approach 1		Approach 1		Approach 1			
IPCC Category Code	IPCC Category	GHG	Level Assessment	Level Assessment	Trend Assessment	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}	Share Latest Year (2022)	
			1990	2022	1990-2022				
1 A 1 a other	Public Electricity and Heat Production	CO2	44	16	13	286	1 028	1.4%	
1 A 1 a solid	Public Electricity and Heat Production	CO2	3			6 247	NO		
1 A 1 b gaseous	Petroleum refining	CO2	36	33	44	437	300	0.4%	
1 A 1 b liquid	Petroleum refining	CO2	11	8	38	1 958	1 955	2.7%	
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO2	31	29	42	506	344	0.5%	
1 A 2 a gaseous	Iron and Steel	CO2	24	15	20	650	1 049	1.4%	
1 A 2 a solid	Iron and Steel	CO2	17	19	37	1 107	843	1.2%	
1 A 2 b gaseous	Non-ferrous Metals	CO2		36	30	75	279	0.4%	
1 A 2 c gaseous	Chemicals	CO2	28	17	17	519	991	1.4%	
1 A 2 c other	Chemicals	CO2		31	33	125	308	0.4%	
1 A 2 d gaseous	Pulp, Paper and Print	CO2	20	12	18	943	1 372	1.9%	
1 A 2 d liquid	Pulp, Paper and Print	CO2	21		14	853	24	0.0%	
1 A 2 d solid	Pulp, Paper and Print	CO2	37		28	398	130	0.2%	
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	30	21	23	507	776	1.1%	
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	41		27	345	73	0.1%	
1 A 2 f gaseous	Non-Metallic Minerals	CO2	26	25	48	559	593	0.8%	
1 A 2 f liquid	Non-Metallic Minerals	CO2	29		24	508	160	0.2%	
1 A 2 f other	Non-Metallic Minerals	CO2		24	16	67	616	0.8%	
1 A 2 f solid	Non-Metallic Minerals	CO2	27	39	26	535	209	0.3%	
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	46	11	10	256	1 453	2.0%	
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	19	14	22	1 014	1 272	1.7%	
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	25		19	610	107	0.1%	
1 A 2 g 8 solid	Other Manufacturing Industries	CO2			46	91	2	0.0%	
1 A 3 b diesel oil	Road Transportation	CO2	5	1	1	5 358	15 639	21.5%	
1 A 3 b diesel oil	Road Transportation	N2O		41	36	11	190	0.3%	
1 A 3 b gasoline	Road Transportation	CO2	1	4	4	7 896	4 389	6.0%	
1 A 3 e gaseous	Other Transportation	CO2	48			224	152	0.2%	
1 A 4 a gaseous	Commercial/Institutional	CO2	23	22		698	718	1.0%	
1 A 4 a liquid	Commercial/Institutional	CO2	14	27	12	1 420	495	0.7%	
1 A 4 b biomass	Residential	CH4	45	40		264	200	0.3%	
1 A 4 b gaseous	Residential	CO2	12	6	9	1 856	3 032	4.2%	
1 A 4 b liquid	Residential	CO2	4	7	5	5 633	2 791	3.8%	
1 A 4 b solid	Residential	CO2	9		6	2 511	34	0.0%	
1 A 4 b solid	Residential	CH4	49		32	224	3	0.0%	
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO2	16	20	25	1 180	800	1.1%	
1 B 1 a	Coal Mining and Handling	CH4	38			373	NA		
1 B 2 b	Natural Gas	CH4	43	38		290	225	0.3%	
2 A 1	Cement Production	CO2	10	9		2 033	1 832	2.5%	
2 A 2	Lime Production	CO2	35	23	31	456	624	0.9%	
2 A 4 c	Non-metallurgical Magnesium	CO2	32	30	41	481	317	0.4%	
2 B 1	Ammonia Production	CO2	34	28		467	418	0.6%	
2 B 2	Nitric Acid Production	N2O	22		15	780	23	0.0%	
2 C 1	Iron and Steel Production	CO2	2	2	2	6 840	10 280	14.1%	
2 C 3	Aluminium Production	PFC	18			1 032	0	0.0%	
2 C 3	Aluminium Production	CO2			40	150	5	0.0%	
2 C 4	SF6 used in Mg Foundries	SF6	47		29	235	2	0.0%	
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	40	42	39	349	172	0.2%	

IPCC Category Code	IPCC Category	GHG	Approach 1			Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}	Share Latest Year (2022)
			Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022			
2 E	Electronics Industry	SF6			47	100	13	0.0%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		13	8	0	1 355	1.9%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6		32	34	124	301	0.4%
3 A 1	Cattle	CH4	6	5	21	4 854	4 035	5.5%
3 B 1 1	Cattle	CH4	33	26	45	467	522	0.7%
3 B 1 1	Cattle	N2O	42	35		294	281	0.4%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	13	10	35	1 776	1 455	2.0%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	39	34		357	288	0.4%
5 A	Solid Waste Disposal	CH4	7	18	3	4 081	846	1.2%
5 D	Waste Water Treatment and Discharge	CH4			43	137	24	0.0%

Table A 8: Approach 1 – Key categories identified including their ranking in the level and trend assessment for the KCA including LULUCF.

IPCC Category Code	IPCC Category	GHG	Approach 1			Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}
			Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022		
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	9	3	6	3 294	4 500
1 A 1 a liquid	Public Electricity and Heat Production	CO2	18	43	14	1 229	236
1 A 1 a other	Public Electricity and Heat Production	CO2	51	19	13	286	1 028
1 A 1 a solid	Public Electricity and Heat Production	CO2	4			6 247	NO
1 A 1 b gaseous	Petroleum Refining	CO2	41	39		437	300
1 A 1 b liquid	Petroleum Refining	CO2	14	10	23	1 958	1 955
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO2	35	34		506	344
1 A 2 a gaseous	Iron and Steel	CO2	28	18	21	650	1 049
1 A 2 a solid	Iron and Steel	CO2	20	22		1 107	843
1 A 2 b gaseous	Non-Ferrous Metals	CO2		42	30	75	279
1 A 2 c gaseous	Chemicals	CO2	32	20	19	519	991
1 A 2 c other	Chemicals	CO2		36	32	125	308
1 A 2 d gaseous	Pulp, Paper and Print	CO2	23	15	17	943	1 372
1 A 2 d liquid	Pulp, Paper and Print	CO2	25		15	853	24
1 A 2 d solid	Pulp, Paper and Print	CO2	42		36	398	130
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	34	24	25	507	776
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	47		34	345	73
1 A 2 f gaseous	Non-Metallic Minerals	CO2	30	29	43	559	593
1 A 2 f liquid	Non-Metallic Minerals	CO2	33		28	508	160
1 A 2 f other	Non-Metallic Minerals	CO2		28	20	67	616
1 A 2 f solid	Non-Metallic Minerals	CO2	31	46	31	535	209
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	53	13	11	256	1 453
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	22	17	22	1 014	1 272
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	29		24	610	107
1 A 3 b diesel oil	Road Transportation	CO2	6	1	1	5 358	15 639
1 A 3 b diesel oil	Road Transportation	N2O		48	38	11	190
1 A 3 b gasoline	Road Transportation	CO2	2	4	7	7 896	4 389
1 A 4 a gaseous	Commercial/Institutional	CO2	27	26	41	698	718

IPCC Category Code	IPCC Category	GHG	Approach 1	Approach 1	Approach 1	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}
			Level Assessment t 1990	Level Assessment 2022	Trend Assessment t 1990-2022		
1 A 4 a liquid	Commercial/Institutional	CO2	17	32	16	1 420	495
1 A 4 b biomass	Residential	CH4	52	47		264	200
1 A 4 b gaseous	Residential	CO2	15	7	9	1 856	3 032
1 A 4 b liquid	Residential	CO2	5	8	8	5 633	2 791
1 A 4 b solid	Residential	CO2	12		5	2 511	34
1 A 4 b solid	Residential	CH4			39	224	3
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO2	19	23	44	1 180	800
1 B 1 a	Coal Mining and Handling	CH4	44			373	NA
1 B 2 b	Natural Gas	CH4	50	45		290	225
2 A 1	Cement Production	CO2	13	11	29	2 033	1 832
2 A 2	Lime Production	CO2	40	27	27	456	624
2 A 4 c	Non-metallurgical Magnesium	CO2	37	35		481	317
2 B 1	Ammonia Production	CO2	39	33		467	418
2 B 2	Nitric Acid Production	N2O	26		18	780	23
2 C 1	Iron and Steel Production	CO2	3	2	2	6 840	10 280
2 C 3	Aluminium Production	PFC	21			1 032	0
2 C 3	Aluminium Production	CO2			46	150	5
2 C 4	Magnesium Production	SF6	54		37	235	2
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	46	49	47	349	172
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		16	10	0	1 355
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6		38	33	124	301
3 A 1	Cattle	CH4	7	5	35	4 854	4 035
3 B 1 1	Cattle	CH4	38	30	42	467	522
3 B 1 1	Cattle	N2O	49	41		294	281
3 D 1	Direct N2O Emissions from Managed Soils	N2O	16	12		1 776	1 455
3 D 2	Indirect N2O emissions from Managed Soils	N2O	45	40		357	288
4 A 1	Forest land remaining forest land	CO2	1	6	3	-8 122	-3 192
4 A 2	Land converted to forest land	CO2	11	14	12	-2 955	-1 420
4 B 2	Land converted to cropland	CO2		44	50	202	233
4 C 1	Grassland remaining grassland	CO2	48	37		304	304
4 C 2	Land converted to grassland	CO2	43		40	393	140
4 E 2	Land converted to Settlements	CO2	24	25		917	746
4 F 2	Land converted to Other land	CO2	36	31	45	502	517
4 G	HWP	CO2	10	9	26	-3 122	-2 110
5 A	Solid Waste Disposal	CH4	8	21	4	4 081	846
5 D	Waste Water Treatment and Discharge	N2O			48	86	152
5 D	Waste Water Treatment and Discharge	CH4			49	137	24

Table A 9: Approach 2 – Level Assessment of the KCA excluding LULUCF for 1990.

IPCC Category Code	IPCC Category	GHG	Latest Year (1990) Estimate E _{x,t}	Level Assessment with Uncertainty LUX,t	Cumulative Total of L _{x,t}
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1.776	0,328	32,8%
5 A	Solid Waste Disposal	CH4	4.081	0,104	43,2%
3 A 1	Cattle	CH4	4.854	0,100	53,2%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	357	0,066	59,8%

IPCC Category Code	IPCC Category	GHG	Latest Year (1990) Estimate E _{x,t}	Level Assessment with Uncertainty LU _{x,t}	Cumulative Total of L _{x,t}
2 C 3	Aluminium Production	PFC	1.032	0,048	64,6%
1 A 3 b gasoline	Road Transportation	CO2	7.896	0,031	67,7%
3 B 1 1	Cattle	N2O	294	0,027	70,4%
1 A 3 b diesel oil	Road Transportation	CO2	5.358	0,021	72,5%
3 B 2 5	Indirect N2O Emissions	N2O	103	0,019	74,4%
1 B 1 a	Coal Mining and Handling	CH4	373	0,017	76,1%
2 C 1	Iron and Steel Production	CO2	6.840	0,013	77,4%
1 A 4 b biomass	Residential	CH4	264	0,012	78,7%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	349	0,012	79,9%
1 A 4 b solid	Residential	CH4	224	0,010	80,9%
2 A 1	Cement Production	CO2	2.033	0,010	81,9%
3 B 1 1	Cattle	CH4	467	0,010	82,9%
3 B 1 3	Swine	N2O	99	0,009	83,8%
1 A 4 b gaseous	Residential	CO2	1.856	0,009	84,6%
5 D	Waste Water Treatment and Discharge	N2O	86	0,008	85,4%
5 D	Waste Water Treatment and Discharge	CH4	137	0,007	86,1%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6	124	0,006	86,8%
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	3.294	0,006	87,4%
1 A 4 b liquid	Residential	CO2	5.633	0,006	87,9%
1 A 3 b gasoline	Road Transportation	N2O	83	0,005	88,5%
1 A 1 a other	Public Electricity and Heat Production	CO2	286	0,005	89,0%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1.014	0,005	89,4%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	943	0,004	89,9%
2 A 2	Lime Production	CO2	456	0,004	90,3%

Table A 10: Approach 2 – Level Assessment of the KCA excluding LULUCF for 2022.

IPCC Category Code	IPCC Category	GHG	Latest Year (2022) Estimate E _{x,t}	Level Assessment with Uncertainty LU _{x,t}	Cumulative Total of L _{x,t}
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 455	0.317	31.7%
3 A 1	Cattle	CH4	4 035	0.088	40.5%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 355	0.075	48.1%
1 A 3 b diesel oil	Road Transportation	CO2	15 639	0.072	55.3%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	288	0.063	61.6%
3 B 1 1	Cattle	N2O	281	0.031	64.6%
5 A	Solid Waste Disposal	CH4	846	0.026	67.2%
3 B 2 5	Indirect N2O Emissions	N2O	111	0.024	69.6%
1 A 3 b gasoline	Road Transportation	CO2	4 389	0.020	71.6%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6	301	0.018	73.5%
1 A 1 a other	Public Electricity and Heat Production	CO2	1 028	0.018	75.2%
5 D	Waste Water Treatment and Discharge	N2O	152	0.017	76.9%
1 A 4 b gaseous	Residential	CO2	3 032	0.017	78.6%
1 A 2 f other	Non-Metallic Minerals	CO2	616	0.012	79.8%
3 B 1 1	Cattle	CH4	522	0.011	80.9%
1 A 4 b biomass	Residential	CH4	200	0.011	82.0%
2 C 1	Iron and Steel Production	CO2	10 280	0.008	82.8%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	1 372	0.007	83.6%

IPCC Category Code	IPCC Category	GHG	Latest Year (2022) Estimate Ex,t	Level Assessment with Uncertainty LU _{x,t}	Cumulative Total of L _{x,t}
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1 272	0.007	84.3%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	172	0.007	85.0%
1 A 3 b diesel oil	Road Transportation	N2O	190	0.006	85.6%
1 A 2 c other	Chemicals	CO2	308	0.006	86.2%
3 B 1 3	Swine	N2O	53	0.006	86.8%
1 A 2 a gaseous	Iron and Steel	CO2	1 049	0.006	87.3%
3 G	Liming	CO2	99	0.005	87.9%
1 A 2 c gaseous	Chemicals	CO2	991	0.005	88.4%
2 G 1	Other product manufacture and use - Electrical Equipment	SF6	49	0.005	89.0%
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	4 500	0.005	89.5%
5 B	Biological Treatment of Solid Waste	CH4	77	0.005	89.9%
2 A 1	Cement Production	CO2	1 832	0.004	90.4%

Table A 11: Approach 2 – Trend Assessment of the KCA excluding LULUCF for the trend 1990–2022.

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate Ex,t	Trend Assessment with Uncertainty TU _{x,t}	% Contribution to Trend	Cumulative Total of TU _{x,t}
5 A	Solid Waste Disposal	CH4	4 081	846	1.022	18.3%	18.3%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	0	1 355	0.874	15.6%	33.9%
1 A 3 b diesel oil	Road Transportation	CO2	5 358	15 639	0.574	10.3%	44.2%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 776	1 455	0.459	8.2%	52.4%
1 A 3 b gasoline	Road Transportation	CO2	7 896	4 389	0.155	2.8%	55.2%
1 A 1 a other	Public Electricity and Heat Production	CO2	286	1 028	0.153	2.7%	57.9%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6	124	301	0.132	2.4%	60.3%
1 A 4 b solid	Residential	CH4	224	3	0.128	2.3%	62.6%
1 A 2 f other	Non-Metallic Minerals	CO2	67	616	0.126	2.3%	64.8%
3 A 1	Cattle	CH4	4 854	4 035	0.111	2.0%	66.8%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	357	288	0.104	1.9%	68.7%
5 D	Waste Water Treatment and Discharge	N2O	86	152	0.095	1.7%	70.4%
1 A 4 b gaseous	Residential	CO2	1 856	3 032	0.084	1.5%	71.9%
5 D	Waste Water Treatment and Discharge	CH4	137	24	0.069	1.2%	73.1%
1 A 3 b diesel oil	Road Transportation	N2O	11	190	0.068	1.2%	74.3%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	349	172	0.068	1.2%	75.6%
1 A 3 b gasoline	Road Transportation	N2O	83	6	0.062	1.1%	76.7%
2 G 1	Other product manufacture and use - Electrical Equipment	SF6	11	49	0.049	0.9%	77.5%
3 B 1 3	Swine	N2O	99	53	0.047	0.8%	78.4%
1 A 2 c other	Chemicals	CO2	125	308	0.044	0.8%	79.2%
5 B	Biological Treatment of Solid Waste	CH4	15	77	0.043	0.8%	80.0%
3 B 2 5	Indirect N2O Emissions	N2O	103	111	0.042	0.7%	80.7%
1 A 1 a biomass	Public Electricity and Heat Production	N2O	3	67	0.041	0.7%	81.4%
5 B	Biological Treatment of Solid Waste	N2O	20	72	0.036	0.7%	82.1%
3 G	Liming	CO2	46	99	0.036	0.6%	82.7%
2 C 1	Iron and Steel Production	CO2	6 840	10 280	0.036	0.6%	83.4%
2 C 3	Aluminium Production	CO2	150	5	0.035	0.6%	84.0%
1 A 4 b liquid	Residential	CO2	5 633	2 791	0.034	0.6%	84.6%

IPCC Category Code	IPCC Category	GHG	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}	Trend Assessment with Uncertainty TU _{x,t}	% Contribution to Trend	Cumulative Total of TU _{x,t}
1 A 2 c gaseous	Chemicals	CO2	519	991	0.032	0.6%	85.2%
1 A 4 b solid	Residential	CO2	2 511	34	0.032	0.6%	85.8%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	943	1 372	0.032	0.6%	86.3%
3 A 4	Other (please specify)	CH4	44	95	0.029	0.5%	86.8%
1 A 2 a gaseous	Iron and Steel	CO2	650	1 049	0.028	0.5%	87.4%
1 A 4 b biomass	Residential	CH4	264	200	0.028	0.5%	87.9%
2 B 2	Nitric Acid Production	N2O	780	23	0.025	0.4%	88.3%
1 A 3 b gasoline	Road Transportation	CH4	77	7	0.024	0.4%	88.7%
3 B 1 1	Cattle	CH4	467	522	0.023	0.4%	89.1%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1 014	1 272	0.021	0.4%	89.5%
1 A 4 c liquid	Agriculture/Forestry/Fishing	N2O	68	30	0.021	0.4%	89.9%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	507	776	0.020	0.4%	90.3%

Table A 12: Approach 2 – Level Assessment of the KCA including LULUCF for 1990.

IPCC Category Code	IPCC Category	GHG	Latest Year (1990) Estimate E _{x,t}	Absolute Value of Year 1990 Estimate E _{x,t}	Level Assessment with Uncertainty LUX _t	Cumulative Total of L _{x,t}
4A1	Forest land remaining forest land	CO2	-8.122	8.122	0,210	21,0%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1.776	1.776	0,182	39,2%
4 G	HWP	CO2	-3.122	3.122	0,078	47,0%
5 A	Solid Waste Disposal	CH4	4.081	4.081	0,058	52,8%
3 A 1	Cattle	CH4	4.854	4.854	0,056	58,4%
4 A 2	Land converted to forest land	CO2	-2.955	2.955	0,054	63,8%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	357	357	0,037	67,4%
4 C 1	Grassland remaining grassland	CO2	304	304	0,036	71,0%
2 C 3	Aluminium Production	PFC	1.032	1.032	0,026	73,7%
4 F 2	Land converted to Other land	CO2	502	502	0,020	75,7%
1 A 3 b gasoline	Road Transportation	CO2	7.896	7.896	0,017	77,4%
4 E 2	Land converted to Settlements	CO2	917	917	0,016	79,0%
3 B 1 1	Cattle	N2O	294	294	0,015	80,5%
1 A 3 b diesel oil	Road Transportation	CO2	5.358	5.358	0,012	81,6%
4 C 2	Land converted to grassland	CO2	393	393	0,011	82,7%
3 B 2 5	Indirect N2O Emissions	N2O	103	103	0,011	83,8%
1 B 1 a	Coal Mining and Handling	CH4	373	373	0,010	84,7%
4	Total land use categories	N2O	143	143	0,008	85,5%
2 C 1	Iron and Steel Production	CO2	6.840	6.840	0,007	86,2%
1 A 4 b biomass	Residential	CH4	264	264	0,007	86,9%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	349	349	0,006	87,6%
4 B 2	Land converted to cropland	CO2	202	202	0,006	88,2%
1 A 4 b solid	Residential	CH4	224	224	0,006	88,8%
2 A 1	Cement Production	CO2	2.033	2.033	0,006	89,3%
3 B 1 1	Cattle	CH4	467	467	0,005	89,9%
3 B 1 3	Swine	N2O	99	99	0,005	90,4%

Table A 13: Approach 2 – Level Assessment of the KCA including LULUCF for 2022.

IPCC Category Code	IPCC Category	GHG	Latest Year (2022) Estimate Ex,t	Absolute Value of Year 2022 Estimate Ex,t	Level Assessment with Uncertainty LUX,t	Cumulative Total of L _{x,t}
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 455	1 455	0.191	19.1%
4 A 2	Land converted to forest land	CO2	-1 420	1 420	0.105	29.6%
4 A 1	Forest land remaining forest land	CO2	-3 192	3 192	0.081	37.7%
4 G	HWP	CO2	-2 110	2 110	0.068	44.5%
3 A 1	Cattle	CH4	4 035	4 035	0.053	49.8%
4 C 1	Grassland remaining grassland	CO2	304	304	0.046	54.3%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	1 355	1 355	0.045	58.8%
1 A 3 b diesel oil	Road Transportation	CO2	15 639	15 639	0.043	63.2%
4 F 2	Land converted to Other land	CO2	517	517	0.042	67.4%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	288	288	0.038	71.1%
3 B 1 1	Cattle	N2O	281	281	0.018	73.0%
5 A	Solid Waste Disposal	CH4	846	846	0.015	74.5%
4 C 2	Land converted to grassland	CO2	140	140	0.015	76.0%
4 E 2	Land converted to Settlements	CO2	746	746	0.015	77.5%
3 B 2 5	Indirect N2O Emissions	N2O	111	111	0.015	79.0%
1 A 3 b gasoline	Road Transportation	CO2	4 389	4 389	0.012	80.2%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6	301	301	0.011	81.3%
1 A 1 a other	Public Electricity and Heat Production	CO2	1 028	1 028	0.011	82.3%
5 D	Waste Water Treatment and Discharge	N2O	152	152	0.010	83.4%
4	Total land use categories	N2O	127	127	0.010	84.4%
1 A 4 b gaseous	Residential	CO2	3 032	3 032	0.010	85.4%
4 B 2	Land converted to cropland	CO2	233	233	0.008	86.1%
1 A 2 f other	Non-Metallic Minerals	CO2	616	616	0.007	86.9%
3 B 1 1	Cattle	CH4	522	522	0.007	87.6%
1 A 4 b biomass	Residential	CH4	200	200	0.007	88.2%
2 C 1	Iron and Steel Production	CO2	10 280	10 280	0.005	88.7%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	1 372	1 372	0.004	89.1%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	1 272	1 272	0.004	89.6%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	172	172	0.004	90.0%
4	Total land use categories	CH4	27	27	0.004	90.4%

Table A 14: Approach 2 – Trend Assessment of the KCA including LULUCF for the trend 1990–2022.

IPCC Category Code	IPCC Category	GHG	Latest Year (2022) Estimate Ex,t	Absolute Value of Year 2022 Estimate Ex,t	Level Assessment with Uncertainty LUX,t	Cumulative Total of L _{x,t}
4 A 1	Forest land remaining forest land	CO2	8 122	3 192	1.311	17.7%
4 A 2	Land converted to forest land	CO2	2 955	1 420	1.088	14.7%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	0	1 355	0.721	9.7%
5 A	Solid Waste Disposal	CH4	4 081	846	0.691	9.3%
1 A 3 b diesel oil	Road Transportation	CO2	5 358	15 639	0.504	6.8%
4 C 2	Land converted to grassland	CO2	393	140	0.299	4.0%
4 G	HWP	CO2	3 122	2 110	0.186	2.5%
4 F 2	Land converted to Other land	CO2	502	517	0.154	2.1%
4 C 1	Grassland remaining grassland	CO2	304	304	0.151	2.0%
1 A 1 a other	Public Electricity and Heat Production	CO2	286	1 028	0.132	1.8%

IPCC Category Code	IPCC Category	GHG	Latest Year (2022) Estimate Ex,t	Absolute Value of Year 2022 Estimate Ex,t	Level Assessment with Uncertainty LUX,t	Cumulative Total of L _{x,t}
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6	124	301	0.118	1.6%
1 A 2 f other	Non-Metallic Minerals	CO2	67	616	0.106	1.4%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	1 776	1 455	0.100	1.3%
1 A 4 b solid	Residential	CH4	224	3	0.091	1.2%
5 D	Waste Water Treatment and Discharge	N2O	86	152	0.090	1.2%
1 A 3 b gasoline	Road Transportation	CO2	7 896	4 389	0.083	1.1%
1 A 4 b gaseous	Residential	CO2	1 856	3 032	0.082	1.1%
3 B 2 5	Indirect N2O Emissions	N2O	103	111	0.062	0.8%
1 A 3 b diesel oil	Road Transportation	N2O	11	190	0.057	0.8%
3 B 1 1	Cattle	N2O	294	281	0.051	0.7%
5 D	Waste Water Treatment and Discharge	CH4	137	24	0.047	0.6%
1 A 3 b gasoline	Road Transportation	N2O	83	6	0.043	0.6%
2 G 1	Other product manufacture and use - Electrical Equipment	SF6	11	49	0.042	0.6%
4 B 1	Cropland remaining cropland	CO2	18	84	0.041	0.5%
3 A 1	Cattle	CH4	4 854	4 035	0.040	0.5%
1 A 2 c other	Chemicals	CO2	125	308	0.039	0.5%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	349	172	0.039	0.5%
4 B 2	Land converted to cropland	CO2	202	233	0.039	0.5%
5 B	Biological Treatment of Solid Waste	CH4	15	77	0.037	0.5%
2 C 1	Iron and Steel Production	CO2	6 840	10 280	0.036	0.5%
1 A 1 a biomass	Public Electricity and Heat Production	N2O	3	67	0.034	0.5%
3 G	Liming	CO2	46	99	0.033	0.4%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	943	1 372	0.033	0.4%
3 B 1 1	Cattle	CH4	467	522	0.032	0.4%
5 B	Biological Treatment of Solid Waste	N2O	20	72	0.032	0.4%
1 A 2 c gaseous	Chemicals	CO2	519	991	0.030	0.4%
1 A 2 a gaseous	Iron and Steel	CO2	650	1 049	0.028	0.4%

Table A 15: Approach 2 – Key categories identified including their ranking in the level and trend assessment for the KCA excluding LULUCF.

IPCC Category Code	IPCC Category	GHG	Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2	Base Year (1990) Estimate Ex,t	Latest Year (2022) Estimate Ex,t	Share Latest Year (2022)
			Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022	Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022			
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	8	3	7	7	3		3 294	4 500	6.2%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	15	37	11				1 229	236	0.3%
1 A 1 a other	Public Electricity and Heat Production	CO2	44	16	13	20	13	6	286	1 028	1.4%
1 A 1 a solid	Public Electricity and Heat Production	CO2	3						6 247	NO	-
1 A 1 a biomass	Public Electricity and Heat Production	N2O						23	3	67	0.1%
1 A 1 b gaseous	Petroleum refining	CO2	36	33	44				437	300	0.4%
1 A 1 b liquid	Petroleum refining	CO2	11	8	38				1 958	1 955	2.7%

IPCC Category Code	IPCC Category	GHG	Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}	Share Latest Year (2022)
			Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022	Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022			
1 A 1 c	Manufacture of Solid fuels and Other Energy Industries	CO2	31	29	42				506	344	0.5%
1 A 2 a	Iron and Steel	CO2	24	15	20		12	33	650	1 049	1.4%
1 A 2 a	Iron and Steel	CO2	17	19	37				1 107	843	1.2%
1 A 2 b	Non-ferrous Metals	CO2		36	30				75	279	0.4%
1 A 2 c	Chemicals	CO2	28	17	17		14	29	519	991	1.4%
1 A 2 c	Chemicals	CO2		31	33		18	20	125	308	0.4%
1 A 2 d	Pulp, Paper and Print	CO2	20	12	18	13	9	31	943	1 372	1.9%
1 A 2 d	Pulp, Paper and Print	CO2	21		14				853	24	0.0%
1 A 2 d	Pulp, Paper and Print	CO2	37		28				398	130	0.2%
1 A 2 e	Food Processing, Beverages and Tobacco	CO2	30	21	23			40	507	776	1.1%
1 A 2 e	Food Processing, Beverages and Tobacco	CO2	41		27				345	73	0.1%
1 A 2 f	Other	CO2	26	25	48				559	593	0.8%
1 A 2 f	Other	CO2	29		24				508	160	0.2%
1 A 2 f	Other	CO2		24	16		16	9	67	616	0.8%
1 A 2 f	Other	CO2	27	39	26				535	209	0.3%
1 A 2 g 7	Off-road vehicles and other machinery	CO2	46	11	10				256	1 453	2.0%
1 A 2 g 8	Other Manufacturing Industries	CO2	19	14	22	12	11	38	1 014	1 272	1.7%
1 A 2 g 8	Other Manufacturing Industries	CO2	25		19				610	107	0.1%
1 A 2 g 8	Other Manufacturing Industries	CO2			46				91	2	0.0%
1 A 3 b	Road Transportation	CO2	5	1	1	4	1	3	5 358	15 639	21.5%
1 A 3 b	Road Transportation	N2O		41	36		23	15	11	190	0.3%
1 A 3 b	Road Transportation	CO2	1	4	4	1	4	5	7 896	4 389	6.0%
1 A 3 b	Road Transportation	CH4						36	77	7	0.0%
1 A 3 b	Road Transportation	N2O				28		17	83	6	0.0%
1 A 3 e	Other	CO2	48						224	152	0.2%
1 A 4 a	Commercial/Institutional	CO2	23	22					698	718	1.0%
1 A 4 a	Commercial/Institutional	CO2	14	27	12				1 420	495	0.7%
1 A 4 b	Residential	CH4	45	40		21	22	34	264	200	0.3%
1 A 4 b	Residential	CO2	12	6	9	9	6	13	1 856	3 032	4.2%

IPCC Category Code	IPCC Category	GHG	Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}	Share Latest Year (2022)	
			Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022	Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022				
1 A 4 b liquid	Residential	CO2	4	7	5	3		28	5 633	2 791	3.8%	
1 A 4 b solid	Residential	CO2	9		6			30	2 511	34	0.0%	
1 A 4 b solid	Residential	CH4	49		32	22		8	224	3	0.0%	
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO2	16	20	25				1 180	800	1.1%	
1 A 4 c liquid	Agriculture/Forestry/Fishing	N2O						39	68	30	0.0%	
1 B 1 a	Coal Mining and Handling	CH4	38			16			373	NA	-	
1 B 2 b	Natural Gas	CH4	43	38					290	225	0.3%	
2 A 1	Cement Production	CO2	10	9		8	7		2 033	1 832	2.5%	
2 A 2	Lime Production	CO2	35	23	31	15			456	624	0.9%	
2 A 4 c	Non-metallurgical Magnesium	CO2	32	30	41				481	317	0.4%	
2 B 1	Ammonia Production	CO2	34	28					467	418	0.6%	
2 B 2	Nitric Acid Production	N2O	22		15			35	780	23	0.0%	
2 C 1	Iron and Steel Production	CO2	2	2	2	2	2	26	6 840	10 280	14.1%	
2 C 3	Aluminium Production	PFC	18			11			1 032	0	0.0%	
2 C 3	Aluminium Production	CO2			40			27	150	5	0.0%	
2 C 4	SF6 used in Mg Foundries	SF6	47		29				235	2	0.0%	
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	40	42	39	18	24	16	349	172	0.2%	
2 E	Electronics Industry	SF6			47				100	13	0.0%	
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		13	8		10	2	0	1 355	1.9%	
2 G 1	Other product manufacture and use - Electrical Equipment	SF6					30	18	11	49	0.1%	
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6		32	34	24	19	7	124	301	0.4%	
3 A 1	Cattle	CH4	6	5	21	5	5	10	4 854	4 035	5.5%	
3 A 4	Other (please specify)	CH4						32	44	95	0.1%	
3 B 1 1	Cattle	CH4	33	26	45	14	17	37	467	522	0.7%	
3 B 1 1	Cattle	N2O	42	35		19	21		294	281	0.4%	
3 B 1 3	Swine	N2O				26	29	19	99	53	0.1%	
3 B 2 5	Indirect N2O Emissions	N2O				25	26	22	103	111	0.2%	
3 D 1	Direct N2O Emissions from Managed Soils	N2O	13	10	35	10	8	4	1 776	1 455	2.0%	
3 D 2	Indirect N2O emissions from Managed Soils	N2O	39	34		17	20	11	357	288	0.4%	
3 G	Liming	CO2						27	25	46	99	0.1%
5 A	Solid Waste Disposal	CH4	7	18	3	6	15	1	4 081	846	1.2%	
5 B	Biological Treatment of Solid Waste	CH4						28	21	15	77	0.1%
5 B	Biological Treatment of Solid Waste	N2O						24	20	72	0.1%	
5 D	Waste Water Treatment and Discharge	N2O				27	25	12	86	152	0.2%	
5 D	Waste Water Treatment and Discharge	CH4			43	23		14	137	24	0.0%	

Table A 16: Approach 2 – Key categories identified including their ranking in the level and trend assessment for the KCA including LULUCF.

IPCC Category Code	IPCC Category	GHG	Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2	Base Year (1990) Estimate _{x,0}	Latest Year (2022) Estimate _{x,t}	Share Latest Year (2022)
			Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022	Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022			
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	9	3	6				3 294	4 500	5.5%
1 A 1 a liquid	Public Electricity and Heat Production	CO2	18	40	14				1 229	236	0.3%
1 A 1 a other	Public Electricity and Heat Production	CO2	51	16	13		13	10	286	1 028	1.3%
1 A 1 a solid	Public Electricity and Heat Production	CO2	4						6 247	NO	0.0%
1 A 1 a biomass	Public Electricity and Heat Production	N2O						31	3	67	0.1%
1 A 1 b gaseous	Petroleum refining	CO2	41	36					437	300	0.4%
1 A 1 b liquid	Petroleum refining	CO2	14	8	23				1 958	1 955	2.4%
1 A 1 c gaseous	Manufacture of Solid fuels and Other Energy Industries	CO2	35	31					506	344	0.4%
1 A 2 a gaseous	Iron and Steel	CO2	28	15	21			37	650	1 049	1.3%
1 A 2 a solid	Iron and Steel	CO2	20	19					1 107	843	1.0%
1 A 2 b gaseous	Non-ferrous Metals	CO2		39	30				75	279	0.3%
1 A 2 c gaseous	Chemicals	CO2	32	17	19			36	519	991	1.2%
1 A 2 c other	Chemicals	CO2		33	32			26	125	308	0.4%
1 A 2 d gaseous	Pulp, Paper and Print	CO2	23	12	17		10	33	943	1 372	1.7%
1 A 2 d liquid	Pulp, Paper and Print	CO2	25		15				853	24	0.0%
1 A 2 d solid	Pulp, Paper and Print	CO2	42		36				398	130	0.2%
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	34	21	25				507	776	0.9%
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	47		34				345	73	0.1%
1 A 2 f gaseous	Other	CO2	30	26	43				559	593	0.7%
1 A 2 f liquid	Other	CO2	33		28				508	160	0.2%
1 A 2 f other	Other	CO2		25	20		16	12	67	616	0.8%
1 A 2 f solid	Other	CO2	31	43	31				535	209	0.3%
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	53	11	11				256	1 453	1.8%
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	22	14	22		12		1 014	1 272	1.6%
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	29		24				610	107	0.1%
1 A 3 b diesel oil	Road Transportation	CO2	6	1	1	4	1	5	5 358	15 639	19.1%
1 A 3 b diesel oil	Road Transportation	N2O		45	38			19	11	190	0.2%
1 A 3 b gasoline	Road Transportation	CO2	2	4	7	2	3	16	7 896	4 389	5.4%

IPCC Category Code	IPCC Category	GHG	Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}	Share Latest Year (2022)
			Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022	Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022			
1 A 3 b gasoline	Road Transportation	N2O						22	83	6	0.0%
1 A 4 a gaseous	Commercial/Institutional	CO2	27	23	41				698	718	0.9%
1 A 4 a liquid	Commercial/Institutional	CO2	17	29	16				1 420	495	0.6%
1 A 4 b biomass	Residential	CH4	52	44		21	24		264	200	0.2%
1 A 4 b gaseous	Residential	CO2	15	6	9		6	17	1 856	3 032	3.7%
1 A 4 b liquid	Residential	CO2	5	7	8				5 633	2 791	3.4%
1 A 4 b solid	Residential	CO2	12		5				2 511	34	0.0%
1 A 4 b solid	Residential	CH4			39	22		14	224	3	0.0%
1 A 4 c liquid	Agriculture/Forestry/Fisheries	CO2	19	20	44				1 180	800	1.0%
1 B 1 a	Coal Mining and Handling	CH4	44			16			373	NA	0.0%
1 B 2 b	Natural Gas	CH4	50	42					290	225	0.3%
2 A 1	Cement Production	CO2	13	9	29	9			2 033	1 832	2.2%
2 A 2	Lime Production	CO2	40	24	27				456	624	0.8%
2 A 4 c	Non-metallurgical Magnesium	CO2	37	32					481	317	0.4%
2 B 1	Ammonia Production	CO2	39	30					467	418	0.5%
2 B 2	Nitric Acid Production	N2O	26		18				780	23	0.0%
2 C 1	Iron and Steel Production	CO2	3	2	2	3	2	30	6 840	10 280	12.6%
2 C 3	Aluminium Production	PFC	21			11			1 032	0	0.0%
2 C 3	Aluminium Production	CO2			46				150	5	0.0%
2 C 4	SF6 used in Mg Foundries	SF6	54		37				235	2	0.0%
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	46	46	47	18	25	27	349	172	0.2%
2 F 1	Refrigeration and Air Conditioning Equipment	HFC		13	10		11	3	0	1 355	1.7%
2 G 1	Other product manufacture and use - Electrical Equipment	SF6						23	11	49	0.1%
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6		35	33		20	11	124	301	0.4%
3 A 1	Cattle	CH4	7	5	35	5	4	25	4 854	4 035	4.9%
3 B 1 1	Cattle	CH4	38	27	42	14	17	34	467	522	0.6%
3 B 1 1	Cattle	N2O	49	38		20	22	20	294	281	0.3%
3 B 1 3	Swine	N2O				26			99	53	0.1%
3 B 2 5	Indirect N2O Emissions	N2O				25	29	18	103	111	0.1%
3 D 1	Direct N2O Emissions from Managed Soils	N2O	16	10		10	8	13	1 776	1 455	1.8%
3 D 2	Indirect N2O emissions from Managed Soils	N2O	45	37		17	21		357	288	0.4%
3 G	Liming	CO2						32	46	99	0.1%
4	Total land use categories	N2O				24	28		143	127	0.2%
4	Total land use categories	CH4					30		27	27	0.0%
4 A 1	Forest land remaining forest land	CO2	1	49	3	1	5	1	-8 122	-3 192	3.9%

IPCC Category Code	IPCC Category	GHG	Approach 1	Approach 1	Approach 1	Approach 2	Approach 2	Approach 2	Base Year (1990) Estimate E _{x,0}	Latest Year (2022) Estimate E _{x,t}	Share Latest Year (2022)
			Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022	Level Assessment 1990	Level Assessment 2022	Trend Assessment 1990-2022			
4 A 2	Land converted to forest land	CO2	11	47	12	8	9	2	-2 955	-1 420	1.7%
4 B 1	Cropland remaining cropland	CO2						24	-18	84	0.1%
4 B 2	Land converted to cropland	CO2		41	50	23	23	28	202	233	0.3%
4 C 1	Grassland remaining grassland	CO2	48	34		19	19	9	304	304	0.4%
4 C 2	Land converted to grassland	CO2	43		40	15	27	6	393	140	0.2%
4 E 2	Land converted to Settlements	CO2	24	22		12	15		917	746	0.9%
4 F 2	Land converted to Other land	CO2	36	28	45	13	18	8	502	517	0.6%
4 G	HWP	CO2	10	48	26	7	7	7	-3 122	-2 110	2.6%
5 A	Solid Waste Disposal	CH4	8	18	4	6	14	4	4 081	846	1.0%
5 B	Biological Treatment of Solid Waste	CH4						29	15	77	0.1%
5 B	Biological Treatment of Solid Waste	N2O						35	20	72	0.1%
5 D	Waste Water Treatment and Discharge	N2O			48		26	15	86	152	0.2%
5 D	Waste Water Treatment and Discharge	CH4			49			21	137	24	0.0%

Table A 17: Source/sink categories and emissions/removals for key category analysis.

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2020	2021	2022
1 A 1 a liquid	Public Electricity and Heat Production	CO2	Gg	1 229	1 561	1 184	1 111	672	255	65	120	236
1 A 1 a solid	Public Electricity and Heat Production	CO2	Gg	6 247	4 529	4 824	5 844	3 870	2 335	356	NO	NO
1 A 1 a gaseous	Public Electricity and Heat Production	CO2	Gg	3 294	3 439	3 472	5 277	5 233	3 626	4 227	4 499	4 500
1 A 1 a other	Public Electricity and Heat Production	CO2	Gg	286	282	288	495	886	1 083	1 016	1 049	1 028
1 A 1 b liquid	Petroleum Refining	CO2	Gg	1 958	2 169	1 852	2 311	2 226	2 463	2 235	2 217	1 955
1 A 1 b gaseous	Petroleum Refining	CO2	Gg	437	421	362	516	499	341	497	533	300
1 A 1 c liquid	Manufacture of Solid Fuels and Other Energy Industries	CO2	Gg	4	0	NO	NO	NO	NO	NO	NO	NO
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CO2	Gg	506	611	281	394	238	275	289	375	344
1 A 2 a liquid	Iron and Steel	CO2	Gg	76	83	73	59	32	6	7	20	45
1 A 2 a solid	Iron and Steel	CO2	Gg	1 107	497	180	695	142	284	715	760	843
1 A 2 a gaseous	Iron and Steel	CO2	Gg	650	757	1 022	1 090	1 101	1 116	1 081	1 004	1 049
1 A 2 b liquid	Non-Ferrous Metals	CO2	Gg	35	41	47	33	20	29	8	9	9
1 A 2 b solid	Non-Ferrous Metals	CO2	Gg	22	10	18	13	7	14	13	10	14
1 A 2 b gaseous	Non-Ferrous Metals	CO2	Gg	75	205	128	172	209	252	246	277	279
1 A 2 b other	Non-Ferrous Metals	CO2	Gg	NO	NO	NO	NO	NO	1	1	0	1
1 A 2 c liquid	Chemicals	CO2	Gg	97	102	64	74	142	57	75	35	48
1 A 2 c solid	Chemicals	CO2	Gg	106	150	250	149	76	103	42	34	52
1 A 2 c gaseous	Chemicals	CO2	Gg	519	572	874	1 019	1 014	1 013	1 131	1 231	991
1 A 2 c other	Chemicals	CO2	Gg	125	161	153	106	315	222	245	231	308
1 A 2 d liquid	Pulp, Paper and Print	CO2	Gg	853	523	171	139	72	42	13	14	24
1 A 2 d solid	Pulp, Paper and Print	CO2	Gg	398	381	446	438	326	384	298	210	130
1 A 2 d gaseous	Pulp, Paper and Print	CO2	Gg	943	1 361	1 763	1 709	1 906	1 378	1 480	1 594	1 372
1 A 2 d other	Pulp, Paper and Print	CO2	Gg	15	36	NO	7	8	25	9	2	2
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CO2	Gg	345	342	166	242	201	68	29	35	73
1 A 2 e solid	Food Processing, Beverages and Tobacco	CO2	Gg	18	6	22	13	15	23	12	13	17
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CO2	Gg	507	583	694	704	749	888	749	750	776
1 A 2 e other	Food Processing, Beverages and Tobacco	CO2	Gg	NO	NO	NO	NO	0	0	0	NO	0
1 A 2 f liquid	Non-Metallic Minerals	CO2	Gg	508	348	198	296	195	159	79	147	160
1 A 2 f solid	Non-Metallic Minerals	CO2	Gg	535	435	503	373	312	266	311	253	209
1 A 2 f gaseous	Non-Metallic Minerals	CO2	Gg	559	615	641	659	602	625	699	665	593
1 A 2 f other	Non-Metallic Minerals	CO2	Gg	67	122	197	327	419	555	566	616	616
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CO2	Gg	256	358	551	809	1 074	1 064	1 234	1 356	1 453
1 A 2 g 7 other	Off-road vehicles and other machinery	CO2	Gg	NO	NO	NO	0	4	4	4	4	5
1 A 2 g 8 liquid	Other Manufacturing Industries	CO2	Gg	610	791	605	713	506	259	150	134	107

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2020	2021	2022
1 A 2 g 8 solid	Other Manufacturing Industries	CO2	Gg	91	18	30	35	NO	0	0	3	2
1 A 2 g 8 gaseous	Other Manufacturing Industries	CO2	Gg	1 014	1 423	1 070	1 290	1 547	1 202	1 235	1 322	1 272
1 A 2 g 8 other	Other Manufacturing Industries	CO2	Gg	3	50	33	44	45	28	32	32	29
1 A 3 a aviation gasoline	Domestic Aviation	CO2	Gg	8	7	6	9	9	8	6	6	5
1 A 3 a jet kerosene	Domestic Aviation	CO2	Gg	31	46	61	58	54	42	18	18	24
1 A 3 b gasoline	Road Transportation	CO2	Gg	7 896	7 397	6 092	6 393	5 284	4 781	3 962	4 213	4 389
1 A 3 b diesel oil	Road Transportation	CO2	Gg	5 358	7 756	11 896	17 625	16 214	16 738	16 242	16 829	15 639
1 A 3 b LPG	Road Transportation	CO2	Gg	26	32	43	60	57	36	8	10	7
1 A 3 b other	Road Transportation	CO2	Gg	NO	NO	NO	13	69	85	56	58	55
1 A 3 b gaseous	Road Transportation	CO2	Gg	NO	NO	NO	1	25	40	44	43	40
1 A 3 c liquid	Railways	CO2	Gg	171	143	133	160	142	86	81	80	80
1 A 3 c other	Railways	CO2	Gg	NO	NO	NO	0	1	0	0	0	0
1 A 3 c solid	Railways	CO2	Gg	7	6	3	1	0	0	0	0	0
1 A 3 d gas/diesel oil	Domestic Navigation	CO2	Gg	18	25	33	46	47	58	17	29	62
1 A 3 d other	Domestic Navigation	CO2	Gg	NO	NO	NO	0	0	0	0	0	0
1 A 3 d gasoline	Domestic Navigation	CO2	Gg	10	9	9	9	8	7	7	7	7
1 A 3 e gaseous	Other Transportation	CO2	Gg	224	227	338	359	459	586	472	374	152
1 A 3 e liquid	Other Transportation	CO2	Gg	5	7	9	11	11	10	6	7	11
1 A 3 e other	Other Transportation	CO2	Gg	NO	NO	NO	0	0	0	0	0	0
1 A 4 a liquid	Commercial/Institutional	CO2	Gg	1 420	1 316	1 338	1 986	682	446	447	585	495
1 A 4 a solid	Commercial/Institutional	CO2	Gg	91	60	105	68	21	0	NO	NO	NO
1 A 4 a gaseous	Commercial/Institutional	CO2	Gg	698	1 623	1 311	1 283	952	845	842	939	718
1 A 4 a other	Commercial/Institutional	CO2	Gg	83	39	42	81	4	6	0	0	0
1 A 4 b liquid	Residential	CO2	Gg	5 633	5 844	5 602	4 934	4 311	3 347	3 076	3 232	2 791
1 A 4 b other	Residential	CO2	Gg	NO	NO	NO	0	0	0	0	0	0
1 A 4 b solid	Residential	CO2	Gg	2 511	1 651	851	372	244	86	55	45	34
1 A 4 b gaseous	Residential	CO2	Gg	1 856	2 453	2 709	3 640	3 627	3 149	3 339	3 677	3 032
1 A 4 b peat	Residential	CO2	Gg	0	0	0	0	0	0	NO	NO	NO
1 A 4 c liquid	Agriculture/Forestry/Fishing	CO2	Gg	1 180	926	999	952	803	788	828	808	800
1 A 4 c other	Agriculture/Forestry/Fishing	CO2	Gg	NO	NO	NO	0	3	3	2	2	2
1 A 4 c solid	Agriculture/Forestry/Fishing	CO2	Gg	51	37	17	12	5	2	2	1	1
1 A 4 c gaseous	Agriculture/Forestry/Fishing	CO2	Gg	20	27	30	43	47	34	50	54	46
1 A 4 c biomass	Agriculture/Forestry/Fishing	CO2	Gg	NA	NA	NA	NA	NA	NA	NA	NA	NA
1 A 5 other	Other	CO2	Gg	NO	NO	NO	0	0	0	0	0	0
1 A 5 b liquid	Mobile combustion - Military	CO2	Gg	37	34	42	44	42	35	28	28	27
1 B 2 a	Oil	CO2	Gg	0	0	0	0	0	0	0	0	0

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2020	2021	2022
1 B 2 b	Natural Gas	CO2	Gg	102	127	165	160	184	162	109	84	80
2 A 1	Cement Production	CO2	Gg	2 033	1 631	1 712	1 797	1 622	1 701	1 821	1 889	1 832
2 A 2	Lime Production	CO2	Gg	456	452	556	618	604	609	579	653	624
2 A 3	Glass Production	CO2	Gg	39	42	36	35	40	40	39	36	35
2 A 4 a	Ceramics	CO2	Gg	116	149	116	128	81	91	106	96	100
2 A 4 b	Other uses of soda ash	CO2	Gg	5	6	8	13	10	10	9	10	10
2 A 4 c	Non-metallurgical Magnesium	CO2	Gg	481	410	339	310	314	301	282	357	317
2 A 4 d	Other	CO2	Gg	NO	NO	NO	NO	NO	NO	NO	NO	NO
2 B 1	Ammonia Production	CO2	Gg	467	509	491	462	475	501	491	500	418
2 B 2	Nitric Acid Production	CO2	Gg	0	0	0	0	0	0	0	0	0
2 B 5	Carbide Production	CO2	Gg	38	32	43	38	37	46	40	44	43
2 B-10	Other (please specify)	CO2	Gg	138	134	135	145	157	135	146	143	138
2 C 1	Iron and Steel Production	CO2	Gg	6 840	7 564	8 420	9 764	10 388	10 787	9 482	11 002	10 280
2 C 2	Ferroalloys Production	CO2	Gg	21	21	19	19	20	20	17	17	17
2 C 3	Aluminium Production	CO2	Gg	150	1	2	1	4	5	5	6	5
2 C 5	Lead Production	CO2	Gg	5	4	4	5	5	5	5	5	5
2 D	Non-Energy Products from Fuels and Solvent Use	CO2	Gg	349	234	198	174	169	135	155	162	172
2 G	Other Product Manufacture and Use	CO2	Gg	NA	NA	NA	NA	NA	NA	NA	NA	NE
3 G	Liming	CO2	Gg	46	36	43	54	69	83	99	99	99
3 H	Urea application	CO2	Gg	10	20	19	22	29	35	25	23	26
3 I	Other (please specify)	CO2	Gg	31	29	27	20	15	27	25	27	24
5 C	Incineration and Open Burning of Waste	CO2	Gg	28	11	12	12	2	2	2	2	2
1 A 1 a liquid	Public Electricity and Heat Production	CH4	Gg CO2 e	1	2	1	1	1	0	0	0	0
1 A 1 a solid	Public Electricity and Heat Production	CH4	Gg CO2 e	2	1	1	2	1	1	0	NO	NO
1 A 1 a gaseous	Public Electricity and Heat Production	CH4	Gg CO2 e	2	2	2	3	3	2	2	2	2
1 A 1 a biomass	Public Electricity and Heat Production	CH4	Gg CO2 e	1	2	3	6	17	18	18	19	19
1 A 1 a other	Public Electricity and Heat Production	CH4	Gg CO2 e	1	1	1	2	3	4	4	4	4
1 A 1 c liquid	Manufacture of Solid Fuels and Other Energy Industries	CH4	Gg CO2 e	0	0	NO	NO	NO	NO	NO	NO	NO
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 1 c biomass	Manufacture of Solid Fuels and Other Energy Industries	CH4	Gg CO2 e	1	1	1	1	1	1	1	1	1
1 A 1 b gaseous	Petroleum Refining	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 1 b liquid	Petroleum Refining	CH4	Gg CO2 e	1	1	1	2	2	2	2	2	1
1 A 2 a liquid	Iron and Steel	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 a solid	Iron and Steel	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 a gaseous	Iron and Steel	CH4	Gg CO2 e	0	0	1	1	1	1	1	1	1
1 A 2 a biomass	Iron and Steel	CH4	Gg CO2 e	NO	NO	NO	NO	0	0	0	0	0

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2020	2021	2022
1 A 2 b liquid	Non-Ferrous Metals	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 b solid	Non-Ferrous Metals	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 b gaseous	Non-Ferrous Metals	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 b other	Non-Ferrous Metals	CH4	Gg CO2 e	NO	NO	NO	NO	NO	0	0	0	0
1 A 2 b biomass	Non-Ferrous Metals	CH4	Gg CO2 e	NO	NO	NO	NO	NO	0	0	0	0
1 A 2 c liquid	Chemicals	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 c solid	Chemicals	CH4	Gg CO2 e	0	0	1	0	0	0	0	0	0
1 A 2 c gaseous	Chemicals	CH4	Gg CO2 e	0	0	0	1	1	1	1	1	0
1 A 2 c biomass	Chemicals	CH4	Gg CO2 e	1	0	1	1	1	1	1	1	1
1 A 2 c other	Chemicals	CH4	Gg CO2 e	1	1	1	0	1	1	1	1	1
1 A 2 d liquid	Pulp, Paper and Print	CH4	Gg CO2 e	1	1	0	0	0	0	0	0	0
1 A 2 d solid	Pulp, Paper and Print	CH4	Gg CO2 e	1	1	1	1	1	1	1	1	0
1 A 2 d gaseous	Pulp, Paper and Print	CH4	Gg CO2 e	0	1	1	1	1	1	1	1	1
1 A 2 d biomass	Pulp, Paper and Print	CH4	Gg CO2 e	3	5	3	5	4	4	5	4	5
1 A 2 d other	Pulp, Paper and Print	CH4	Gg CO2 e	0	0	NO	0	0	0	0	0	0
1 A 2 e liquid	Food Processing, Beverages and Tobacco	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 e solid	Food Processing, Beverages and Tobacco	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 e biomass	Food Processing, Beverages and Tobacco	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 e other	Food Processing, Beverages and Tobacco	CH4	Gg CO2 e	NO	NO	NO	NO	0	0	0	NO	0
1 A 2 f liquid	Non-Metallic Minerals	CH4	Gg CO2 e	1	0	0	0	0	0	0	0	0
1 A 2 f solid	Non-Metallic Minerals	CH4	Gg CO2 e	2	1	1	1	1	1	1	1	1
1 A 2 f gaseous	Non-Metallic Minerals	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 f biomass	Non-Metallic Minerals	CH4	Gg CO2 e	NO	NO	NO	0	1	1	1	1	1
1 A 2 f other	Non-Metallic Minerals	CH4	Gg CO2 e	0	1	1	2	2	2	2	3	3
1 A 2 g 7 liquid	Off-road vehicles and other machinery	CH4	Gg CO2 e	0	0	1	1	0	0	0	0	0
1 A 2 g 7 biomass	Off-road vehicles and other machinery	CH4	Gg CO2 e	NO	NO	NO	0	0	0	0	0	0
1 A 2 g 8 liquid	Other Manufacturing Industries	CH4	Gg CO2 e	1	1	1	1	0	0	0	0	0
1 A 2 g 8 solid	Other Manufacturing Industries	CH4	Gg CO2 e	0	0	0	0	NO	0	0	0	0
1 A 2 g 8 gaseous	Other Manufacturing Industries	CH4	Gg CO2 e	1	1	1	1	1	1	1	1	1
1 A 2 g 8 biomass	Other Manufacturing Industries	CH4	Gg CO2 e	1	1	3	5	7	7	5	5	6
1 A 2 g 8 other	Other Manufacturing Industries	CH4	Gg CO2 e	0	0	0	1	1	0	0	0	0
1 A 3 a aviation gasoline	Domestic Aviation	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 a jet kerosene	Domestic Aviation	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 b gasoline	Road Transportation	CH4	Gg CO2 e	77	50	29	24	15	11	8	7	7
1 A 3 b diesel oil	Road Transportation	CH4	Gg CO2 e	4	4	4	5	4	6	11	12	12

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2020	2021	2022
1 A 3 b LPG	Road Transportation	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 b gaseous	Road Transportation	CH4	Gg CO2 e	NO	NO	NO	0	0	0	0	0	0
1 A 3 b biomass	Road Transportation	CH4	Gg CO2 e	NO	NO	NO	0	1	1	1	1	1
1 A 3 c liquid	Railways	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 c solid	Railways	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 c biomass	Railways	CH4	Gg CO2 e	NO	NO	NO	0	0	0	0	0	0
1 A 3 d gas/diesel oil	Domestic Navigation	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 d gasoline	Domestic Navigation	CH4	Gg CO2 e	1	1	1	1	0	0	0	0	0
1 A 3 d biomass	Domestic Navigation	CH4	Gg CO2 e	NO	NO	NO	0	0	0	0	0	0
1 A 3 e gaseous	Other Transportation	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 e liquid	Other Transportation	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 e biomass	Other Transportation	CH4	Gg CO2 e	NO	NO	NO	0	0	0	0	0	0
1 A 3 e other	Other Transportation	CH4	Gg CO2 e	IE	IE	IE	IE	IE	IE	IE	IE	IE
1 A 4 a liquid	Commercial/Institutional	CH4	Gg CO2 e	5	4	3	3	1	1	1	1	1
1 A 4 a solid	Commercial/Institutional	CH4	Gg CO2 e	0	0	0	0	0	0	NO	NO	NO
1 A 4 a gaseous	Commercial/Institutional	CH4	Gg CO2 e	2	4	3	3	2	2	2	2	2
1 A 4 a biomass	Commercial/Institutional	CH4	Gg CO2 e	8	6	6	4	6	3	4	4	3
1 A 4 a other	Commercial/Institutional	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 4 b liquid	Residential	CH4	Gg CO2 e	22	19	17	13	8	6	5	5	5
1 A 4 b solid	Residential	CH4	Gg CO2 e	224	147	76	33	22	8	5	4	3
1 A 4 b gaseous	Residential	CH4	Gg CO2 e	5	6	7	9	9	8	8	9	8
1 A 4 b biomass	Residential	CH4	Gg CO2 e	264	270	240	219	260	228	212	251	200
1 A 4 b peat	Residential	CH4	Gg CO2 e	0	0	0	0	0	0	NO	NO	NO
1 A 4 c liquid	Agriculture/Forestry/Fishing	CH4	Gg CO2 e	7	5	5	4	2	2	1	1	1
1 A 4 c solid	Agriculture/Forestry/Fishing	CH4	Gg CO2 e	5	3	1	1	0	0	0	0	0
1 A 4 c gaseous	Agriculture/Forestry/Fishing	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 4 c biomass	Agriculture/Forestry/Fishing	CH4	Gg CO2 e	34	38	42	48	54	58	53	63	51
1 A 5 b liquid	Mobile combustion - Military	CH4	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 5 b biomass	Mobile combustion - Military	CH4	Gg CO2 e	NO	NO	NO	0	0	0	0	0	0
1 B 1 a	Coal Mining and Handling	CH4	Gg CO2 e	373	41	30	0	NA	NA	NA	NA	NA
1 B 2 a	Oil	CH4	Gg CO2 e	8	9	9	9	8	10	9	9	6
1 B 2 b	Natural Gas	CH4	Gg CO2 e	290	327	332	301	310	285	237	238	225
2 B 1	Ammonia Production	CH4	Gg CO2 e	2	2	2	3	2	3	2	1	1
2 B 8	Petrochemical and Carbon Black Production	CH4	Gg CO2 e	29	29	29	29	42	42	42	42	42
2 B-10	Other (please specify)	CH4	Gg CO2 e	9	9	10	10	10	10	11	11	12
2 C 1	Iron and Steel Production	CH4	Gg CO2 e	6	7	7	7	3	4	4	4	5

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2020	2021	2022
3 A 1	Cattle	CH4	Gg CO2 e	4 854	4 774	4 477	4 194	4 220	4 155	4 007	4 018	4 035
3 A 2	Sheep	CH4	Gg CO2 e	69	82	76	73	80	79	88	90	90
3 A 3	Swine	CH4	Gg CO2 e	88	84	76	74	74	68	68	68	64
3 A 4	Other (please specify)	CH4	Gg CO2 e	44	58	63	69	80	87	95	96	95
3 B 1 1	Cattle	CH4	Gg CO2 e	467	444	409	376	442	511	514	515	522
3 B 1 2	Sheep	CH4	Gg CO2 e	3	3	3	3	3	3	3	3	3
3 B 1 3	Swine	CH4	Gg CO2 e	148	134	116	106	101	90	88	87	83
3 B 1 4	Other (please specify)	CH4	Gg CO2 e	14	16	16	17	19	22	24	24	24
3 F	Field Burning of Agricultural Residues	CH4	Gg CO2 e	1	1	1	1	1	0	0	NO	NO
5 A	Solid Waste Disposal	CH4	Gg CO2 e	4 081	3 758	2 987	2 730	1 978	1 328	950	898	846
5 B	Biological Treatment of Solid Waste	CH4	Gg CO2 e	15	29	35	55	70	76	78	79	77
5 C	Incineration and Open Burning of Waste	CH4	Gg CO2 e	1	1	1	0	0	0	0	0	0
5 D	Waste Water Treatment and Discharge	CH4	Gg CO2 e	137	119	77	49	34	29	25	25	24
1 A 1 a liquid	Public Electricity and Heat Production	N2O	Gg CO2 e	2	3	2	2	1	1	0	0	0
1 A 1 a solid	Public Electricity and Heat Production	N2O	Gg CO2 e	24	18	20	24	16	10	2	NO	NO
1 A 1 a gaseous	Public Electricity and Heat Production	N2O	Gg CO2 e	2	2	2	3	3	2	2	2	2
1 A 1 a biomass	Public Electricity and Heat Production	N2O	Gg CO2 e	3	6	11	23	61	65	66	69	67
1 A 1 a other	Public Electricity and Heat Production	N2O	Gg CO2 e	4	3	3	6	11	13	12	12	12
1 A 1 b liquid	Petroleum Refining	N2O	Gg CO2 e	2	2	2	3	3	4	4	3	2
1 A 1 b gaseous	Petroleum Refining	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 1 c liquid	Manufacture of Solid Fuels and Other Energy Industries	N2O	Gg CO2 e	0	0	NO	NO	NO	NO	NO	NO	NO
1 A 1 c gaseous	Manufacture of Solid Fuels and Other Energy Industries	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 a liquid	Iron and Steel	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 a solid	Iron and Steel	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 a gaseous	Iron and Steel	N2O	Gg CO2 e	0	0	0	1	1	1	1	0	0
1 A 2 a biomass	Iron and Steel	N2O	Gg CO2 e	NO	NO	NO	NO	0	0	0	0	0
1 A 2 b liquid	Non-Ferrous Metals	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 b solid	Non-Ferrous Metals	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 b gaseous	Non-Ferrous Metals	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 b other	Non-Ferrous Metals	N2O	Gg CO2 e	NO	NO	NO	NO	NO	0	0	0	0
1 A 2 b biomass	Non-Ferrous Metals	N2O	Gg CO2 e	NO	NO	NO	NO	NO	0	0	0	0
1 A 2 c liquid	Chemicals	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 c solid	Chemicals	N2O	Gg CO2 e	0	1	1	1	0	0	0	0	0
1 A 2 c gaseous	Chemicals	N2O	Gg CO2 e	0	0	0	0	0	0	1	1	0
1 A 2 c biomass	Chemicals	N2O	Gg CO2 e	3	2	4	2	3	2	3	3	4
1 A 2 c other	Chemicals	N2O	Gg CO2 e	2	2	2	2	4	3	3	3	4

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2020	2021	2022
1 A 2 d liquid	Pulp, Paper and Print	N2O	Gg CO2 e	2	1	0	0	0	0	0	0	0
1 A 2 d solid	Pulp, Paper and Print	N2O	Gg CO2 e	2	2	2	2	1	2	1	1	1
1 A 2 d gaseous	Pulp, Paper and Print	N2O	Gg CO2 e	0	1	1	1	1	1	1	1	1
1 A 2 d biomass	Pulp, Paper and Print	N2O	Gg CO2 e	15	22	17	24	22	21	23	22	25
1 A 2 d other	Pulp, Paper and Print	N2O	Gg CO2 e	0	1	NO	0	0	0	0	0	0
1 A 2 e liquid	Food Processing, Beverages and Tobacco	N2O	Gg CO2 e	1	1	0	0	0	0	0	0	0
1 A 2 e solid	Food Processing, Beverages and Tobacco	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 e gaseous	Food Processing, Beverages and Tobacco	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 e biomass	Food Processing, Beverages and Tobacco	N2O	Gg CO2 e	0	0	0	0	1	0	0	0	1
1 A 2 e other	Food Processing, Beverages and Tobacco	N2O	Gg CO2 e	NO	NO	NO	NO	0	0	0	NO	0
1 A 2 f liquid	Non-Metallic Minerals	N2O	Gg CO2 e	1	1	0	1	0	0	0	0	0
1 A 2 f solid	Non-Metallic Minerals	N2O	Gg CO2 e	2	2	2	2	1	1	1	1	1
1 A 2 f gaseous	Non-Metallic Minerals	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 2 f biomass	Non-Metallic Minerals	N2O	Gg CO2 e	NO	NO	NO	2	3	4	4	4	5
1 A 2 f other	Non-Metallic Minerals	N2O	Gg CO2 e	1	2	4	5	5	8	8	8	8
1 A 2 g 7 liquid	Off-road vehicles and other machinery	N2O	Gg CO2 e	24	35	59	62	48	38	35	38	40
1 A 2 g 7 biomass	Off-road vehicles and other machinery	N2O	Gg CO2 e	NO	NO	NO	1	3	3	2	2	2
1 A 2 g 8 liquid	Other Manufacturing Industries	N2O	Gg CO2 e	1	1	1	1	1	0	0	0	0
1 A 2 g 8 solid	Other Manufacturing Industries	N2O	Gg CO2 e	0	0	0	0	NO	0	0	0	0
1 A 2 g 8 gaseous	Other Manufacturing Industries	N2O	Gg CO2 e	0	1	1	1	1	1	1	1	1
1 A 2 g 8 biomass	Other Manufacturing Industries	N2O	Gg CO2 e	4	2	9	18	24	28	19	20	23
1 A 2 g 8 other	Other Manufacturing Industries	N2O	Gg CO2 e	0	1	0	2	2	0	1	0	1
1 A 3 a aviation gasoline	Domestic Aviation	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 a jet kerosene	Domestic Aviation	N2O	Gg CO2 e	0	1	1	1	1	1	0	0	0
1 A 3 b gasoline	Road Transportation	N2O	Gg CO2 e	83	96	70	53	25	11	7	7	6
1 A 3 b diesel oil	Road Transportation	N2O	Gg CO2 e	11	21	44	78	111	158	190	199	190
1 A 3 b LPG	Road Transportation	N2O	Gg CO2 e	0	0	1	1	0	0	0	0	0
1 A 3 b gaseous	Road Transportation	N2O	Gg CO2 e	NO	NO	NO	0	0	0	0	0	0
1 A 3 b biomass	Road Transportation	N2O	Gg CO2 e	NO	NO	NO	1	12	24	13	14	13
1 A 3 c liquid	Railways	N2O	Gg CO2 e	16	13	13	15	11	5	4	4	4
1 A 3 c solid	Railways	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 c biomass	Railways	N2O	Gg CO2 e	NO	NO	NO	0	1	0	0	0	0
1 A 3 d gas/diesel oil	Domestic Navigation	N2O	Gg CO2 e	2	3	4	5	5	5	1	2	5
1 A 3 d gasoline	Domestic Navigation	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 d biomass	Domestic Navigation	N2O	Gg CO2 e	NO	NO	NO	0	0	0	0	0	0
1 A 3 e gaseous	Other Transportation	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2020	2021	2022
1 A 3 e liquid	Other Transportation	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 3 e biomass	Other Transportation	N2O	Gg CO2 e	NO	NO	NO	0	0	0	0	0	0
1 A 3 e other	Other Transportation	N2O	Gg CO2 e	IE	IE	IE	IE	IE	IE	IE	IE	IE
1 A 4 a liquid	Commercial/Institutional	N2O	Gg CO2 e	3	2	3	4	1	1	1	1	1
1 A 4 a solid	Commercial/Institutional	N2O	Gg CO2 e	0	0	0	0	0	0	NO	NO	NO
1 A 4 a gaseous	Commercial/Institutional	N2O	Gg CO2 e	0	1	1	1	0	0	0	0	0
1 A 4 a biomass	Commercial/Institutional	N2O	Gg CO2 e	2	2	4	3	4	3	4	4	3
1 A 4 a other	Commercial/Institutional	N2O	Gg CO2 e	1	1	1	1	0	0	0	0	0
1 A 4 b liquid	Residential	N2O	Gg CO2 e	18	19	18	16	13	9	8	8	7
1 A 4 b solid	Residential	N2O	Gg CO2 e	11	7	4	2	1	0	0	0	0
1 A 4 b gaseous	Residential	N2O	Gg CO2 e	1	1	1	2	2	2	2	2	1
1 A 4 b biomass	Residential	N2O	Gg CO2 e	62	66	64	62	80	77	75	91	73
1 A 4 b peat	Residential	N2O	Gg CO2 e	0	0	0	0	0	0	NO	NO	NO
1 A 4 c liquid	Agriculture/Forestry/Fishing	N2O	Gg CO2 e	68	68	77	76	54	39	34	32	30
1 A 4 c solid	Agriculture/Forestry/Fishing	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 4 c gaseous	Agriculture/Forestry/Fishing	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
1 A 4 c biomass	Agriculture/Forestry/Fishing	N2O	Gg CO2 e	4	5	5	7	10	10	9	10	8
1 A 5 b liquid	Mobile combustion - Military	N2O	Gg CO2 e	1	1	1	1	1	1	1	1	0
1 A 5 b biomass	Mobile combustion - Military	N2O	Gg CO2 e	NO	NO	NO	0	0	0	0	0	0
2 B 2	Nitric Acid Production	N2O	Gg CO2 e	780	733	813	234	54	42	47	41	23
2 G	Other Product Manufacture and Use	N2O	Gg CO2 e	117	117	117	67	47	37	33	32	32
3 B 1 1	Cattle	N2O	Gg CO2 e	294	279	262	247	265	284	280	280	281
3 B 1 2	Sheep	N2O	Gg CO2 e	5	6	6	6	6	6	7	7	7
3 B 1 3	Swine	N2O	Gg CO2 e	99	88	74	66	63	57	57	56	53
3 B 1 4	Other (please specify)	N2O	Gg CO2 e	8	11	11	12	14	15	17	17	17
3 B 2 5	Indirect N2O Emissions	N2O	Gg CO2 e	103	104	99	99	105	107	110	111	111
3 D 1	Direct N2O Emissions from Managed Soils	N2O	Gg CO2 e	1 776	1 645	1 570	1 468	1 417	1 539	1 495	1 502	1 455
3 D 2	Indirect N2O emissions from Managed Soils	N2O	Gg CO2 e	357	331	310	289	287	309	296	297	288
3 F	Field Burning of Agricultural Residues	N2O	Gg CO2 e	0	0	0	0	0	0	0	NO	NO
5 B	Biological Treatment of Solid Waste	N2O	Gg CO2 e	20	38	46	61	63	65	71	74	72
5 C	Incineration and Open Burning of Waste	N2O	Gg CO2 e	0	0	0	0	0	0	0	0	0
5 D	Waste Water Treatment and Discharge	N2O	Gg CO2 e	86	99	120	133	141	145	151	152	152
2 C 3	Aluminium Production	PFC	Gg CO2 e	1 032	0	0	0	0	0	0	0	0
2 C 4	Magnesium Production – Mg Foundries	SF6	Gg CO2 e	235	422	37	5	0	2	5	5	2
2 C 3	Aluminium Production – Al Foundries	SF6	Gg CO2 e	14	14	0	0	0	0	0	0	0
2 E	Electronics Industry	HFC	Gg CO2 e	2	9	4	4	2	2	3	3	3

IPCC Category Code	IPCC Category	GHG	Unit	1990	1995	2000	2005	2010	2015	2020	2021	2022
2 E	Electronics Industry	PFC	Gg CO2 e	31	75	79	145	71	45	27	23	26
2 E	Electronics Industry	SF6	Gg CO2 e	100	422	327	166	68	43	13	15	13
2 E	Electronics Industry	NF3	Gg CO2 e	0	6	10	26	4	13	11	12	14
2 F 1	Refrigeration and Air Conditioning Equipment	HFC	Gg CO2 e	0	36	382	914	1 366	1 797	1 599	1 379	1 355
2 F 2	Foam Blowing Agents	HFC	Gg CO2 e	0	275	267	146	35	15	15	14	14
2 F 3	Fire Protection	HFC	Gg CO2 e	0	0	0	6	11	12	11	12	12
2 F 4	Aerosols	HFC	Gg CO2 e	0	4	25	38	20	24	24	23	27
2 F 5	Solvents	HFC	Gg CO2 e	0	0	0	0	0	0	0	0	0
2 F 6	Other Applications	PFC	Gg CO2 e	0	0	0	0	0	0	0	0	0
2 G 1	Other product manufacture and use - Electrical Equipment	SF6	Gg CO2 e	11	15	18	23	30	37	45	47	49
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	PFC	Gg CO2 e	0	0	0	0	0	0	0	0	0
2 G 2	Other product manufacture and use - SF6 and PFCs from other product use	SF6	Gg CO2 e	124	262	211	315	248	236	391	304	301
2 G 4 b	ORC	PFC	Gg CO2 e	0	0	1	5	0	0	0	0	0
2 G 4 b	ORC	HFC	Gg CO2 e	0	0	0	0	0	0	0	0	0
4 A 1	Forest land remaining forest land	CO2	Gg	-8 122	-15 891	-11 608	-14 683	-17 223	-5 476	-6 430	-9 965	-3 192
4 A 2	Land converted to forest land	CO2	Gg	-2 955	-2 973	-2 319	-2 083	-1 871	-1 581	-1 465	-1 441	-1 420
4 B 1	Cropland remaining cropland	CO2	Gg	-18	-37	-192	-304	-303	-222	-39	49	84
4 B 2	Land converted to cropland	CO2	Gg	202	177	175	186	182	197	227	230	233
4 C 1	Grassland remaining grassland	CO2	Gg	304	304	304	304	304	304	304	304	304
4 C 2	Land converted to grassland	CO2	Gg	393	176	184	436	241	225	150	141	140
4 D 1	Wetlands remaining Wetlands	CO2	Gg	0	0	0	0	0	0	0	0	0
4 D 2	Land converted to Wetlands	CO2	Gg	48	34	40	52	86	75	73	70	70
4 E 2	Land converted to Settlements	CO2	Gg	917	861	783	941	937	843	792	758	746
4 F 2	Land converted to Other land	CO2	Gg	502	413	406	353	495	494	510	514	517
4 G	HWP	CO2	Gg	-3 122	-2 569	-1 889	-3 461	-2 452	-1 254	-122	-1 889	-2 110
4	Total land use categories	CH4	Gg CO2 e	27	27	27	27	27	27	27	27	27
4	Total land use categories	N2O	Gg CO2 e	143	146	132	133	138	134	129	128	127

ANNEX 2: ASSESSMENT OF UNCERTAINTY

A consistent assessment of uncertainties of the Austrian greenhouse gas inventory requires a detailed understanding of the uncertainties of the respective input parameters. Since the first detailed uncertainty evaluation (WINIWARTER & ORTHOFER 2000, WINIWARTER & RYPDAL 2001), the Austrian inventory compilers have spent considerable effort to also obtain uncertainties from individual contributors to the inventory. This leads to a situation where national information or at least national expert knowledge directly from the stage of inventory development may flow into the assessment of uncertainties.

The respective sectoral uncertainties are documented in detail in the sectoral chapters of this report. Specific uncertainty estimates are e.g. available for agricultural soil, for enteric fermentation from animal husbandry, for F-gases, for transport, and for land-use change and forestry.

Annex 2.1 – Description of methodology used for identifying uncertainties

Theoretical background

The assessment and propagation of uncertainties in emission inventories has been described in detail by IPCC (IPCC 2000, IPCC 2006). Principally, two different pathways may be taken to arrive at a total uncertainty, and to develop an inventory uncertainty. The approach 1 is based on error propagation: assuming input information is available in form of normal distribution, and input uncertainties are statistically independent, the approach allows for reliable assessment of inventory uncertainty. More flexibility is possible in the method for approach 2. The Monte-Carlo approach allows any probability distribution of input parameters, and it also enables to define statistical dependencies between parameters. The most obvious dependency is a full dependency. This occurs when two values are based on the identical set of measurements. A variation or error in one value would then be fully reflected also in the other value. While “full dependency” theoretically can also be covered in error propagation, this is normally not done and only in a very limited way possible in the IPCC spreadsheets.

The general properties of error propagation allow to combine (add up) information in a way that the relative uncertainty (as percentage of the mean value) of the combination becomes lower than the relative uncertainty of any of the input parameters. This advantage of going into detail is often implicitly taken advantage of, when a problem is disassembled into sub-problems and the sub-results are being recombined. Nevertheless it is not always the most detailed level that yields results of lowest uncertainty. If measurements or assessments at the most detailed level are difficult, a more comprehensive level of information may provide the lower overall uncertainty.

As a consequence, optimizing the approach requires collecting input information at the most detailed level an inventory is prepared at. Attaching uncertainty data then may be done at a level where greatest confidence can be expected on the data. This may be the most detailed level, but more often uncertainty data will not be available, or a “balance” approach (energy balance, solvent balance) will allow more reliability at a more aggregated level.

Procedure

For the update of the uncertainty assessment of the Austrian greenhouse gas inventory, the most detailed level of the inventory system was used as the base level. This “base level” of the inventory facilitates compilation of emission data for different purposes. Reporting on air pollution (according to UN-ECE or European Commission requirements) is performed by agglomerating the details in basically the same way as it is done for the GHG inventory according to UNFCCC procedures.

This approach of starting at the most detailed level the inventory offers facilitated an assessment of emission uncertainty at any level that the most reasonable uncertainty data are available. Very detailed information can be entered directly, for aggregate information the same uncertainty (as a statistically dependent entity) is applied for all input entries concerned.

Uncertainty information was taken from national studies, from international information (as e.g. in the IPCC reports) from variation presented in literature, and by contacting national experts. Structured interviews were not held, but information collected previously in structured interviews still could be used.

In all input and output parameters, uncertainty has been expressed as normal or lognormal probability density function. In line with the IPCC requirements, the uncertainty range is presented as the range with 95% probability of a given value being within its boundaries. Thus the boundaries were given as the 2.5 and 97.5-percentiles of the respective distribution. For a normal distribution, this is +/- 2 standard deviations from the mean.

Random uncertainty vs. systematic uncertainty

In a previous study, random and systematic uncertainties were strictly separated. Systematic uncertainty was seen as composed of the errors contained and discovered in the national inventory during the analysis (WINIWARTER & RYPDAL 2001). As systematic uncertainty by the definition above is unknown at the time it occurs, its true magnitude can not be known. Previously, this magnitude of the errors still undiscovered was expected to be of similar magnitude as those identified. Such an assessment obviously refers to the inventory as a whole, and not to a single sector, as one should not expect an error always occurring in the same sector. Furthermore, it is highly questionable that the assumption, an error remaining relates to the error discovered already, can be sustained during all stages of inventory development.

Consequently here we did not perform a specific assessment of systematic uncertainty.

Data origin

Many of the uncertainties included in the calculations have already been covered in the previous submissions. Nevertheless it is worthwhile to consider some of the input uncertainties in detail – especially those that contribute more to the overall uncertainty.

Activities: According to information from the Austrian statistical agency, the Austrian energy balance is strongly affected by inexact reporting, reporting errors or omissions/double counting due to difficult attribution of responsibilities. Detailed statistics are therefore not very reliable, but on the total energy level a number of additional plausibility checks are performed. This procedure allows to expect high quality data of low uncertainty at a rather high level of detail, to be presented separately by the specified fuel types (coal/oil/gas, and also biomass but at a higher uncertainty). Consequently, separate (independent) assessment of energy data has been applied to power

plants, other combustion including industry, and transport. Within each of these ranges of sectors the specific uncertainty has been applied, but is considered statistically dependent.

Some very special fuels are also treated separately (landfill gas, black liquor). Additionally, large industrial plants are considered separately, as long as they remain sufficiently separate of the energy input. Iron and steel industry is considered dependent of energy. Non-energy sectors are assessed using the specific Austrian studies already mentioned above. These studies contain specific information on agricultural soil, enteric fermentation from animal husbandry, F-gases, transport, and on land-use change and forestry.

Activity related uncertainties for base year and target year are considered to be the same in all cases, but statistically independent. There are reports, e.g. on the solvent sector, which assume lower uncertainty for more recent data. As the solvent balance is strongly dependent on the trade statistics, which suffered heavily from the relaxation of reporting requirements after Austria's accession to the EU in 1995, such improvement was not considered.

Carbon dioxide (CO₂): The emission factor of CO₂ is in most cases well contained due to the carbon content of fuels or of raw materials. Still it is basically one set of measurements that is applied uniformly. A large number of single data have been applied to arrive at a reliable carbon content and consequently emission factor, but this is already factored-in in the magnitude of the uncertainty. Consequently, all energy related carbon contents by fuel type are here considered identical for all energy related activities. We assume independence of uncertainties between fuel types only. Some more independent uncertainty figures are available for source categories like solvents, chemical industry, land use change.

Methane (CH₄): Methane emissions are derived from a large variety of individual measurements of total hydrocarbon (HC) or total volatile organic compound emissions. But only the smaller part of uncertainties derives from these measurements. The larger part is caused by assumptions on the fraction of CH₄ in the HC mix, which ranges from 10% (coal fired large plants) to 75% (gas combustion). Therefore statistically independent numbers are no more than the CH₄ fractions considered separately. Such separate data is available only in combustion generally, in power plants, and in transport. Consequently we have here a very similar pattern as in activities.

Agricultural methane (enteric fermentation and manure treatment) has been assessed for Austria in specific studies, which also reported the uncertainty involved in emission factors (AMON et al. 2002, GEBETSROITHER et al. 2002). This uncertainty estimate could be applied here.

Nitrous oxide (N₂O): Very limited measurement data are available on nitrous oxide emissions. When trying to trace emission factors back to their origin, the large Austrian data collection on emission factors from combustion (STANZEL et al. 1995) refers virtually all N₂O factors back to GEMIS. In line with an earlier assessment done in an Austrian N₂O balance (ORTHOFFER et al. 1994), uncertainties by fuel in general and uncertainties in the domestic heating sector were considered independent. Also transport was considered independently, even separated between Diesel fuel and gasoline (as only the latter is equipped with catalysts, which are responsible for the larger share of emissions).

In addition to the definition of statistically independent parameters, some of the uncertainty attributions had to be adapted. Uncertainty figures in the energy sector refer to measurements done around 1990 (VITOVEC 1991). Changes in fuel quality or in combustion equipment are not at all reflected, leading to enhanced uncertainty which we here take from international data. Furthermore (and most importantly, see below), the uncertainty estimate on N₂O from soils used previously (NIR 2006) could not be sustained. A detailed investigation revealed that the source of

the 48% uncertainty presented was a statement in an IPCC report (IPCC 2000) referring to a measurement uncertainty. Here we have to deal with an emission factor uncertainty, which is estimated much higher, at an order of magnitude in the latest IPCC emission inventory guidelines (IPCC 2006). This higher number which we adopt now is still much smaller than the two orders of magnitude recommended by IPCC previously (IPCC 2000), and also smaller than a previous estimate for Austria (WINIWARTER & RYPDAL 2001). The latter was considered in part systematic uncertainty, however (the random uncertainty was considered smaller than the range now used) – this is still in part true, but only reflects our lack of knowledge on soil processes. Choosing to apply a quasi-standardized value conforms to the claim of (WINIWARTER 2007) that application of similar parameters between countries allows for a smaller error in an inter-comparison, even if the difference to a “true value” might be larger.

Fluorinated gases: The uncertainties related to emissions of fluorinated gases (PFC, HFC and SF₆) have been investigated within the emission assessment (NIR 2006). Basically, emissions in areas where substances are specifically brought in, e.g. as solvents, are considered well understood, those that refer to release (refrigeration, electrodes during Al-production) are considered highly uncertain.

Annex 2.2 – Results of the Uncertainty Assessment

Table A 18: Approach 1 Uncertainty Analysis (Article 7(1)(p) MMR) for 1990 – excluding LULUCF

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	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	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A Stationary Combustion – Biomass	CH4	312	287	5.0	50.0	50.2	0.0393	0.0000	0.0036	-0.0003	0.0257	0.0007
1.A Stationary Combustion – Biomass	CO2	0	0	5.0	1.0	5.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A Stationary Combustion – Biomass	N2O	93	211	5.0	50.0	50.2	0.0035	0.0016	0.0027	0.0792	0.0189	0.0066
1.A Stationary Combustion – Gaseous Fuels	CH4	11	15	2.0	50.0	50.0	0.0000	0.0001	0.0002	0.0034	0.0005	0.0000
1.A Stationary Combustion – Gaseous Fuels	CO2	11 076	15 271	2.0	0.2	2.0	0.0792	0.0640	0.1931	0.0128	0.5462	0.2985
1.A Stationary Combustion – Gaseous Fuels	N2O	5	7	2.0	50.0	50.0	0.0000	0.0000	0.0001	0.0015	0.0003	0.0000
1.A Stationary Combustion – Liquid Fuels	CH4	39	9	0.5	50.0	50.0	0.0006	-0.0003	0.0001	-0.0170	0.0001	0.0003
1.A Stationary Combustion – Liquid Fuels	CO2	14 203	8 196	0.5	0.5	0.7	0.0161	-0.0617	0.1036	-0.0308	0.0733	0.0063
1.A Stationary Combustion – Liquid Fuels	N2O	122	82	0.5	50.0	50.0	0.0059	-0.0004	0.0010	-0.0190	0.0007	0.0004
1.A Stationary Combustion – Other fuels	CH4	3	8	10.0	50.0	51.0	0.0000	0.0001	0.0001	0.0037	0.0015	0.0000
1.A Stationary Combustion – Other fuels	CO2	580	1 992	10.0	15.0	18.0	0.0175	0.0184	0.0252	0.2765	0.3563	0.2034
1.A Stationary Combustion – Other fuels	N2O	8	26	10.0	50.0	51.0	0.0000	0.0002	0.0003	0.0117	0.0046	0.0002
1.A Stationary Combustion – Solid Fuels	CH4	234	5	0.5	50.0	50.0	0.0219	-0.0027	0.0001	-0.1333	0.0000	0.0178
1.A Stationary Combustion – Solid Fuels	CO2	11 177	1 302	0.5	0.5	0.7	0.0100	-0.1136	0.0165	-0.0568	0.0116	0.0034
1.A Stationary Combustion – Solid Fuels	N2O	41	2	0.5	50.0	50.0	0.0007	-0.0004	0.0000	-0.0223	0.0000	0.0005
1.A.3.a Transport – Civil Aviation	CH4	0	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Transport – Civil Aviation	CO2	38	30	3.0	3.0	4.2	0.0000	-0.0001	0.0004	-0.0002	0.0016	0.0000
1.A.3.a Transport – Civil Aviation	N2O	1	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CH4	4	12	3.0	30.0	30.1	0.0000	0.0001	0.0002	0.0032	0.0007	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CO2	5 358	15 639	3.0	3.0	4.2	0.0826	0.1353	0.1978	0.4058	0.8390	0.8686
1.A.3.b Transport – Road Transportation – Diesel	N2O	11	190	3.0	30.0	30.1	0.0000	0.0023	0.0024	0.0682	0.0102	0.0047
1.A.3.b Transport – Road Transportation – Gaseous	CO2	0	40	3.0	3.0	4.2	0.0000	0.0005	0.0005	0.0015	0.0022	0.0000

IPCC category/Group	GHG									Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity			
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A.3.b Transport – Road Transportation – Gaseous	CH4	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	N2O	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gasoline	CH4	77	7	3.0	30.0	30.1	0.0009	-0.0008	0.0001	-0.0243	0.0004	0.0006
1.A.3.b Transport – Road Transportation – Gasoline	CO2	7 896	4 389	3.0	3.0	4.2	0.1794	-0.0364	0.0555	-0.1093	0.2355	0.0674
1.A.3.b Transport – Road Transportation – Gasoline	N2O	83	6	3.0	70.0	70.1	0.0054	-0.0009	0.0001	-0.0617	0.0003	0.0038
1.A.3.b Transport – Road Transportation – LPG	CO2	26	7	3.0	3.0	4.2	0.0000	-0.0002	0.0001	-0.0007	0.0004	0.0000
1.A.3.b Transport – Road Transportation – LPG	CH4	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – LPG	N2O	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CH4	0	1	5.0	50.0	50.2	0.0000	0.0000	0.0000	0.0006	0.0001	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CO2	0	0	5.0	30.0	30.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	N2O	0	13	5.0	3.0	5.8	0.0000	0.0002	0.0002	0.0005	0.0011	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CH4	0	0	5.0	70.0	70.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CO2	0	55	5.0	3.0	5.8	0.0000	0.0007	0.0007	0.0021	0.0049	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	N2O	0	0	5.0	50.0	50.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.c Transport – Railways	CH4	0	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.c Transport – Railways	CO2	178	80	3.0	3.0	4.2	0.0001	-0.0011	0.0010	-0.0032	0.0043	0.0000
1.A.3.c Transport – Railways	N2O	16	4	3.0	30.0	30.1	0.0000	-0.0001	0.0001	-0.0039	0.0002	0.0000
1.A.3.d Transport – Navigation	CH4	1	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.d Transport – Navigation	CO2	28	69	3.0	3.0	4.2	0.0000	0.0005	0.0009	0.0016	0.0037	0.0000
1.A.3.d Transport – Navigation	N2O	2	5	3.0	70.0	70.1	0.0000	0.0000	0.0001	0.0028	0.0003	0.0000
1.A.3.e Transport – Other Transportation	CH4	0	0	2.0	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Transport – Other Transportation	CO2	229	163	2.0	0.2	2.0	0.0000	-0.0006	0.0021	-0.0001	0.0058	0.0000
1.A.3.e Transport – Other Transportation	N2O	0	0	2.0	50.0	50.0	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.5.b Mobile	CH4	0	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Mobile	CO2	37	27	1.0	0.5	1.1	0.0000	-0.0001	0.0003	0.0000	0.0005	0.0000
1.A.5.b Mobile	N2O	1	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH4	373	0	5.0	50.0	50.2	0.0562	-0.0043	0.0000	-0.2173	0.0000	0.0472

IPCC category/Group	GHG									Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity			
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.B.2.a Fugitive Emission – Oil	CH4	8	6	0.5	50.0	50.0	0.0000	0.0000	0.0001	-0.0011	0.0001	0.0000
1.B.2.a Fugitive Emission – Oil	CO2	0	0	0.5	0.5	0.7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b Fugitive Emission – Natural Gas	CH4	290	225	5.0	10.0	11.2	0.0017	-0.0005	0.0028	-0.0054	0.0201	0.0004
1.B.2.b Fugitive Emission – Natural Gas	CO2	102	80	5.0	0.2	5.0	0.0000	-0.0002	0.0010	0.0000	0.0072	0.0001
2.A.1 Mineral Industry – Cement Production	CO2	2 033	1 832	5.0	2.0	5.4	0.0192	-0.0005	0.0232	-0.0010	0.1638	0.0268
2.A.2 Mineral Industry – Lime Production	CO2	456	624	10.0	2.0	10.2	0.0035	0.0026	0.0079	0.0052	0.1116	0.0125
2.A.3 Mineral Industry – Glass Production	CO2	39	35	5.0	2.0	5.4	0.0000	0.0000	0.0004	0.0000	0.0031	0.0000
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO2	116	100	5.0	2.0	5.4	0.0001	-0.0001	0.0013	-0.0002	0.0090	0.0001
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO2	5	10	30.0	2.0	30.1	0.0000	0.0001	0.0001	0.0001	0.0055	0.0000
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO2	481	317	2.0	2.0	2.8	0.0003	-0.0016	0.0040	-0.0032	0.0113	0.0001
2.A.4.d Other Process Uses of Carbonates – other	CO2	0	0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.1 Chemical Industry – Ammonia Production	CH4	2	1	2.0	10.0	10.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.1 Chemical Industry – Ammonia Production	CO2	467	418	2.0	5.0	5.4	0.0010	-0.0002	0.0053	-0.0008	0.0150	0.0002
2.B.2 Chemical Industry – Nitric Acid Production	CO2	0	0	2.0	2.0	2.8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.2 Chemical Industry – Nitric Acid Production	N2O	780	23	2.0	2.0	2.8	0.0008	-0.0088	0.0003	-0.0176	0.0008	0.0003
2.B.5 Chemical Industry – Carbide Production	CO2	38	43	1.0	5.0	5.1	0.0000	0.0001	0.0005	0.0005	0.0008	0.0000
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH4	29	42	20.0	10.0	22.4	0.0001	0.0002	0.0005	0.0019	0.0150	0.0002
2.B.10 Chemical Industry – Other	CH4	9	12	2.0	2.0	2.8	0.0000	0.0000	0.0001	0.0001	0.0004	0.0000
2.B.10 Chemical Industry – Other	CO2	138	138	2.0	2.0	2.8	0.0000	0.0001	0.0017	0.0003	0.0049	0.0000
2.C.1 Metal Industry – Iron and Steel Production	CO2	6 840	10 280	2.0	0.5	2.1	0.0318	0.0503	0.1300	0.0251	0.3677	0.1358
2.C.1 Metal Industry – Iron and Steel Production	CH4	6	5	2.0	20.0	20.1	0.0000	0.0000	0.0001	-0.0001	0.0002	0.0000
2.C.2 Metal Industry – Ferroalloys Production	CO2	21	17	5.0	25.0	25.5	0.0000	0.0000	0.0002	-0.0007	0.0015	0.0000
2.C.3 Metal Industry – Aluminium Production	CO2	150	5	2.0	5.0	5.4	0.0001	-0.0017	0.0001	-0.0084	0.0002	0.0001
2.C.3 Metal Industry – Aluminium Production	PFC	1 032	0	2.0	50.0	50.0	0.4267	-0.0120	0.0000	-0.6011	0.0000	0.3613
2.C.3 Metal Industry – Aluminium Production	SF6	14	0	2.0	50.0	50.0	0.0001	-0.0002	0.0000	-0.0082	0.0000	0.0001
2.C.4 Metal Industry – Magnesium Production	SF6	235	2	5.0	5.0	7.1	0.0004	-0.0027	0.0000	-0.0135	0.0002	0.0002

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivi ty	Type B sensitiv ity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
2.C.5 Metal Industry – Lead Production	CO2	5	5	5.0	50.0	50.2	0.0000	0.0000	0.0001	0.0007	0.0005	0.0000
2.D Non-Energy Products from Fuels and Solvent Use	CO2	349	172	20.0	30.0	36.1	0.0253	-0.0019	0.0022	-0.0565	0.0617	0.0070
2.E Electronics Industry	HFC	2	3	5.0	10.0	11.2	0.0000	0.0000	0.0000	0.0001	0.0002	0.0000
2.E Electronics Industry	PFC	31	26	5.0	10.0	11.2	0.0000	0.0000	0.0003	-0.0003	0.0023	0.0000
2.E Electronics Industry	SF6	100	13	5.0	10.0	11.2	0.0002	-0.0010	0.0002	-0.0101	0.0011	0.0001
2.E Electronics Industry	NF3	0	14	5.0	10.0	11.2	0.0000	0.0002	0.0002	0.0018	0.0013	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	0	1 355	10.0	50.0	51.0	0.0000	0.0171	0.0171	0.8569	0.2424	0.7929
2.F.2 Foam Blowing	HFC	0	14	10.0	0.0	10.0	0.0000	0.0002	0.0002	0.0000	0.0026	0.0000
2.F.3 Fire Extinguishers	HFC	0	12	10.0	100.0	100.5	0.0000	0.0002	0.0002	0.0158	0.0022	0.0003
2.F.4 Aerosols	HFC	0	27	20.0	10.0	22.4	0.0000	0.0003	0.0003	0.0034	0.0095	0.0001
2.F.5 Solvents	HFC	0	0	100.0	0.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	11	49	5.0	100.0	100.1	0.0002	0.0005	0.0006	0.0493	0.0044	0.0024
2.G.2 Other product manufacture and use – SF6 and PFCs from other product use	PFC	0	0	5.0	100.0	100.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.2 Other product manufacture and use – SF6 and PFCs from other product use	SF6	124	301	5.0	100.0	100.1	0.0248	0.0024	0.0038	0.2356	0.0269	0.0562
2.G. Other Product Manufacture and Use	N2O	117	32	20.0	0.0	20.0	0.0009	-0.0010	0.0004	0.0000	0.0115	0.0001
3.A.1 Enteric Fermentation – Cattle	CH4	4 854	4 035	10.0	20.0	22.4	1.8835	-0.0055	0.0510	-0.1103	0.7215	0.5327
3.A.2 Enteric Fermentation – Sheep	CH4	69	90	10.0	40.0	41.2	0.0013	0.0003	0.0011	0.0131	0.0160	0.0004
3.A.3 Enteric Fermentation – Swine	CH4	88	64	10.0	20.0	22.4	0.0006	-0.0002	0.0008	-0.0043	0.0114	0.0001
3.A.4 Enteric Fermentation – Other	CH4	44	95	10.0	40.0	41.2	0.0005	0.0007	0.0012	0.0280	0.0171	0.0011
3.B.1.1 Manure Management – Cattle	CH4	467	522	10.0	20.0	22.4	0.0175	0.0011	0.0066	0.0230	0.0933	0.0092
3.B.1.1 Manure Management – Cattle	N2O	294	281	10.0	100.0	100.5	0.1394	0.0001	0.0036	0.0135	0.0503	0.0027
3.B.1.2 Manure Management – Sheep	CH4	3	3	10.0	30.0	31.6	0.0000	0.0000	0.0000	0.0004	0.0006	0.0000
3.B.1.2 Manure Management – Sheep	N2O	5	7	10.0	100.0	100.5	0.0000	0.0000	0.0001	0.0026	0.0013	0.0000
3.B.1.3 Manure Management – Swine	CH4	148	83	10.0	20.0	22.4	0.0017	-0.0007	0.0010	-0.0136	0.0148	0.0004
3.B.1.3 Manure Management – Swine	N2O	99	53	10.0	100.0	100.5	0.0157	-0.0005	0.0007	-0.0472	0.0096	0.0023

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	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	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
3.B.1.4. Manure Management – Other	CH4	14	24	10.0	30.0	31.6	0.0000	0.0001	0.0003	0.0041	0.0043	0.0000
3.B.1.4. Manure Management – Other	N2O	8	17	10.0	100.0	100.5	0.0001	0.0001	0.0002	0.0120	0.0031	0.0002
3.B.2.5 Indirect N2O Emissions	N2O	103	111	5.0	200.0	200.1	0.0673	0.0002	0.0014	0.0417	0.0099	0.0018
3.D.1 Direct N2O Emissions from Managed Soils	N2O	1 776	1 455	5.0	200.0	200.1	20.1934	-0.0023	0.0184	-0.4590	0.1301	0.2276
3.D.2 Indirect N2O emissions from Managed Soils	N2O	357	288	5.0	200.0	200.1	0.8166	-0.0005	0.0036	-0.1040	0.0257	0.0115
3.F Field Burning of Agricultural Residues	CH4	1	0	100.0	40.0	107.7	0.0000	0.0000	0.0000	-0.0004	0.0000	0.0000
3.F Field Burning of Agricultural Residues	N2O	0	0	100.0	50.0	111.8	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
3.G Liming	CO2	46	99	5.0	50.0	50.2	0.0008	0.0007	0.0013	0.0361	0.0089	0.0014
3.H Urea application	CO2	10	26	5.0	50.0	50.2	0.0000	0.0002	0.0003	0.0106	0.0023	0.0001
3.I Other	CO2	31	24	5.0	50.0	50.2	0.0004	0.0000	0.0003	-0.0024	0.0022	0.0000
5.A Solid Waste Disposal	CH4	4 081	846	12.0	25.0	27.7	2.0480	-0.0368	0.0107	-0.9205	0.1815	0.8803
5.B Biological Treatment of Solid Waste	CH4	15	77	20.0	50.0	53.9	0.0001	0.0008	0.0010	0.0402	0.0275	0.0024
5.B Biological Treatment of Solid Waste	N2O	20	72	20.0	50.0	53.9	0.0002	0.0007	0.0009	0.0338	0.0258	0.0018
5.C Incineration and Open Burning of Waste	CH4	1	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.C Incineration and Open Burning of Waste	CO2	28	2	7.0	20.0	21.2	0.0001	-0.0003	0.0000	-0.0060	0.0003	0.0000
5.C Incineration and Open Burning of Waste	N2O	0	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.D Waste Water Treatment and Discharge	CH4	137	24	20.0	50.0	53.9	0.0087	-0.0013	0.0003	-0.0644	0.0086	0.0042
5.D Waste Water Treatment and Discharge	N2O	86	152	20.0	100.0	102.0	0.0122	0.0009	0.0019	0.0929	0.0545	0.0116
Total		79 083	72 844				26.27					4.62
Total Uncertainties						Uncertainty in total inventory %:	5.12			Trend uncertainty %:		2.15

Table A 19: Approach 1 Uncertainty Analysis (Article 7(1)(p) MMR) for 2022 – excluding LULUCF

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	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	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A Stationary Combustion – Biomass	CH4	312	287	5.0	50.0	50.2	0.0392	0.0000	0.0036	-0.0003	0.0257	0.0007
1.A Stationary Combustion – Biomass	CO2	0	0	5.0	1.0	5.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A Stationary Combustion – Biomass	N2O	93	211	5.0	50.0	50.2	0.0212	0.0016	0.0027	0.0792	0.0189	0.0066
1.A Stationary Combustion – Gaseous Fuels	CH4	11	15	1.0	50.0	50.0	0.0001	0.0001	0.0002	0.0034	0.0003	0.0000
1.A Stationary Combustion – Gaseous Fuels	CO2	11 076	15 271	1.0	0.2	1.0	0.0457	0.0640	0.1931	0.0128	0.2731	0.0747
1.A Stationary Combustion – Gaseous Fuels	N2O	5	7	1.0	50.0	50.0	0.0000	0.0000	0.0001	0.0015	0.0001	0.0000
1.A Stationary Combustion – Liquid Fuels	CH4	39	9	0.5	50.0	50.0	0.0000	-0.0003	0.0001	-0.0170	0.0001	0.0003
1.A Stationary Combustion – Liquid Fuels	CO2	14 203	8 196	0.5	0.5	0.7	0.0063	-0.0617	0.1036	-0.0308	0.0733	0.0063
1.A Stationary Combustion – Liquid Fuels	N2O	122	82	0.5	50.0	50.0	0.0032	-0.0004	0.0010	-0.0190	0.0007	0.0004
1.A Stationary Combustion – Other fuels	CH4	3	8	5.0	50.0	50.2	0.0000	0.0001	0.0001	0.0037	0.0007	0.0000
1.A Stationary Combustion – Other fuels	CO2	580	1 992	5.0	15.0	15.8	0.1870	0.0184	0.0252	0.2765	0.1781	0.1082
1.A Stationary Combustion – Other fuels	N2O	8	26	5.0	50.0	50.2	0.0003	0.0002	0.0003	0.0117	0.0023	0.0001
1.A Stationary Combustion – Solid Fuels	CH4	234	5	0.5	50.0	50.0	0.0000	-0.0027	0.0001	-0.1333	0.0000	0.0178
1.A Stationary Combustion – Solid Fuels	CO2	11 177	1 302	0.5	0.5	0.7	0.0002	-0.1136	0.0165	-0.0568	0.0116	0.0034
1.A Stationary Combustion – Solid Fuels	N2O	41	2	0.5	50.0	50.0	0.0000	-0.0004	0.0000	-0.0223	0.0000	0.0005
1.A.3.a Transport – Civil Aviation	CH4	0	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Transport – Civil Aviation	CO2	38	30	3.0	3.0	4.2	0.0000	-0.0001	0.0004	-0.0002	0.0016	0.0000
1.A.3.a Transport – Civil Aviation	N2O	1	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CH4	4	12	3.0	30.0	30.1	0.0000	0.0001	0.0002	0.0032	0.0007	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CO2	5 358	15 639	3.0	3.0	4.2	0.8297	0.1353	0.1978	0.4058	0.8390	0.8686
1.A.3.b Transport – Road Transportation – Diesel	N2O	11	190	3.0	30.0	30.1	0.0062	0.0023	0.0024	0.0682	0.0102	0.0047
1.A.3.b Transport – Road Transportation – Gaseous	CO2	0	40	3.0	3.0	4.2	0.0000	0.0005	0.0005	0.0015	0.0022	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	CH4	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	N2O	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gasoline	CH4	77	7	3.0	30.0	30.1	0.0000	-0.0008	0.0001	-0.0243	0.0004	0.0006

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivi ty	Type B sensitiv ity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A.3.b Transport – Road Transportation – Gasoline	CO2	7 896	4 389	3.0	3.0	4.2	0.0653	-0.0364	0.0555	-0.1093	0.2355	0.0674
1.A.3.b Transport – Road Transportation – Gasoline	N2O	83	6	3.0	70.0	70.1	0.0000	-0.0009	0.0001	-0.0617	0.0003	0.0038
1.A.3.b Transport – Road Transportation – LPG	CO2	26	7	3.0	3.0	4.2	0.0000	-0.0002	0.0001	-0.0007	0.0004	0.0000
1.A.3.b Transport – Road Transportation – LPG	CH4	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – LPG	N2O	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CH4	0	1	5.0	50.0	50.2	0.0000	0.0000	0.0000	0.0006	0.0001	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CO2	0	0	5.0	30.0	30.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	N2O	0	13	5.0	3.0	5.8	0.0000	0.0002	0.0002	0.0005	0.0011	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CH4	0	0	5.0	70.0	70.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CO2	0	55	5.0	3.0	5.8	0.0000	0.0007	0.0007	0.0021	0.0049	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	N2O	0	0	5.0	50.0	50.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.c Transport – Railways	CH4	0	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.c Transport – Railways	CO2	178	80	3.0	3.0	4.2	0.0000	-0.0011	0.0010	-0.0032	0.0043	0.0000
1.A.3.c Transport – Railways	N2O	16	4	3.0	30.0	30.1	0.0000	-0.0001	0.0001	-0.0039	0.0002	0.0000
1.A.3.d Transport – Navigation	CH4	1	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.d Transport – Navigation	CO2	28	69	3.0	3.0	4.2	0.0000	0.0005	0.0009	0.0016	0.0037	0.0000
1.A.3.d Transport – Navigation	N2O	2	5	3.0	70.0	70.1	0.0000	0.0000	0.0001	0.0028	0.0003	0.0000
1.A.3.e Transport – Other Transportation	CH4	0	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Transport – Other Transportation	CO2	229	163	1.0	0.2	1.0	0.0000	-0.0006	0.0021	-0.0001	0.0029	0.0000
1.A.3.e Transport – Other Transportation	N2O	0	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.5.b Mobile	CH4	0	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Mobile	CO2	37	27	1.0	0.5	1.1	0.0000	-0.0001	0.0003	0.0000	0.0005	0.0000
1.A.5.b Mobile	N2O	1	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH4	373	0	5.0	50.0	50.2	0.0000	-0.0043	0.0000	-0.2173	0.0000	0.0472
1.B.2.a Fugitive Emission – Oil	CH4	8	6	0.5	50.0	50.0	0.0000	0.0000	0.0001	-0.0011	0.0001	0.0000
1.B.2.a Fugitive Emission – Oil	CO2	0	0	0.5	0.5	0.7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b Fugitive Emission – Natural Gas	CH4	290	225	5.0	10.0	11.2	0.0012	-0.0005	0.0028	-0.0054	0.0201	0.0004

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivi ty	Type B sensitiv ity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.B.2.b Fugitive Emission – Natural Gas	CO2	102	80	5.0	0.2	5.0	0.0000	-0.0002	0.0010	0.0000	0.0072	0.0001
2.A.1 Mineral Industry – Cement Production	CO2	2 033	1 832	1.0	2.0	2.2	0.0032	-0.0005	0.0232	-0.0010	0.0328	0.0011
2.A.2 Mineral Industry – Lime Production	CO2	456	624	5.0	2.0	5.4	0.0021	0.0026	0.0079	0.0052	0.0558	0.0031
2.A.3 Mineral Industry – Glass Production	CO2	39	35	1.0	2.0	2.2	0.0000	0.0000	0.0004	0.0000	0.0006	0.0000
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO2	116	100	1.0	2.0	2.2	0.0000	-0.0001	0.0013	-0.0002	0.0018	0.0000
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO2	5	10	30.0	2.0	30.1	0.0000	0.0001	0.0001	0.0001	0.0055	0.0000
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO2	481	317	2.0	2.0	2.8	0.0002	-0.0016	0.0040	-0.0032	0.0113	0.0001
2.A.4.d Other Process Uses of Carbonates – other	CO2	0	0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.1 Chemical Industry – Ammonia Production	CH4	2	1	2.0	10.0	10.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.1 Chemical Industry – Ammonia Production	CO2	467	418	2.0	5.0	5.4	0.0010	-0.0002	0.0053	-0.0008	0.0150	0.0002
2.B.2 Chemical Industry – Nitric Acid Production	CO2	0	0	2.0	2.0	2.8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.2 Chemical Industry – Nitric Acid Production	N2O	780	23	2.0	2.0	2.8	0.0000	-0.0088	0.0003	-0.0176	0.0008	0.0003
2.B.5 Chemical Industry – Carbide Production	CO2	38	43	1.0	5.0	5.1	0.0000	0.0001	0.0005	0.0005	0.0008	0.0000
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH4	29	42	20.0	10.0	22.4	0.0002	0.0002	0.0005	0.0019	0.0150	0.0002
2.B.10 Chemical Industry – Other	CH4	9	12	2.0	2.0	2.8	0.0000	0.0000	0.0001	0.0001	0.0004	0.0000
2.B.10 Chemical Industry – Other	CO2	138	138	2.0	2.0	2.8	0.0000	0.0001	0.0017	0.0003	0.0049	0.0000
2.C.1 Metal Industry – Iron and Steel Production	CO2	6 840	10 280	0.5	0.5	0.7	0.0100	0.0503	0.1300	0.0251	0.0919	0.0091
2.C.1 Metal Industry – Iron and Steel Production	CH4	6	5	0.5	20.0	20.0	0.0000	0.0000	0.0001	-0.0001	0.0000	0.0000
2.C.2 Metal Industry – Ferroalloys Production	CO2	21	17	5.0	25.0	25.5	0.0000	0.0000	0.0002	-0.0007	0.0015	0.0000
2.C.3 Metal Industry – Aluminium Production	CO2	150	5	20.0	5.0	20.6	0.0000	-0.0017	0.0001	-0.0084	0.0019	0.0001
2.C.3 Metal Industry – Aluminium Production	PFC	1 032	0	20.0	50.0	53.9	0.0000	-0.0120	0.0000	-0.6011	0.0000	0.3613
2.C.3 Metal Industry – Aluminium Production	SF6	14	0	20.0	50.0	53.9	0.0000	-0.0002	0.0000	-0.0082	0.0000	0.0001
2.C.4 Metal Industry – Magnesium Production	SF6	235	2	5.0	5.0	7.1	0.0000	-0.0027	0.0000	-0.0135	0.0002	0.0002
2.C.5 Metal Industry – Lead Production	CO2	5	5	5.0	50.0	50.2	0.0000	0.0000	0.0001	0.0007	0.0005	0.0000
2.D Non-Energy Products from Fuels and Solvent Use	CO2	349	172	20.0	30.0	36.1	0.0073	-0.0019	0.0022	-0.0565	0.0617	0.0070
2.E Electronics Industry	HFC	2	3	5.0	10.0	11.2	0.0000	0.0000	0.0000	0.0001	0.0002	0.0000

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										Gg CO ₂ equivalent	Gg CO ₂ equivalent	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
2.E Electronics Industry	PFC	31	26	5.0	10.0	11.2	0.0000	0.0000	0.0003	-0.0003	0.0023	0.0000
2.E Electronics Industry	SF6	100	13	5.0	10.0	11.2	0.0000	-0.0010	0.0002	-0.0101	0.0011	0.0001
2.E Electronics Industry	NF3	0	14	5.0	10.0	11.2	0.0000	0.0002	0.0002	0.0018	0.0013	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	0	1 355	10.0	50.0	51.0	0.9000	0.0171	0.0171	0.8569	0.2424	0.7929
2.F.2 Foam Blowing	HFC	0	14	10.0	0.0	10.0	0.0000	0.0002	0.0002	0.0000	0.0026	0.0000
2.F.3 Fire Extinguishers	HFC	0	12	10.0	100.0	100.5	0.0003	0.0002	0.0002	0.0158	0.0022	0.0003
2.F.4 Aerosols	HFC	0	27	20.0	10.0	22.4	0.0001	0.0003	0.0003	0.0034	0.0095	0.0001
2.F.5 Solvents	HFC	0	0	100.0	0.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	11	49	5.0	100.0	100.1	0.0046	0.0005	0.0006	0.0493	0.0044	0.0024
2.G.2 Other product manufacture and use – SF6 and PFCs from other product use	PFC	0	0	5.0	100.0	100.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.2 Other product manufacture and use – SF6 and PFCs from other product use	SF6	124	301	5.0	100.0	100.1	0.1711	0.0024	0.0038	0.2356	0.0269	0.0562
2.G. Other Product Manufacture and Use	N2O	117	32	20.0	0.0	20.0	0.0001	-0.0010	0.0004	0.0000	0.0115	0.0001
3.A.1 Enteric Fermentation – Cattle	CH4	4 854	4 035	1.0	20.0	20.0	1.2301	-0.0055	0.0510	-0.1103	0.0721	0.0174
3.A.2 Enteric Fermentation – Sheep	CH4	69	90	10.0	40.0	41.2	0.0026	0.0003	0.0011	0.0131	0.0160	0.0004
3.A.3 Enteric Fermentation – Swine	CH4	88	64	4.0	20.0	20.4	0.0003	-0.0002	0.0008	-0.0043	0.0046	0.0000
3.A.4 Enteric Fermentation – Other	CH4	44	95	10.0	40.0	41.2	0.0029	0.0007	0.0012	0.0280	0.0171	0.0011
3.B.1.1 Manure Management – Cattle	CH4	467	522	1.0	20.0	20.0	0.0206	0.0011	0.0066	0.0230	0.0093	0.0006
3.B.1.1 Manure Management – Cattle	N2O	294	281	1.0	100.0	100.0	0.1492	0.0001	0.0036	0.0135	0.0050	0.0002
3.B.1.2 Manure Management – Sheep	CH4	3	3	10.0	30.0	31.6	0.0000	0.0000	0.0000	0.0004	0.0006	0.0000
3.B.1.2 Manure Management – Sheep	N2O	5	7	10.0	100.0	100.5	0.0001	0.0000	0.0001	0.0026	0.0013	0.0000
3.B.1.3 Manure Management – Swine	CH4	148	83	4.0	20.0	20.4	0.0005	-0.0007	0.0010	-0.0136	0.0059	0.0002
3.B.1.3 Manure Management – Swine	N2O	99	53	4.0	100.0	100.1	0.0054	-0.0005	0.0007	-0.0472	0.0038	0.0022
3.B.1.4. Manure Management – Other	CH4	14	24	10.0	30.0	31.6	0.0001	0.0001	0.0003	0.0041	0.0043	0.0000
3.B.1.4. Manure Management – Other	N2O	8	17	10.0	100.0	100.5	0.0006	0.0001	0.0002	0.0120	0.0031	0.0002
3.B.2.5 Indirect N2O Emissions	N2O	103	111	5.0	200.0	200.1	0.0929	0.0002	0.0014	0.0417	0.0099	0.0018

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	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	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
3.D.1 Direct N2O Emissions from Managed Soils	N2O	1 776	1 455	5.0	200.0	200.1	15.9607	-0.0023	0.0184	-0.4590	0.1301	0.2276
3.D.2 Indirect N2O emissions from Managed Soils	N2O	357	288	5.0	200.0	200.1	0.6253	-0.0005	0.0036	-0.1040	0.0257	0.0115
3.F Field Burning of Agricultural Residues	CH4	1	0	100.0	40.0	107.7	0.0000	0.0000	0.0000	-0.0004	0.0000	0.0000
3.F Field Burning of Agricultural Residues	N2O	0	0	100.0	50.0	111.8	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
3.G Liming	CO2	46	99	5.0	50.0	50.2	0.0047	0.0007	0.0013	0.0361	0.0089	0.0014
3.H Urea application	CO2	10	26	5.0	50.0	50.2	0.0003	0.0002	0.0003	0.0106	0.0023	0.0001
3.I Other	CO2	31	24	5.0	50.0	50.2	0.0003	0.0000	0.0003	-0.0024	0.0022	0.0000
5.A Solid Waste Disposal	CH4	4 081	846	12.0	25.0	27.7	0.1037	-0.0368	0.0107	-0.9205	0.1815	0.8803
5.B Biological Treatment of Solid Waste	CH4	15	77	20.0	50.0	53.9	0.0032	0.0008	0.0010	0.0402	0.0275	0.0024
5.B Biological Treatment of Solid Waste	N2O	20	72	20.0	50.0	53.9	0.0028	0.0007	0.0009	0.0338	0.0258	0.0018
5.C Incineration and Open Burning of Waste	CH4	1	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.C Incineration and Open Burning of Waste	CO2	28	2	7.0	20.0	21.2	0.0000	-0.0003	0.0000	-0.0060	0.0003	0.0000
5.C Incineration and Open Burning of Waste	N2O	0	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.D Waste Water Treatment and Discharge	CH4	137	24	20.0	50.0	53.9	0.0003	-0.0013	0.0003	-0.0644	0.0086	0.0042
5.D Waste Water Treatment and Discharge	N2O	86	152	20.0	100.0	102.0	0.0456	0.0009	0.0019	0.0929	0.0545	0.0116
Total		79 082	72 844				20.56					3.61
Total Uncertainties						Uncertainty in total inventory %:	4,53			Trend uncertainty %:		1,90

Table A 20: Approach 1 Uncertainty Analysis (Article 7(1)(p) MMR) for 1990 – including LULUCF

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertain	Emission factor / estimation parameter uncertain	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	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A Stationary Combustion – Biomass	CH4	312	287	5.0	50.0	50.2	0.0541	-0.0004	0.0043	-0.0219	0.0301	0.0014
1.A Stationary Combustion – Biomass	CO2	0	0	5.0	1.0	5.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A Stationary Combustion – Biomass	N2O	93	211	5.0	50.0	50.2	0.0048	0.0017	0.0031	0.0865	0.0221	0.0080
1.A Stationary Combustion – Gaseous Fuels	CH4	11	15	2.0	50.0	50.0	0.0001	0.0001	0.0002	0.0032	0.0006	0.0000
1.A Stationary Combustion – Gaseous Fuels	CO2	11 076	15 271	2.0	0.2	2.0	0.1091	0.0598	0.2266	0.0120	0.6408	0.4108
1.A Stationary Combustion – Gaseous Fuels	N2O	5	7	2.0	50.0	50.0	0.0000	0.0000	0.0001	0.0014	0.0003	0.0000
1.A Stationary Combustion – Liquid Fuels	CH4	39	9	0.5	50.0	50.0	0.0008	-0.0005	0.0001	-0.0227	0.0001	0.0005
1.A Stationary Combustion – Liquid Fuels	CO2	14 203	8 196	0.5	0.5	0.7	0.0222	-0.0920	0.1216	-0.0460	0.0860	0.0095
1.A Stationary Combustion – Liquid Fuels	N2O	122	82	0.5	50.0	50.0	0.0082	-0.0006	0.0012	-0.0307	0.0009	0.0009
1.A Stationary Combustion – Other fuels	CH4	3	8	10.0	50.0	51.0	0.0000	0.0001	0.0001	0.0042	0.0017	0.0000
1.A Stationary Combustion – Other fuels	CO2	580	1 992	10.0	15.0	18.0	0.0241	0.0208	0.0296	0.3124	0.4180	0.2723
1.A Stationary Combustion – Other fuels	N2O	8	26	10.0	50.0	51.0	0.0000	0.0003	0.0004	0.0131	0.0054	0.0002
1.A Stationary Combustion – Solid Fuels	CH4	234	5	0.5	50.0	50.0	0.0301	-0.0035	0.0001	-0.1726	0.0000	0.0298
1.A Stationary Combustion – Solid Fuels	CO2	11 177	1 302	0.5	0.5	0.7	0.0138	-0.1487	0.0193	-0.0743	0.0137	0.0057
1.A Stationary Combustion – Solid Fuels	N2O	41	2	0.5	50.0	50.0	0.0009	-0.0006	0.0000	-0.0290	0.0000	0.0008
1.A.3.a Transport – Civil Aviation	CH4	0	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Transport – Civil Aviation	CO2	38	30	3.0	3.0	4.2	0.0000	-0.0001	0.0004	-0.0004	0.0019	0.0000
1.A.3.a Transport – Civil Aviation	N2O	1	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CH4	4	12	3.0	30.0	30.1	0.0000	0.0001	0.0002	0.0036	0.0008	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CO2	5 358	15 639	3.0	3.0	4.2	0.1138	0.1513	0.2320	0.4538	0.9844	1.1751
1.A.3.b Transport – Road Transportation – Diesel	N2O	11	190	3.0	30.0	30.1	0.0000	0.0027	0.0028	0.0795	0.0119	0.0065
1.A.3.b Transport – Road Transportation – Gaseous	CO2	0	40	3.0	3.0	4.2	0.0000	0.0006	0.0006	0.0018	0.0025	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	CH4	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	N2O	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gasoline	CH4	77	7	3.0	30.0	30.1	0.0012	-0.0011	0.0001	-0.0317	0.0004	0.0010

IPCC category/Group	GHG	Base year emissions	Year x emissions	Activity data	Emission factor	Combined uncertainty	Contribution to variance	Type A	Type B	Uncertainty in trend in national emissions	Uncertainty in trend in national emissions	Uncertainty introduced into the trend in total national emissions
		or removals	or removals	uncertain	/ estimation parameter uncertain		by category in year x	sensitivity	sensitivity	introduced by emission factor / estimation parameter uncertainty	introduced by activity data uncertainty	introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%		%	%	%	%	%	%
		input data	input data	input data	input data	$\sqrt{E^2 + F^2}$	$\frac{(G \cdot D)^2}{(\sum D)^2}$	Note B	$\left \frac{D}{\sum C} \right $	I*F	J*E*sqrt(2)	K^2 + L^2
		Note A	Note A	Note A	Note A					Note C	Note D	
1.A.3.b Transport – Road Transportation – Gasoline	CO2	7 896	4 389	3.0	3.0	4.2	0.2470	-0.0537	0.0651	-0.1610	0.2763	0.1022
1.A.3.b Transport – Road Transportation – Gasoline	N2O	83	6	3.0	70.0	70.1	0.0074	-0.0011	0.0001	-0.0804	0.0004	0.0065
1.A.3.b Transport – Road Transportation – LPG	CO2	26	7	3.0	3.0	4.2	0.0000	-0.0003	0.0001	-0.0009	0.0004	0.0000
1.A.3.b Transport – Road Transportation – LPG	CH4	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – LPG	N2O	0	0	3.0	50.0	50.1	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CH4	0	1	5.0	50.0	50.2	0.0000	0.0000	0.0000	0.0007	0.0001	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CO2	0	0	5.0	30.0	30.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	N2O	0	13	5.0	3.0	5.8	0.0000	0.0002	0.0002	0.0006	0.0013	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CH4	0	0	5.0	70.0	70.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CO2	0	55	5.0	3.0	5.8	0.0000	0.1392	0.1392	0.4176	0.9843	1.1432
1.A.3.b Transport – Road Transportation – Other Fuels	N2O	0	0	5.0	50.0	50.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.c Transport – Railways	CH4	0	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.c Transport – Railways	CO2	178	80	3.0	3.0	4.2	0.0001	-0.0015	0.0012	-0.0045	0.0051	0.0000
1.A.3.c Transport – Railways	N2O	16	4	3.0	30.0	30.1	0.0001	-0.0002	0.0001	-0.0053	0.0003	0.0000
1.A.3.d Transport – Navigation	CH4	1	0	3.0	30.0	30.1	0.0000	0.0000	0.0000	-0.0003	0.0000	0.0000
1.A.3.d Transport – Navigation	CO2	28	69	3.0	3.0	4.2	0.0000	0.0006	0.0010	0.0018	0.0043	0.0000
1.A.3.d Transport – Navigation	N2O	2	5	3.0	70.0	70.1	0.0000	0.0000	0.0001	0.0031	0.0003	0.0000
1.A.3.e Transport – Other Transportation	CH4	0	0	2.0	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Transport – Other Transportation	CO2	229	163	2.0	0.2	2.0	0.0000	-0.0010	0.0024	-0.0002	0.0068	0.0000
1.A.3.e Transport – Other Transportation	N2O	0	0	2.0	50.0	50.0	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.5.b Mobile	CH4	0	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Mobile	CO2	37	27	1.0	0.5	1.1	0.0000	-0.0002	0.0004	-0.0001	0.0006	0.0000
1.A.5.b Mobile	N2O	1	0	1.0	50.0	50.0	0.0000	0.0000	0.0000	-0.0004	0.0000	0.0000
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH4	373	0	5.0	50.0	50.2	0.0774	-0.0056	0.0000	-0.2808	0.0000	0.0789
1.B.2.a Fugitive Emission – Oil	CH4	8	6	0.5	50.0	50.0	0.0000	0.0000	0.0001	-0.0019	0.0001	0.0000
1.B.2.a Fugitive Emission – Oil	CO2	0	0	0.5	0.5	0.7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b Fugitive Emission – Natural Gas	CH4	290	225	5.0	10.0	11.2	0.0023	-0.0010	0.0033	-0.0103	0.0236	0.0007

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertain	Emission factor / estimation parameter uncertain	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	Uncertainty in trend in national emissions introduced by activity data	Uncertainty introduced into the trend in total national emissions
										/ estimation parameter uncertainty	introduced by activity data uncertainty	introduced into the trend in total national emissions
										%	%	%
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.B.2.b Fugitive Emission – Natural Gas	CO2	102	80	5.0	0.2	5.0	0.0001	-0.0003	0.0012	-0.0001	0.0084	0.0001
2.A.1 Mineral Industry – Cement Production	CO2	2 033	1 832	5.0	2.0	5.4	0.0264	-0.0034	0.0272	-0.0069	0.1922	0.0370
2.A.2 Mineral Industry – Lime Production	CO2	456	624	10.0	2.0	10.2	0.0048	0.0024	0.0093	0.0048	0.1309	0.0172
2.A.3 Mineral Industry – Glass Production	CO2	39	35	5.0	2.0	5.4	0.0000	-0.0001	0.0005	-0.0001	0.0037	0.0000
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO2	116	100	5.0	2.0	5.4	0.0001	-0.0003	0.0015	-0.0005	0.0105	0.0001
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO2	5	10	30.0	2.0	30.1	0.0000	0.0001	0.0002	0.0001	0.0064	0.0000
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO2	481	317	2.0	2.0	2.8	0.0004	-0.0025	0.0047	-0.0051	0.0133	0.0002
2.A.4.d Other Process Uses of Carbonates – other	CO2	0	0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.1 Chemical Industry – Ammonia Production	CH4	2	1	2.0	10.0	10.2	0.0000	0.0000	0.0000	-0.0001	0.0001	0.0000
2.B.1 Chemical Industry – Ammonia Production	CO2	467	418	2.0	5.0	5.4	0.0014	-0.0008	0.0062	-0.0042	0.0175	0.0003
2.B.2 Chemical Industry – Nitric Acid Production	CO2	0	0	2.0	2.0	2.8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.2 Chemical Industry – Nitric Acid Production	N2O	780	23	2.0	2.0	2.8	0.0011	-0.0114	0.0003	-0.0228	0.0010	0.0005
2.B.5 Chemical Industry – Carbide Production	CO2	38	43	1.0	5.0	5.1	0.0000	0.0001	0.0006	0.0004	0.0009	0.0000
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH4	29	42	20.0	10.0	22.4	0.0001	0.0002	0.0006	0.0018	0.0176	0.0003
2.B.10 Chemical Industry – Other	CH4	9	12	2.0	2.0	2.8	0.0000	0.0000	0.0002	0.0001	0.0005	0.0000
2.B.10 Chemical Industry – Other	CO2	138	138	2.0	2.0	2.8	0.0000	0.0000	0.0020	-0.0001	0.0058	0.0000
2.C.1 Metal Industry – Iron and Steel Production	CO2	6 840	10 280	2.0	0.5	2.1	0.0438	0.0495	0.1525	0.0248	0.4314	0.1867
2.C.1 Metal Industry – Iron and Steel Production	CH4	6	5	2.0	20.0	20.1	0.0000	0.0000	0.0001	-0.0003	0.0002	0.0000
2.C.2 Metal Industry – Ferroalloys Production	CO2	21	17	5.0	25.0	25.5	0.0001	-0.0001	0.0003	-0.0015	0.0018	0.0000
2.C.3 Metal Industry – Aluminium Production	CO2	150	5	2.0	5.0	5.4	0.0001	-0.0022	0.0001	-0.0109	0.0002	0.0001
2.C.3 Metal Industry – Aluminium Production	PFC	1 032	0	2.0	50.0	50.0	0.5874	-0.0155	0.0000	-0.7767	0.0000	0.6033
2.C.3 Metal Industry – Aluminium Production	SF6	14	0	2.0	50.0	50.0	0.0001	-0.0002	0.0000	-0.0106	0.0000	0.0001
2.C.4 Metal Industry – Magnesium Production	SF6	235	2	5.0	5.0	7.1	0.0006	-0.0035	0.0000	-0.0175	0.0002	0.0003
2.C.5 Metal Industry – Lead Production	CO2	5	5	5.0	50.0	50.2	0.0000	0.0000	0.0001	0.0005	0.0006	0.0000
2.D Non-Energy Products from Fuels and Solvent Use	CO2	349	172	20.0	30.0	36.1	0.0348	-0.0027	0.0026	-0.0808	0.0724	0.0118
2.E Electronics Industry	HFC	2	3	5.0	10.0	11.2	0.0000	0.0000	0.0000	0.0001	0.0003	0.0000

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	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	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
										Gg CO ₂ equivalent	Gg CO ₂ equivalent	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
2.E Electronics Industry	PFC	31	26	5.0	10.0	11.2	0.0000	-0.0001	0.0004	-0.0007	0.0027	0.0000
2.E Electronics Industry	SF6	100	13	5.0	10.0	11.2	0.0003	-0.0013	0.0002	-0.0132	0.0013	0.0002
2.E Electronics Industry	NF3	0	14	5.0	10.0	11.2	0.0000	0.0002	0.0002	0.0021	0.0015	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	0	1 355	10.0	50.0	51.0	0.0000	0.0201	0.0201	1.0054	0.2844	1.0916
2.F.2 Foam Blowing	HFC	0	14	10.0	0.0	10.0	0.0000	0.0002	0.0002	0.0000	0.0030	0.0000
2.F.3 Fire Extinguishers	HFC	0	12	10.0	100.0	100.5	0.0000	0.0002	0.0002	0.0185	0.0026	0.0003
2.F.4 Aerosols	HFC	0	27	20.0	10.0	22.4	0.0000	0.0004	0.0004	0.0039	0.0111	0.0001
2.F.5 Solvents	HFC	0	0	100.0	0.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	11	49	5.0	100.0	100.1	0.0003	0.0006	0.0007	0.0563	0.0052	0.0032
2.G.2 Other product manufacture and use – SF6 and PFCs from other product use	PFC	0	0	5.0	100.0	100.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.2 Other product manufacture and use – SF6 and PFCs from other product use	SF6	124	301	5.0	100.0	100.1	0.0342	0.0026	0.0045	0.2593	0.0316	0.0682
2.G. Other Product Manufacture and Use	N2O	117	32	20.0	0.0	20.0	0.0012	-0.0013	0.0005	0.0000	0.0135	0.0002
3.A.1 Enteric Fermentation – Cattle	CH4	4 854	4 035	10.0	20.0	22.4	2.5930	-0.0132	0.0599	-0.2636	0.8465	0.7861
3.A.2 Enteric Fermentation – Sheep	CH4	69	90	10.0	40.0	41.2	0.0018	0.0003	0.0013	0.0115	0.0188	0.0005
3.A.3 Enteric Fermentation – Swine	CH4	88	64	10.0	20.0	22.4	0.0008	-0.0004	0.0009	-0.0074	0.0134	0.0002
3.A.4 Enteric Fermentation – Other	CH4	44	95	10.0	40.0	41.2	0.0007	0.0008	0.0014	0.0304	0.0200	0.0013
3.B.1.1 Manure Management – Cattle	CH4	467	522	10.0	20.0	22.4	0.0241	0.0007	0.0077	0.0140	0.1094	0.0122
3.B.1.1 Manure Management – Cattle	N2O	294	281	10.0	100.0	100.5	0.1919	-0.0002	0.0042	-0.0248	0.0590	0.0041
3.B.1.2 Manure Management – Sheep	CH4	3	3	10.0	30.0	31.6	0.0000	0.0000	0.0001	0.0003	0.0007	0.0000
3.B.1.2 Manure Management – Sheep	N2O	5	7	10.0	100.0	100.5	0.0001	0.0000	0.0001	0.0023	0.0015	0.0000
3.B.1.3 Manure Management – Swine	CH4	148	83	10.0	20.0	22.4	0.0024	-0.0010	0.0012	-0.0200	0.0173	0.0007
3.B.1.3 Manure Management – Swine	N2O	99	53	10.0	100.0	100.5	0.0216	-0.0007	0.0008	-0.0691	0.0112	0.0049
3.B.1.4. Manure Management – Other	CH4	14	24	10.0	30.0	31.6	0.0000	0.0001	0.0004	0.0042	0.0050	0.0000
3.B.1.4. Manure Management – Other	N2O	8	17	10.0	100.0	100.5	0.0002	0.0001	0.0003	0.0129	0.0036	0.0002
3.B.2.5 Indirect N2O Emissions	N2O	103	111	5.0	200.0	200.1	0.0927	0.0001	0.0016	0.0205	0.0116	0.0006

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertain	Emission factor / estimation parameter uncertain	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivi ty	Type B sensitiv ity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
3.D.1 Direct N2O Emissions from Managed Soils	N2O	1 776	1 455	5.0	200.0	200.1	27.7997	-0.0052	0.0216	-1.0301	0.1526	1.0843
3.D.2 Indirect N2O emissions from Managed Soils	N2O	357	288	5.0	200.0	200.1	1.1242	-0.0011	0.0043	-0.2208	0.0302	0.0497
3.F Field Burning of Agricultural Residues	CH4	1	0	100.0	40.0	107.7	0.0000	0.0000	0.0000	-0.0006	0.0000	0.0000
3.F Field Burning of Agricultural Residues	N2O	0	0	100.0	50.0	111.8	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
3.G Liming	CO2	46	99	5.0	50.0	50.2	0.0012	0.0008	0.0015	0.0392	0.0104	0.0016
3.H Urea application	CO2	10	26	5.0	50.0	50.2	0.0001	0.0002	0.0004	0.0117	0.0027	0.0001
3.I Other	CO2	31	24	5.0	50.0	50.2	0.0005	-0.0001	0.0004	-0.0050	0.0026	0.0000
4 Total land use categories	CH4	27	27			220.4	0.0079	0.0000	0.0004	0.0000	0.0000	0.0000
4 Total land use categories	N2O	143	127			109.5	0.0540	-0.0003	0.0019	0.0000	0.0000	0.0000
4.A.1 Forest land remaining forest land	CO2	-8 122	-3 192			50.4	36.9178	0.0750	0.0474	0.0000	0.0000	0.0000
4.A.2 Land converted to forest land	CO2	-2 955	-1 420			35.7	2.4562	0.0234	0.0211	0.0000	0.0000	0.0000
4.B.1 Cropland remaining cropland	CO2	-18	84			229.0	0.0038	0.0015	0.0012	0.0000	0.0000	0.0000
4.B.2 Land converted to cropland	CO2	202	233			59.2	0.0315	0.0004	0.0035	0.0000	0.0000	0.0000
4.C.1 Grassland remaining grassland	CO2	304	304			230.5	1.0819	-0.0001	0.0045	0.0000	0.0000	0.0000
4.C.2 Land converted to grassland	CO2	393	140			52.6	0.0942	-0.0038	0.0021	0.0000	0.0000	0.0000
4.D.1 Wetlands remaining Wetlands	CO2	0	0			42.6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4.D.2 Land converted to Wetlands	CO2	48	70			42.6	0.0009	0.0003	0.0010	0.0000	0.0000	0.0000
4.E.2 Land converted to Settlements	CO2	917	746			34.0	0.2141	-0.0027	0.0111	0.0000	0.0000	0.0000
4.F.2 Land converted to Other land	CO2	502	517			76.9	0.3273	0.0001	0.0077	0.0000	0.0000	0.0000
4.G HWP	CO2	-3 122	-2 110			49.0	5.1523	0.0157	0.0313	0.0000	0.0000	0.0000
5.A Solid Waste Disposal	CH4	4 081	846	12.0	25.0	27.7	2.8194	-0.0488	0.0125	-1.2211	0.2130	1.5363
5.B Biological Treatment of Solid Waste	CH4	15	77	20.0	50.0	53.9	0.0001	0.0009	0.0011	0.0461	0.0323	0.0032
5.B Biological Treatment of Solid Waste	N2O	20	72	20.0	50.0	53.9	0.0003	0.0008	0.0011	0.0383	0.0303	0.0024
5.C Incineration and Open Burning of Waste	CH4	1	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.C Incineration and Open Burning of Waste	CO2	28	2	7.0	20.0	21.2	0.0001	-0.0004	0.0000	-0.0078	0.0003	0.0001
5.C Incineration and Open Burning of Waste	N2O	0	0	7.0	0.0	7.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.D Waste Water Treatment and Discharge	CH4	137	24	20.0	50.0	53.9	0.0119	-0.0017	0.0004	-0.0850	0.0101	0.0073

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	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	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
5.D Waste Water Treatment and Discharge	N2O	86	152	20.0	100.0	102.0	0.0169	0.0010	0.0023	0.0971	0.0640	0.0135
Total		67 401	68 370				82.50					8.79
Total Uncertainties						Uncertainty in total inventory %:	9.08				Trend uncertainty %:	2.96

Table A 21: Approach 1 Uncertainty Analysis (Article 7(1)(p) MMR) for 2022 – including LULUCF

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	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	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A Stationary Combustion – Biomass	CH4	312	287	5.0	50.0	50.25	0.0445	-0.0004	0.0043	-0.0219	0.0301	0.0014
1.A Stationary Combustion – Biomass	CO2	0	0	5.0	1.0	5.10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A Stationary Combustion – Biomass	N2O	93	211	5.0	50.0	50.25	0.0240	0.0017	0.0031	0.0865	0.0221	0.0080
1.A Stationary Combustion – Gaseous Fuels	CH4	11	15	1.0	50.0	50.01	0.0001	0.0001	0.0002	0.0032	0.0003	0.0000
1.A Stationary Combustion – Gaseous Fuels	CO2	11 076	15 271	1.0	0.2	1.02	0.0519	0.0598	0.2266	0.0120	0.3204	0.1028
1.A Stationary Combustion – Gaseous Fuels	N2O	5	7	1.0	50.0	50.01	0.0000	0.0000	0.0001	0.0014	0.0002	0.0000
1.A Stationary Combustion – Liquid Fuels	CH4	39	9	0.5	50.0	50.00	0.0000	-0.0005	0.0001	-0.0227	0.0001	0.0005

IPCC category/Group	GHG	Base year	Year x	Activity	Emission factor	Combined	Contribution	Type A	Type B	Uncertainty in	Uncertainty in	Uncertainty in
		emissions	emissions	data	/ estimation					trend in	trend in	trend in
		or removals	or removals	uncertainty	parameter					national	national	national
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%	by category in year x	sensitivity	sensitivity	/ estimation parameter uncertainty	introduced by activity data uncertainty	introduced into the trend in total national emissions
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A Stationary Combustion – Liquid Fuels	CO2	14 203	8 196	0.5	0.5	0.71	0.0072	-0.0920	0.1216	-0.0460	0.0860	0.0095
1.A Stationary Combustion – Liquid Fuels	N2O	122	82	0.5	50.0	50.00	0.0036	-0.0006	0.0012	-0.0307	0.0009	0.0009
1.A Stationary Combustion – Other fuels	CH4	3	8	5.0	50.0	50.25	0.0000	0.0001	0.0001	0.0042	0.0009	0.0000
1.A Stationary Combustion – Other fuels	CO2	580	1 992	5.0	15.0	15.81	0.2123	0.0208	0.0296	0.3124	0.2090	0.1413
1.A Stationary Combustion – Other fuels	N2O	8	26	5.0	50.0	50.25	0.0004	0.0003	0.0004	0.0131	0.0027	0.0002
1.A Stationary Combustion – Solid Fuels	CH4	234	5	0.5	50.0	50.00	0.0000	-0.0035	0.0001	-0.1726	0.0000	0.0298
1.A Stationary Combustion – Solid Fuels	CO2	11 177	1 302	0.5	0.5	0.71	0.0002	-0.1487	0.0193	-0.0743	0.0137	0.0057
1.A Stationary Combustion – Solid Fuels	N2O	41	2	0.5	50.0	50.00	0.0000	-0.0006	0.0000	-0.0290	0.0000	0.0008
1.A.3.a Transport – Civil Aviation	CH4	0	0	3.0	30.0	30.15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.a Transport – Civil Aviation	CO2	38	30	3.0	3.0	4.24	0.0000	-0.0001	0.0004	-0.0004	0.0019	0.0000
1.A.3.a Transport – Civil Aviation	N2O	1	0	3.0	30.0	30.15	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CH4	4	12	3.0	30.0	30.15	0.0000	0.0001	0.0002	0.0036	0.0008	0.0000
1.A.3.b Transport – Road Transportation – Diesel	CO2	5 358	15 639	3.0	3.0	4.24	0.9418	0.1513	0.2320	0.4538	0.9844	1.1751
1.A.3.b Transport – Road Transportation – Diesel	N2O	11	190	3.0	30.0	30.15	0.0070	0.0027	0.0028	0.0795	0.0119	0.0065
1.A.3.b Transport – Road Transportation – Gaseous	CO2	0	40	3.0	3.0	4.24	0.0000	0.0006	0.0006	0.0018	0.0025	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	CH4	0	0	3.0	50.0	50.09	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gaseous	N2O	0	0	3.0	50.0	50.09	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Gasoline	CH4	77	7	3.0	30.0	30.15	0.0000	-0.0011	0.0001	-0.0317	0.0004	0.0010
1.A.3.b Transport – Road Transportation – Gasoline	CO2	7 896	4 389	3.0	3.0	4.24	0.0742	-0.0537	0.0651	-0.1610	0.2763	0.1022
1.A.3.b Transport – Road Transportation – Gasoline	N2O	83	6	3.0	70.0	70.06	0.0000	-0.0011	0.0001	-0.0804	0.0004	0.0065
1.A.3.b Transport – Road Transportation – LPG	CO2	26	7	3.0	3.0	4.24	0.0000	-0.0003	0.0001	-0.0009	0.0004	0.0000
1.A.3.b Transport – Road Transportation – LPG	CH4	0	0	3.0	50.0	50.09	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – LPG	N2O	0	0	3.0	50.0	50.09	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CH4	0	1	5.0	50.0	50.25	0.0000	0.0000	0.0000	0.0007	0.0001	0.0000
1.A.3.b Transport – Road Transportation – Biomass	CO2	0	0	5.0	30.0	30.41	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b Transport – Road Transportation – Biomass	N2O	0	13	5.0	3.0	5.83	0.0000	0.0002	0.0002	0.0006	0.0013	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	CH4	0	0	5.0	70.0	70.18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	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		
										Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
1.A.3.b Transport – Road Transportation – Other Fuels	CO2	0	55	5.0	3.0	5.83	0.0000	0.0008	0.0008	0.0024	0.0057	0.0000
1.A.3.b Transport – Road Transportation – Other Fuels	N2O	0	0	5.0	50.0	50.25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.c Transport – Railways	CH4	0	0	3.0	30.0	30.15	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
1.A.3.c Transport – Railways	CO2	178	80	3.0	3.0	4.24	0.0000	-0.0015	0.0012	-0.0045	0.0051	0.0000
1.A.3.c Transport – Railways	N2O	16	4	3.0	30.0	30.15	0.0000	-0.0002	0.0001	-0.0053	0.0003	0.0000
1.A.3.d Transport – Navigation	CH4	1	0	3.0	30.0	30.15	0.0000	0.0000	0.0000	-0.0003	0.0000	0.0000
1.A.3.d Transport – Navigation	CO2	28	69	3.0	3.0	4.24	0.0000	0.0006	0.0010	0.0018	0.0043	0.0000
1.A.3.d Transport – Navigation	N2O	2	5	3.0	70.0	70.06	0.0000	0.0000	0.0001	0.0031	0.0003	0.0000
1.A.3.e Transport – Other Transportation	CH4	0	0	1.0	50.0	50.01	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e Transport – Other Transportation	CO2	229	163	1.0	0.2	1.02	0.0000	-0.0010	0.0024	-0.0002	0.0034	0.0000
1.A.3.e Transport – Other Transportation	N2O	0	0	1.0	50.0	50.01	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.5.b Mobile	CH4	0	0	1.0	50.0	50.01	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.5.b Mobile	CO2	37	27	1.0	0.5	1.12	0.0000	-0.0002	0.0004	-0.0001	0.0006	0.0000
1.A.5.b Mobile	N2O	1	0	1.0	50.0	50.01	0.0000	0.0000	0.0000	-0.0004	0.0000	0.0000
1.B.1.a Fugitive Emission – Coal Mining and Handling	CH4	373	0	5.0	50.0	50.25	0.0000	-0.0056	0.0000	-0.2808	0.0000	0.0789
1.B.2.a Fugitive Emission – Oil	CH4	8	6	0.5	50.0	50.00	0.0000	0.0000	0.0001	-0.0019	0.0001	0.0000
1.B.2.a Fugitive Emission – Oil	CO2	0	0	0.5	0.5	0.71	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b Fugitive Emission – Natural Gas	CH4	290	225	5.0	10.0	11.18	0.0013	-0.0010	0.0033	-0.0103	0.0236	0.0007
1.B.2.b Fugitive Emission – Natural Gas	CO2	102	80	5.0	0.2	5.00	0.0000	-0.0003	0.0012	-0.0001	0.0084	0.0001
2.A.1 Mineral Industry – Cement Production	CO2	2 033	1 832	1.0	2.0	2.24	0.0036	-0.0034	0.0272	-0.0069	0.0384	0.0015
2.A.2 Mineral Industry – Lime Production	CO2	456	624	5.0	2.0	5.39	0.0024	0.0024	0.0093	0.0048	0.0655	0.0043
2.A.3 Mineral Industry – Glass Production	CO2	39	35	1.0	2.0	2.24	0.0000	-0.0001	0.0005	-0.0001	0.0007	0.0000
2.A.4.a Other Process Uses of Carbonates – Ceramics	CO2	116	100	1.0	2.0	2.24	0.0000	-0.0003	0.0015	-0.0005	0.0021	0.0000
2.A.4.b Other Process Uses of Carbonates – Soda ash	CO2	5	10	30.0	2.0	30.07	0.0000	0.0001	0.0002	0.0001	0.0064	0.0000
2.A.4.c Other Process Uses of Carbonates – Non Metallurgical Magnesia Production	CO2	481	317	2.0	2.0	2.83	0.0002	-0.0025	0.0047	-0.0051	0.0133	0.0002
2.A.4.d Other Process Uses of Carbonates – other	CO2	0	0	0.0	0.0	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	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	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
										/ estimation parameter uncertainty	introduced by activity data uncertainty	introduced into the trend in total national emissions
										%	%	%
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
2.B.1 Chemical Industry – Ammonia Production	CH4	2	1	2.0	10.0	10.20	0.0000	0.0000	0.0000	-0.0001	0.0001	0.0000
2.B.1 Chemical Industry – Ammonia Production	CO2	467	418	2.0	5.0	5.39	0.0011	-0.0008	0.0062	-0.0042	0.0175	0.0003
2.B.2 Chemical Industry – Nitric Acid Production	CO2	0	0	2.0	2.0	2.83	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.2 Chemical Industry – Nitric Acid Production	N2O	780	23	2.0	2.0	2.83	0.0000	-0.0114	0.0003	-0.0228	0.0010	0.0005
2.B.5 Chemical Industry – Carbide Production	CO2	38	43	1.0	5.0	5.10	0.0000	0.0001	0.0006	0.0004	0.0009	0.0000
2.B.8 Chemical Industry – Petrochemical and Carbon Black Production	CH4	29	42	20.0	10.0	22.36	0.0002	0.0002	0.0006	0.0018	0.0176	0.0003
2.B.10 Chemical Industry – Other	CH4	9	12	2.0	2.0	2.83	0.0000	0.0000	0.0002	0.0001	0.0005	0.0000
2.B.10 Chemical Industry – Other	CO2	138	138	2.0	2.0	2.83	0.0000	0.0000	0.0020	-0.0001	0.0058	0.0000
2.C.1 Metal Industry – Iron and Steel Production	CO2	6 840	10 280	0.5	0.5	0.71	0.0113	0.0495	0.1525	0.0248	0.1078	0.0122
2.C.1 Metal Industry – Iron and Steel Production	CH4	6	5	0.5	20.0	20.01	0.0000	0.0000	0.0001	-0.0003	0.0001	0.0000
2.C.2 Metal Industry – Ferroalloys Production	CO2	21	17	5.0	25.0	25.50	0.0000	-0.0001	0.0003	-0.0015	0.0018	0.0000
2.C.3 Metal Industry – Aluminium Production	CO2	150	5	20.0	5.0	20.62	0.0000	-0.0022	0.0001	-0.0109	0.0022	0.0001
2.C.3 Metal Industry – Aluminium Production	PFC	1 032	0	20.0	50.0	53.85	0.0000	-0.0155	0.0000	-0.7767	0.0000	0.6033
2.C.3 Metal Industry – Aluminium Production	SF6	14	0	20.0	50.0	53.85	0.0000	-0.0002	0.0000	-0.0106	0.0000	0.0001
2.C.4 Metal Industry – Magnesium Production	SF6	235	2	5.0	5.0	7.07	0.0000	-0.0035	0.0000	-0.0175	0.0002	0.0003
2.C.5 Metal Industry – Lead Production	CO2	5	5	5.0	50.0	50.25	0.0000	0.0000	0.0001	0.0005	0.0006	0.0000
2.D Non–Energy Products from Fuels and Solvent Use	CO2	349	172	20.0	30.0	36.06	0.0083	-0.0027	0.0026	-0.0808	0.0724	0.0118
2.E Electronics Industry	HFC	2	3	5.0	10.0	11.18	0.0000	0.0000	0.0000	0.0001	0.0003	0.0000
2.E Electronics Industry	PFC	31	26	5.0	10.0	11.18	0.0000	-0.0001	0.0004	-0.0007	0.0027	0.0000
2.E Electronics Industry	SF6	100	13	5.0	10.0	11.18	0.0000	-0.0013	0.0002	-0.0132	0.0013	0.0002
2.E Electronics Industry	NF3	0	14	5.0	10.0	11.18	0.0000	0.0002	0.0002	0.0021	0.0015	0.0000
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	0	1 355	10.0	50.0	50.99	1.0216	0.0201	0.0201	1.0054	0.2844	1.0916
2.F.2 Foam Blowing	HFC	0	14	10.0	0.0	10.00	0.0000	0.0002	0.0002	0.0000	0.0030	0.0000
2.F.3 Fire Extinguishers	HFC	0	12	10.0	100.0	100.50	0.0003	0.0002	0.0002	0.0185	0.0026	0.0003
2.F.4 Aerosols	HFC	0	27	20.0	10.0	22.36	0.0001	0.0004	0.0004	0.0039	0.0111	0.0001
2.F.5 Solvents	HFC	0	0	100.0	0.0	100.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivi ty	Type B sensitiv ity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
2.G.1 Other product manufacture and use – Electrical Equipment	PFC	11	49	5.0	100.0	100.12	0.0052	0.0006	0.0007	0.0563	0.0052	0.0032
2.G.2 Other product manufacture and use – SF6 and PFCs from other product use	PFC	0	0	5.0	100.0	100.12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.2 Other product manufacture and use – SF6 and PFCs from other product use	SF6	124	301	5.0	100.0	100.12	0.1943	0.0026	0.0045	0.2593	0.0316	0.0682
2.G. Other Product Manufacture and Use	N2O	117	32	20.0	0.0	20.00	0.0001	-0.0013	0.0005	0.0000	0.0135	0.0002
3.A.1 Enteric Fermentation – Cattle	CH4	4 854	4 035	1.0	20.0	20.02	1.3964	-0.0132	0.0599	-0.2636	0.0847	0.0767
3.A.2 Enteric Fermentation – Sheep	CH4	69	90	10.0	40.0	41.23	0.0029	0.0003	0.0013	0.0115	0.0188	0.0005
3.A.3 Enteric Fermentation – Swine	CH4	88	64	4.0	20.0	20.40	0.0004	-0.0004	0.0009	-0.0074	0.0054	0.0001
3.A.4 Enteric Fermentation – Other	CH4	44	95	10.0	40.0	41.23	0.0033	0.0008	0.0014	0.0304	0.0200	0.0013
3.B.1.1 Manure Management – Cattle	CH4	467	522	1.0	20.0	20.02	0.0233	0.0007	0.0077	0.0140	0.0109	0.0003
3.B.1.1 Manure Management – Cattle	N2O	294	281	1.0	100.0	100.00	0.1693	-0.0002	0.0042	-0.0248	0.0059	0.0006
3.B.1.2 Manure Management – Sheep	CH4	3	3	10.0	30.0	31.62	0.0000	0.0000	0.0001	0.0003	0.0007	0.0000
3.B.1.2 Manure Management – Sheep	N2O	5	7	10.0	100.0	100.50	0.0001	0.0000	0.0001	0.0023	0.0015	0.0000
3.B.1.3 Manure Management – Swine	CH4	148	83	4.0	20.0	20.40	0.0006	-0.0010	0.0012	-0.0200	0.0069	0.0004
3.B.1.3 Manure Management – Swine	N2O	99	53	4.0	100.0	100.08	0.0061	-0.0007	0.0008	-0.0691	0.0045	0.0048
3.B.1.4. Manure Management – Other	CH4	14	24	10.0	30.0	31.62	0.0001	0.0001	0.0004	0.0042	0.0050	0.0000
3.B.1.4. Manure Management – Other	N2O	8	17	10.0	100.0	100.50	0.0006	0.0001	0.0003	0.0129	0.0036	0.0002
3.B.2.5 Indirect N2O Emissions	N2O	103	111	5.0	200.0	200.06	0.1054	0.0001	0.0016	0.0205	0.0116	0.0006
3.D.1 Direct N2O Emissions from Managed Soils	N2O	1 776	1 455	5.0	200.0	200.06	18.1179	-0.0052	0.0216	-1.0301	0.1526	1.0843
3.D.2 Indirect N2O emissions from Managed Soils	N2O	357	288	5.0	200.0	200.06	0.7098	-0.0011	0.0043	-0.2208	0.0302	0.0497
3.F Field Burning of Agricultural Residues	CH4	1	0	100.0	40.0	107.70	0.0000	0.0000	0.0000	-0.0006	0.0000	0.0000
3.F Field Burning of Agricultural Residues	N2O	0	0	100.0	50.0	111.80	0.0000	0.0000	0.0000	-0.0002	0.0000	0.0000
3.G Liming	CO2	46	99	5.0	50.0	50.25	0.0053	0.0008	0.0015	0.0392	0.0104	0.0016
3.H Urea application	CO2	10	26	5.0	50.0	50.25	0.0004	0.0002	0.0004	0.0117	0.0027	0.0001
3.I Other	CO2	31	24	5.0	50.0	50.25	0.0003	-0.0001	0.0004	-0.0050	0.0026	0.0000
4 Total land use categories	CH4	27	27			218.82	0.0077	0.0000	0.0004	0.0000	0.0000	0.0000

IPCC category/Group	GHG	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivi ty	Type B sensitivi ty	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO ₂ equivalent	Gg CO ₂ equivalent	%	%	%		%	%	%	%	%
		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	$\left \frac{D}{\sum C} \right $	I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2
4 Total land use categories	N2O	143	127			121.48	0.0513	-0.0003	0.0019	0.0000	0.0000	0.0000
4.A.1 Forest land remaining forest land	CO2	-8 122	-3 192			38.77	3.2758	0.0750	0.0474	0.0000	0.0000	0.0000
4.A.2 Land converted to forest land	CO2	-2 955	-1 420			113.34	5.5428	0.0234	0.0211	0.0000	0.0000	0.0000
4.B.1 Cropland remaining cropland	CO2	-18	84			55.88	0.0047	0.0015	0.0012	0.0000	0.0000	0.0000
4.B.2 Land converted to cropland	CO2	202	233			50.80	0.0301	0.0004	0.0035	0.0000	0.0000	0.0000
4.C.1 Grassland remaining grassland	CO2	304	304			228.90	1.0366	-0.0001	0.0045	0.0000	0.0000	0.0000
4.C.2 Land converted to grassland	CO2	393	140			166.99	0.1165	-0.0038	0.0021	0.0000	0.0000	0.0000
4.D.1 Wetlands remaining Wetlands	CO2	0	0			63.59	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4.D.2 Land converted to Wetlands	CO2	48	70			63.59	0.0042	0.0003	0.0010	0.0000	0.0000	0.0000
4.E.2 Land converted to Settlements	CO2	917	746			30.14	0.1080	-0.0027	0.0111	0.0000	0.0000	0.0000
4.F.2 Land converted to Other land	CO2	502	517			123.14	0.8668	0.0001	0.0077	0.0000	0.0000	0.0000
4.G HWP	CO2	-3 122	-2 110			48.99	2.2859	0.0157	0.0313	0.0000	0.0000	0.0000
5.A Solid Waste Disposal	CH4	4 081	846	12.0	25.0	27.73	0.1177	-0.0488	0.0125	-1.2211	0.2130	1.5363
5.B Biological Treatment of Solid Waste	CH4	15	77	20.0	50.0	53.85	0.0037	0.0009	0.0011	0.0461	0.0323	0.0032
5.B Biological Treatment of Solid Waste	N2O	20	72	20.0	50.0	53.85	0.0032	0.0008	0.0011	0.0383	0.0303	0.0024
5.C Incineration and Open Burning of Waste	CH4	1	0	7.0	0.0	7.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.C Incineration and Open Burning of Waste	CO2	28	2	7.0	20.0	21.19	0.0000	-0.0004	0.0000	-0.0078	0.0003	0.0001
5.C Incineration and Open Burning of Waste	N2O	0	0	7.0	0.0	7.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.D Waste Water Treatment and Discharge	CH4	137	24	20.0	50.0	53.85	0.0004	-0.0017	0.0004	-0.0850	0.0101	0.0073
5.D Waste Water Treatment and Discharge	N2O	86	152	20.0	100.0	101.98	0.0517	0.0010	0.0023	0.0971	0.0640	0.0135
Total		67 400	68 370				36.67					6.26
Total Uncertainties						Uncertainty in total inventory %:	6.06			Trend uncertainty %:		2.50

ANNEX 3: DETAILED METHODOLOGICAL DESCRIPTIONS

Annex 3.1 – CRF 1.A Fuel Combustion

This Annex includes detailed information about category *1.A Fuel Combustion* (trend information by sub-category), a description of the national energy balance (including fuel and fuel categories) and a description of the methodology applied to extract activity data from the energy balance for the calculation of emissions for category *1.A Fuel Combustion* (e.g. correspondence of categories of the energy balance to IPCC categories). Activity data used for estimating emissions in the sectoral approach as taken from the energy balance is also presented.

Furthermore, the revision of the national energy balance as well as the implication of this revision on activity data are described.

1.A.1.a – Biomass – implied emission factors for CO₂, N₂O and CH₄

Following a recommendation of the UNFCCC 2023 review, the fluctuations in the trend of 1.A.1.a biomass CO₂, CH₄ and N₂O implied emission factors are explained.

The following table shows fuel consumption and of solid biomass and biogas of category 1.A.1.a and the calculated implied emission factors which are consistent with CRF Table 1.A(a)s1.

CO₂, CH₄ and N₂O emission factors for the year 2005 are lower than for 2004 because biogas consumption increases, which has lower emission factors than solid biomass. Emissions factors are provided in the NIR chapter for category 1.A.1.a.

Table A 22: 1.A.1.a - Biomass - implied emission factors for CO₂, N₂O and CH₄

	Fuel consumption (TJ)			CH ₄ -IEF	CH ₄ -emissions			N ₂ O-IEF	N ₂ O-emissions			CO ₂ -IEF	CO ₂ -emissions		
	Total	Solid	Biogas		Total	Solid	Biogas		Total	Solid	Biogas		Total	Solid	Biogas
1990	2 901	2 901	0	11.01	0.032	0.032	0.000	4.00	0.012	0.012	0.000	115.8	336	336	0
1995	6 085	6 046	39	10.69	0.065	0.065	0.000	3.98	0.024	0.024	0.000	114.6	697	695	2
2000	10 496	10 397	98	10.44	0.110	0.109	0.000	3.96	0.042	0.042	0.000	113.5	1 191	1 186	5
2001	13 534	13 425	109	10.39	0.141	0.141	0.000	3.97	0.054	0.054	0.000	113.1	1 531	1 525	6
2002	15 722	15 623	99	10.32	0.162	0.162	0.000	3.98	0.063	0.062	0.000	113.1	1 778	1 773	5
2003	17 106	16 816	290	10.25	0.175	0.175	0.000	3.93	0.067	0.067	0.000	112.6	1 926	1 910	16
2004	19 762	19 512	250	10.41	0.206	0.205	0.000	3.95	0.078	0.078	0.000	113.2	2 237	2 223	14
2005	25 105	21 527	3 578	9.14	0.230	0.226	0.004	3.44	0.086	0.086	0.000	105.4	2 647	2 451	195
2006	35 568	30 084	5 484	8.98	0.319	0.314	0.005	3.40	0.121	0.120	0.001	104.6	3 721	3 421	299
2007	42 890	37 076	5 814	9.07	0.389	0.383	0.006	3.47	0.149	0.148	0.001	105.4	4 520	4 202	317
2008	50 023	43 919	6 105	9.16	0.458	0.452	0.006	3.52	0.176	0.176	0.001	106.0	5 303	4 970	333
2009	54 061	48 723	5 337	9.40	0.508	0.503	0.005	3.61	0.195	0.195	0.001	107.5	5 810	5 519	291
2010	62 887	57 675	5 212	9.52	0.598	0.593	0.005	3.68	0.231	0.231	0.001	108.3	6 810	6 525	285
2011	63 833	58 344	5 489	9.51	0.607	0.602	0.005	3.66	0.234	0.233	0.001	108.2	6 904	6 605	300
2012	68 214	61 574	6 640	9.40	0.641	0.634	0.007	3.62	0.247	0.246	0.001	107.4	7 329	6 967	363
2013	66 912	60 846	6 066	9.46	0.633	0.627	0.006	3.65	0.244	0.243	0.001	107.9	7 217	6 886	331
2014	67 850	58 009	9 842	9.00	0.611	0.601	0.010	3.43	0.233	0.232	0.001	104.9	7 117	6 579	537
2015	71 555	61 405	10 150	9.04	0.647	0.637	0.010	3.45	0.247	0.246	0.001	105.1	7 519	6 965	554
2016	70 219	60 065	10 154	9.05	0.635	0.625	0.010	3.44	0.241	0.240	0.001	105.1	7 378	6 823	554
2017	72 697	62 072	10 625	8.99	0.654	0.643	0.011	3.43	0.249	0.248	0.001	104.9	7 622	7 042	580
2018	68 562	60 968	7 594	9.32	0.639	0.631	0.008	3.57	0.245	0.244	0.001	106.9	7 331	6 917	415
2019	65 889	59 064	6 825	9.40	0.620	0.613	0.007	3.60	0.237	0.236	0.001	107.4	7 078	6 705	373
2020	69 309	62 461	6 848	9.46	0.655	0.649	0.007	3.61	0.251	0.250	0.001	107.7	7 468	7 094	374
2021	69 329	64 736	4 594	9.74	0.675	0.671	0.005	3.74	0.259	0.259	0.000	109.6	7 599	7 348	251
2022	68 081	63 497	4 585	9.73	0.662	0.658	0.005	3.74	0.254	0.254	0.000	109.5	7 458	7 207	250

Trend information by sub category

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

Table A 23: Greenhouse gas emissions from Category 1.A.1.a

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	50 828	24	1	51 892
1995	52 649	21	2	53 656
2000	53 833	17	2	54 753
2005	65 315	15	2	66 244
2010	57 785	16	2	58 777
2011	55 520	14	2	56 475
2012	53 347	15	2	54 319
2013	53 515	15	2	54 499
2014	49 887	13	2	50 808
2015	51 662	14	2	52 606
2016	52 907	14	2	53 862
2017	54 565	14	2	55 537
2018	53 216	13	2	54 153
2019	53 623	13	2	54 561
2020	48 737	13	2	49 638
2021	50 600	15	2	51 585
2022	47 260	12	2	48 153
Trend 1990–2022	-7.0%	-49.3%	43.2%	-7.2%

Solid fossil fuels and natural gas are dominant compared to other fuel types. Since 2007 liquid fossil fuels became less important. The share in CO₂ emissions from waste incineration in district heating plants which are reported as 'other fuels' increased from 3% in 1990 to 18% in 2020. Solid fuels 2020 decreased due to the phase-out of coal-fired power generation.

Table A 24: Share of fuel types on total CO₂ emissions from Category 1.A.1.a

	Liquid	Solid	Gaseous	Other
1990	11%	57%	30%	3%
1995	16%	46%	35%	3%
2000	12%	49%	36%	3%
2005	9%	46%	41%	4%
2010	6%	36%	49%	8%
2011	4%	41%	45%	9%
2012	3%	39%	47%	11%
2013	2%	42%	43%	13%
2014	2%	37%	44%	17%
2015	3%	32%	50%	15%
2016	5%	22%	56%	16%
2017	3%	17%	66%	14%
2018	1%	20%	64%	15%
2019	1%	17%	68%	15%
2020	1%	6%	75%	18%
2021	2%	0%	79%	19%
2022	4%	0%	78%	18%

1.A.1.b Petroleum Refining

Table A 25: Greenhouse gas emissions from Category 1.A.1.b.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	2 394	0.05	0.01	2 398
1995	2 590	0.06	0.01	2 594
2000	2 214	0.06	0.01	2 218
2005	2 827	0.08	0.01	2 833
2010	2 724	0.07	0.01	2 730
2011	2 768	0.07	0.01	2 774
2012	2 836	0.08	0.01	2 842
2013	2 827	0.08	0.02	2 833
2014	2 713	0.08	0.01	2 719
2015	2 804	0.09	0.02	2 811
2016	2 784	0.09	0.02	2 791
2017	2 739	0.08	0.01	2 745
2018	2 824	0.08	0.02	2 831
2019	2 791	0.08	0.01	2 797
2020	2 732	0.08	0.01	2 738
2021	2 750	0.08	0.01	2 755
2022	2 255	0.06	0.01	2 259
Trend 1990–2022	-5.8%	9.1%	20.5%	-5.8%

Table A 26 presents the share of CO₂ emissions on the different fuel types.

Table A 26: Share of fuel types on total CO₂ emissions from Category 1.A.1.b.

	Liquid	Gaseous
1990	82%	18%
1995	84%	16%
2000	84%	16%
2005	82%	18%
2010	82%	18%
2011	82%	18%
2012	85%	15%
2013	87%	13%
2014	88%	12%
2015	88%	12%
2016	88%	12%
2017	86%	14%
2018	83%	17%
2019	82%	18%
2020	82%	18%
2021	81%	19%
2022	87%	

1.A.1.c Manufacture of Solid Fuels and Other Energy Industries

Table A 27: Greenhouse gas emissions from Category 1.A.1.c.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	510	0.04	0.0010	511
1995	611	0.04	0.0011	613
2000	281	0.04	0.0005	282
2005	394	0.04	0.0007	395
2010	238	0.04	0.0004	239
2011	266	0.04	0.0005	267

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
2012	206	0.05	0.0004	207
2013	250	0.04	0.0005	252
2014	248	0.04	0.0004	249
2015	275	0.05	0.0005	277
2016	273	0.05	0.0005	275
2017	259	0.04	0.0005	260
2018	240	0.04	0.0004	241
2019	312	0.05	0.0006	314
2020	289	0.05	0.0005	291
2021	375	0.05	0.0007	376
2022	344	0.04	0.0006	346
Trend 1990–2022	-32.5%	-4.4%	-34.8%	-32.4%

Almost all emissions of category 1.A.1.c originate from natural gas combustion.

Table A 28: Share of fuel types on total CO₂ emissions from Category 1.A.1.c.

	Liquid	Gaseous
1990	1%	99%
1995	0%	100%
2000	NO	100%
2005	NO	100%
2010	NO	100%
2011	NO	100%
2012	NO	100%
2013	NO	100%
2014	NO	100%
2015	NO	100%
2016	NO	100%
2017	NO	100%
2018	NO	100%
2019	NO	100%
2020	NO	100%
2021	NO	100%
2022	NO	100%

1.A.2.a Iron and Steel

Table A 29: Greenhouse gas emissions from Category 1.A.2.a.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	1 833	0.03	0.003	1 834
1995	1 338	0.02	0.003	1 339
2000	1 275	0.02	0.003	1 277
2005	1 845	0.03	0.003	1 846
2010	1 275	0.02	0.003	1 277
2011	1 446	0.03	0.003	1 447
2012	1 483	0.03	0.003	1 485
2013	1 606	0.03	0.003	1 608
2014	1 496	0.03	0.003	1 497
2015	1 406	0.02	0.002	1 407
2016	1 577	0.03	0.003	1 578
2017	1 658	0.03	0.003	1 660
2018	1 771	0.03	0.003	1 773
2019	1 805	0.03	0.003	1 806
2020	1 803	0.03	0.003	1 805
2021	1 783	0.03	0.003	1 785

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
2022	1 936	0.03	0.003	1 937
Trend 1990–2022	5.6%	13.4%	13.8%	5.6%

CO₂ emissions from category 1.A.2.a (without blast furnaces) mainly arise from gaseous fuels.

Table A 30: Share of fuel types in total CO₂ emissions from Category 1.A.2.a.

	Liquid	Solid	Gaseous
1990	4.2%	60.4%	35.5%
1995	6.2%	37.1%	56.6%
2000	5.8%	14.1%	80.1%
2005	3.2%	37.7%	59.1%
2010	2.5%	11.2%	86.4%
2011	1.9%	12.4%	85.8%
2012	1.3%	13.0%	85.7%
2013	0.5%	17.4%	82.1%
2014	0.4%	9.8%	89.8%
2015	0.4%	20.2%	79.4%
2016	0.5%	31.7%	67.8%
2017	0.4%	33.2%	66.4%
2018	0.4%	33.1%	66.5%
2019	0.3%	36.2%	63.5%
2020	0.4%	39.7%	60.0%
2021	1.1%	42.6%	56.3%
2022	2.3%	43.5%	54.2%

1.A.2.b Non-Ferrous Metals

Table A 31: Greenhouse gas emissions from Category 1.A.2.b.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	132	0.004	0.001	132
1995	255	0.006	0.001	255
2000	193	0.006	0.001	193
2005	218	0.005	0.001	218
2010	236	0.005	0.001	236
2011	248	0.005	0.001	248
2012	241	0.005	0.001	241
2013	271	0.012	0.003	271
2014	289	0.008	0.001	289
2015	295	0.007	0.001	295
2016	305	0.007	0.001	305
2017	297	0.007	0.001	297
2018	325	0.007	0.001	325
2019	301	0.007	0.001	301
2020	268	0.006	0.001	268
2021	297	0.007	0.001	297
2022	302	0.007	0.001	302
Trend 1990–2022	129.1%	65.3%	61.5%	129.1%

CO₂ emissions from category 1.A.2.b mainly arise from gaseous fuels.

Table A 32: Share of fuel types in total CO₂ emissions from Category 1.A.2.b

	Liquid	Solid	Gaseous	Other
1990	27%	17%	57%	0.0%
1995	16%	4%	80%	0.0%
2000	24%	9%	66%	0.0%
2005	15%	6%	79%	0.0%
2010	8%	3%	89%	0.0%
2011	9%	3%	88%	0.0%
2012	9%	3%	89%	0.0%
2013	13%	5%	81%	0.4%
2014	11%	6%	83%	0.3%
2015	10%	5%	85%	0.4%
2016	7%	5%	88%	0.4%
2017	6%	4%	90%	0.4%
2018	2%	3%	95%	0.2%
2019	3%	4%	93%	0.4%
2020	3%	5%	92%	0.3%
2021	3%	3%	93%	0.1%
2022	3%	5%	92%	0.2%

1.A.2.c Chemicals

Table A 33: Greenhouse gas emissions from Category 1.A.2.c.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	847	0.07	0.02	855
1995	986	0.07	0.02	993
2000	1 341	0.11	0.03	1 352
2005	1 348	0.07	0.02	1 355
2010	1 547	0.11	0.03	1 559
2011	1 487	0.10	0.03	1 498
2012	1 486	0.11	0.03	1 497
2013	1 384	0.09	0.03	1 394
2014	1 418	0.10	0.03	1 427
2015	1 394	0.09	0.02	1 403
2016	1 550	0.10	0.03	1 559
2017	1 627	0.10	0.03	1 637
2018	1 471	0.10	0.03	1 481
2019	1 462	0.09	0.03	1 472
2020	1 493	0.10	0.03	1 503
2021	1 531	0.09	0.03	1 541
2022	1 398	0.11	0.03	1 410
Trend 1990–2022	65.1%	48.4%	52.0%	65.0%

In 2022, natural gas was still the main source of CO₂ emissions from category 1.A.2.c while CO₂ emissions from solid and liquid fossil fuel combustion got less important.

Table A 34: Share of fuel types in total CO₂ emissions from Category 1.A.2.c

	Liquid	Solid	Gaseous	Other
1990	11%	13%	61%	15%
1995	10%	15%	58%	16%
2000	5%	19%	65%	11%
2005	5%	11%	76%	8%
2010	9%	5%	66%	20%
2011	8%	5%	68%	19%
2012	7%	5%	69%	19%

	Liquid	Solid	Gaseous	Other
2013	6%	6%	72%	16%
2014	4%	9%	71%	16%
2015	4%	7%	73%	16%
2016	4%	7%	73%	16%
2017	3%	13%	70%	14%
2018	3%	8%	75%	14%
2019	3%	4%	81%	12%
2020	5%	3%	76%	16%
2021	2%	2%	80%	15%
2022	3%	4%	71%	22%

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

Table A 35: Greenhouse gas emissions from Category 1.A.2.d.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv.[kt]
1990	2 208	0.20	0.07	2 233
1995	2 301	0.25	0.10	2 334
2000	2 379	0.20	0.08	2 405
2005	2 293	0.26	0.10	2 327
2010	2 312	0.23	0.09	2 343
2011	2 264	0.23	0.09	2 295
2012	2 023	0.23	0.10	2 055
2013	1 899	0.23	0.10	1 931
2014	1 741	0.22	0.09	1 772
2015	1 829	0.21	0.09	1 858
2016	1 774	0.22	0.09	1 805
2017	1 776	0.22	0.09	1 807
2018	1 883	0.23	0.10	1 915
2019	1 970	0.24	0.10	2 004
2020	1 800	0.22	0.09	1 831
2021	1 820	0.21	0.09	1 850
2022	1 528	0.22	0.10	1 561
Trend 1990–2022	-30.8%	11.3%	38.8%	-30.1%

Natural gas combustion is the main source of CO₂ emissions from category 1.A.2.d. liquid fuel consumption decreased since 1990 whereas the share of solid fuels in total CO₂ emissions is rather constant.

Table A 36: Share of fuel types in total CO₂ emissions from Category 1.A.2.d.

	Liquid	Solid	Gaseous	Other
1990	39%	18%	43%	1%
1995	23%	17%	59%	2%
2000	7%	19%	74%	0%
2005	6%	19%	75%	0%
2010	3%	14%	82%	0%
2011	2%	16%	82%	0%
2012	2%	17%	81%	0%
2013	3%	19%	76%	1%
2014	2%	21%	76%	1%
2015	2%	21%	75%	1%
2016	2%	21%	77%	1%
2017	1%	22%	76%	1%
2018	1%	20%	78%	1%
2019	1%	19%	80%	0%

	Liquid	Solid	Gaseous	Other
2020	1%	17%	82%	1%
2021	1%	12%	88%	0%
2022	2%	9%	90%	0%

1.A.2.e Food Processing, Beverages and Tobacco

Table A 37: Greenhouse gas emissions from Category 1.A.2.e.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	870	0.03	0.004	872
1995	931	0.03	0.004	933
2000	882	0.02	0.004	884
2005	960	0.03	0.005	962
2010	966	0.03	0.005	968
2011	962	0.03	0.005	964
2012	942	0.03	0.005	944
2013	827	0.02	0.003	828
2014	922	0.02	0.003	924
2015	980	0.02	0.003	981
2016	816	0.02	0.003	817
2017	803	0.02	0.003	804
2018	769	0.02	0.003	771
2019	759	0.02	0.003	761
2020	790	0.02	0.003	791
2021	798	0.02	0.002	799
2022	866	0.02	0.005	868
Trend 1990–2022	-0.5%	-11.9%	6.8%	-0.5%

The share of natural gas consumption is increasing and is the main source of CO₂ emissions from category 1.A.2.e. The share of liquid fossil fuel in total CO₂ emissions strongly decreased since 1990.

Table A 38: Share of fuel types in total CO₂ emissions from Category 1.A.2.e.

	Liquid	Solid	Gaseous	Other
1990	40%	2%	58%	0.00%
1995	37%	1%	63%	0.00%
2000	19%	2%	79%	0.00%
2005	25%	1%	73%	0.00%
2010	21%	2%	78%	0.03%
2011	21%	2%	78%	0.03%
2012	17%	2%	82%	0.03%
2013	9%	2%	89%	0.01%
2014	9%	2%	88%	0.00%
2015	7%	2%	91%	0.00%
2016	7%	2%	91%	0.00%
2017	6%	2%	92%	0.00%
2018	5%	2%	94%	0.05%
2019	5%	2%	94%	0.00%
2020	4%	2%	95%	0.01%
2021	4%	2%	94%	0.00%
2022	8%	2%	90%	0.00%

1.A.2.f Non-Metallic Minerals

Table A 39: Greenhouse gas emissions from Category 1.A.2.f.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	1 669	0.10	0.02	1 677
1995	1 520	0.09	0.02	1 528
2000	1 540	0.11	0.02	1 550
2005	1 656	0.14	0.04	1 669
2010	1 528	0.14	0.04	1 542
2011	1 546	0.14	0.04	1 560
2012	1 530	0.15	0.04	1 545
2013	1 552	0.15	0.04	1 567
2014	1 613	0.16	0.05	1 630
2015	1 605	0.17	0.05	1 623
2016	1 631	0.16	0.05	1 648
2017	1 636	0.17	0.05	1 654
2018	1 694	0.18	0.05	1 713
2019	1 664	0.17	0.05	1 682
2020	1 654	0.17	0.05	1 672
2021	1 682	0.18	0.05	1 701
2022	1 579	0.17	0.05	1 598
Trend 1990–2022	-5.4%	72.5%	192.1%	-4.7%

Natural gas and other fossil fuel (Industrial waste) combustion is the main source of CO₂ emissions from category 1.A.2.f. The share of other fossil fuel increased while liquid and solid fuels decreased.

Table A 40: Share of fuel types in total CO₂ emissions from category 1.A.2.f

	Liquid	Solid	Gaseous	Other
1990	30%	32%	33%	4%
1995	23%	29%	40%	8%
2000	13%	33%	42%	13%
2005	18%	23%	40%	20%
2010	13%	20%	39%	27%
2011	13%	18%	40%	29%
2012	11%	19%	38%	32%
2013	11%	17%	41%	32%
2014	10%	17%	39%	34%
2015	10%	17%	39%	35%
2016	10%	14%	40%	37%
2017	8%	13%	41%	38%
2018	8%	14%	40%	39%
2019	6%	14%	42%	37%
2020	5%	19%	42%	34%
2021	9%	15%	40%	37%
2022	10%	13%	38%	39%

1.A.2.g.7 Manufacturing Industries and Construction – Mobile sources

Table A 41: Greenhouse gas emissions from Category 1.A.2.g.7.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	256	0.01	0.09	280
1995	358	0.02	0.13	393
2000	551	0.02	0.22	610
2005	810	0.02	0.23	873
2010	1 077	0.01	0.19	1 129

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
2011	1 082	0.01	0.19	1 132
2012	1 119	0.01	0.18	1 167
2013	1 128	0.01	0.17	1 174
2014	1 102	0.01	0.16	1 146
2015	1 068	0.01	0.15	1 109
2016	1 083	0.01	0.15	1 122
2017	1 142	0.01	0.15	1 182
2018	1 222	0.01	0.15	1 262
2019	1 289	0.01	0.15	1 329
2020	1 238	0.005	0.14	1 275
2021	1 360	0.005	0.15	1 401
2022	1 458	0.005	0.16	1 500
Trend 1990-2022	469.9%	-63.4%	77.4%	435.8%

All emissions from mobile machinery of industry arise from liquid fuels (diesel, gasoline) and biofuels.

1.A.2.g.8 Manufacturing Industries and Construction – Other – stationary sources

Table A 42: Greenhouse gas emissions from Category 1.A.2.g.8.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	1 719	0.09	0.02	1 727
1995	2 282	0.10	0.02	2 290
2000	1 738	0.15	0.04	1 753
2005	2 082	0.26	0.08	2 111
2010	2 099	0.31	0.10	2 135
2011	1 913	0.32	0.11	1 952
2012	2 017	0.34	0.12	2 058
2013	1 920	0.31	0.11	1 958
2014	1 618	0.29	0.11	1 654
2015	1 489	0.30	0.11	1 526
2016	1 647	0.26	0.09	1 679
2017	1 649	0.26	0.09	1 681
2018	1 566	0.23	0.08	1 594
2019	1 437	0.21	0.07	1 463
2020	1 417	0.22	0.08	1 444
2021	1 492	0.22	0.08	1 520
2022	1 411	0.25	0.09	1 442
Trend 1990-2022	-17.9%	172.9%	345.3%	-16.5%

Natural gas and liquid fossil fuel combustion is the main source of CO₂ emissions from category 1.A.2.g.8.

Table A 43: Share of fuel types on total CO₂ emissions from Category 1.A.2.g.8

	Liquid	Solid	Gaseous	Other
1990	36%	5%	59%	0%
1995	35%	1%	62%	2%
2000	35%	2%	62%	2%
2005	34%	2%	62%	2%
2010	24%	0%	74%	2%
2011	27%	0%	71%	2%
2012	29%	0%	69%	2%
2013	16%	0%	82%	2%
2014	17%	0%	82%	1%

	Liquid	Solid	Gaseous	Other
2015	17%	0%	81%	2%
2016	15%	0%	83%	2%
2017	14%	0%	84%	2%
2018	11%	0%	87%	2%
2019	15%	0%	83%	2%
2020	11%	0%	87%	2%
2021	9%	0%	89%	2%
2022	8%	0%	90%	2%

1.A.3.e.i Other Transportation – Pipeline Compressors

Table A 44: Greenhouse gas emissions from Category 1.A.3.e.i

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	224	0.004	0.0004	225
1995	227	0.004	0.0004	227
2000	338	0.006	0.0006	338
2005	359	0.006	0.0006	359
2010	459	0.008	0.0008	459
2011	568	0.010	0.0010	569
2012	458	0.008	0.0008	458
2013	607	0.011	0.0011	607
2014	505	0.009	0.0009	505
2015	585	0.011	0.0011	586
2016	561	0.010	0.0010	562
2017	634	0.011	0.0011	635
2018	587	0.011	0.0011	588
2019	542	0.010	0.0010	542
2020	472	0.008	0.0008	472
2021	374	0.007	0.0007	375
2022	152	0.003	0.0003	152
Trend 1990–2022	-32.4%	-32.6%	-32.6%	-32.4%

All emissions from pipeline compressors arise from gaseous fuels.

1.A.4 Other sectors

Table A 45: Greenhouse gas emissions from Category 1.A.4.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	13 543	20.49	0.64	14 287
1995	13 976	17.98	0.65	14 652
2000	13 005	14.27	0.67	13 582
2005	13 371	12.14	0.65	13 883
2010	10 700	13.05	0.62	11 231
2011	9 519	11.86	0.60	10 011
2012	9 079	12.32	0.58	9 579
2013	9 305	12.56	0.58	9 810
2014	8 369	10.98	0.54	8 819
2015	8 705	11.26	0.54	9 162
2016	9 007	11.47	0.54	9 472
2017	9 107	11.63	0.53	9 573
2018	8 385	10.57	0.49	8 812
2019	8 644	10.52	0.50	9 071
2020	8 642	10.41	0.50	9 065
2021	9 344	12.18	0.56	9 834
2022	7 920	9.76	0.47	8 318
Trend 1990–2022	-41.5%	-52.4%	-26.6%	-41.8%

As can be seen from Table A 45 liquid fossil fuels are the main source of CO₂ emissions from category 1.A.4 with a quite constant share over time series. Since 1990 solid fossil fuels became less important whereas the share of CO₂ emissions from natural gas combustion more than doubled.

Table A 46: Share of fuel types on total CO₂ emissions from Category 1.A.4.

	Liquid	Solid	Gaseous	Other
1990	61%	20%	19%	1%
1995	58%	13%	29%	0%
2000	61%	7%	31%	0%
2005	59%	3%	37%	1%
2010	54%	3%	43%	0%
2011	55%	2%	43%	0%
2012	51%	2%	47%	0%
2013	52%	1%	46%	0%
2014	54%	1%	45%	0%
2015	53%	1%	46%	0%
2016	51%	1%	48%	0%
2017	52%	1%	47%	0%
2018	51%	1%	48%	0%
2019	50%	1%	49%	0%
2020	50%	1%	49%	0%
2021	49%	1%	50%	0%
2022	52%	0%	48%	0%

1.A.4 Other sectors – stationary sources

Table A 47: Greenhouse gas emissions from Category 1.A.4 Other sectors – stationary sources.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	12 601	19.88	0.37	13 254
1995	13 054	17.43	0.37	13 534
2000	12 054	13.80	0.35	12 453
2005	12 373	11.75	0.34	12 726
2010	9 799	12.84	0.39	10 190
2011	8 556	11.66	0.37	8 915
2012	8 185	12.15	0.38	8 557
2013	8 434	12.41	0.39	8 816
2014	7 426	10.83	0.34	7 760
2015	7 831	11.12	0.36	8 178
2016	8 074	11.34	0.37	8 427
2017	8 232	11.51	0.38	8 591
2018	7 507	10.45	0.35	7 835
2019	7 726	10.41	0.36	8 055
2020	7 717	10.30	0.36	8 043
2021	8 442	12.08	0.43	8 828
2022	7 024	9.65	0.34	7 334
Trend 1990–2022	-44.3%	-51.5%	-5.8%	-44.7%

Liquid fossil fuels are the main stationary source of CO₂ emissions from category 1.A.4 until 2011 with a quite constant share over time. Since 1990 solid fossil fuels became less important whereas the share of CO₂ emissions from natural gas combustion more than doubled.

Table A 48: Share of fuel types in total CO₂ emissions from Category 1.A.4 stationary sources.

	Liquid	Solid	Gaseous	Other
1990	58%	21%	20%	0.7%
1995	55%	13%	31%	0.3%
2000	58%	8%	34%	0.3%
2005	56%	4%	40%	0.7%
2010	50%	3%	47%	0.1%
2011	50%	2%	48%	0.1%
2012	46%	2%	52%	0.0%
2013	48%	2%	51%	0.1%
2014	48%	1%	50%	0.1%
2015	47%	1%	51%	0.1%
2016	45%	1%	53%	0.1%
2017	47%	1%	52%	0.1%
2018	45%	1%	54%	0.1%
2019	44%	1%	55%	0.1%
2020	44%	1%	55%	0.0%
2021	44%	1%	55%	0.0%
2022	45%	0%	54%	0.0%

1.A.4.a.1 Commercial/Institutional – stationary sources

Table A 49: Greenhouse gas emissions from Category 1.A.4.a.1 Commercial/Institutional- stationary sources.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	2 292	0.53	0.03	2 313
1995	3 038	0.51	0.02	3 059
2000	2 797	0.43	0.03	2 817
2005	3 418	0.40	0.03	3 437
2010	1 660	0.34	0.02	1 675
2011	1 487	0.28	0.02	1 499
2012	1 389	0.23	0.01	1 399
2013	1 387	0.23	0.01	1 398
2014	1 247	0.18	0.01	1 255
2015	1 296	0.22	0.01	1 306
2016	1 224	0.19	0.01	1 232
2017	1 420	0.23	0.02	1 431
2018	1 362	0.24	0.02	1 374
2019	1 368	0.24	0.02	1 380
2020	1 290	0.23	0.02	1 301
2021	1 524	0.26	0.02	1 537
2022	1 214	0.20	0.02	1 224
Trend 1990–2022	2 292	0.53	0.03	2 313

1.A.4.b.1 Residential – stationary sources

Table A 50: Greenhouse gas emissions from Category 1.A.4.b.1 Residential – stationary sources.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	9 827	17.93	0.32	10 414
1995	9 776	15.42	0.33	10 294
2000	8 999	11.80	0.30	9 409
2005	8 791	9.57	0.28	9 134
2010	8 049	10.56	0.34	8 436
2011	6 996	9.53	0.32	7 348
2012	6 736	9.92	0.34	7 102
2013	6 977	9.98	0.35	7 349
2014	6 105	8.62	0.30	6 427

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
2015	6 462	8.83	0.32	6 794
2016	6 763	9.02	0.33	7 103
2017	6 734	9.05	0.33	7 075
2018	6 075	8.20	0.30	6 385
2019	6 285	8.29	0.31	6 600
2020	6 364	8.18	0.31	6 676
2021	6 851	9.57	0.38	7 219
2022	5 754	7.62	0.30	6 047
Trend 1990–2022	-41.5%	-57.5%	-5.3%	-41.9%

1.A.4.c.1 Agriculture/Forestry/Fisheries – stationary sources

The following table presents greenhouse gas emissions from 1.A.4.c.1 Agriculture/ Forestry/ Fisheries – stationary sources.

Table A 51: Greenhouse gas emissions from Category 1.A.4.c.1 Agriculture/Forestry/Fisheries – stationary sources.

	CO ₂ [kt]	CH ₄ [kt]	N ₂ O [kt]	CO ₂ equiv. [kt]
1990	482	1.42	0.02	527
1995	240	1.49	0.02	287
2000	258	1.57	0.02	308
2005	165	1.78	0.02	221
2010	91	1.94	0.03	152
2011	74	1.86	0.02	133
2012	60	2.01	0.03	124
2013	70	2.20	0.03	139
2014	75	2.03	0.03	138
2015	73	2.08	0.03	139
2016	88	2.13	0.03	155
2017	78	2.23	0.03	148
2018	69	2.02	0.03	133
2019	73	1.87	0.02	132
2020	63	1.89	0.03	123
2021	67	2.25	0.03	138
2022	57	1.83	0.02	114
Trend 1990–2022	-88.2%	28.9%	21.9%	-78.3%

Activity Data Recalculations

Updates of activity data and NCVs follow the updates of the IEA-compliant energy balance compiled by the federal statistics authority Statistik Austria.

Table A 52: 1.A activity data recalculations by sub categories with respect to previous submission.

IPCC Category / Fuel Group	Fuel Consumption [PJ]								
	1990			2020			2021		
	Subm. 2024	Subm. 2023	Difference	Subm. 2024	Subm. 2023	Difference	Subm. 2024	Subm. 2023	Difference
1 A FUEL COMBUSTION ACTIVITIES	790.39	790.39	-	948.83	948.87	-0.03	997.52	993.90	3.62
1 A liquid	368.39	368.39	-	383.16	383.23	-0.06	400.78	403.13	-2.35
1 A solid	113.46	113.46	-	19.25	19.21	0.04	14.08	14.19	-0.11
1 A gaseous	203.98	203.98	-	294.64	294.64	-	311.81	311.81	-
1 A other	7.72	8.99	-1.27	23.68	35.06	-11.38	23.91	36.12	-12.20
1 A peat	0.00	0.00	-	NO	NO	-	NO	NO	-
1 A biomass	96.85	95.57	1.27	228.10	216.73	11.37	246.94	228.66	18.28

IPCC Category / Fuel Group	Fuel Consumption [PJ]								
	1990			2020			2021		
	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence
1 A 1 Energy Industries	187.35	187.35	-	205.03	205.03	-	209.36	208.34	1.03
1 A 1 liquid	43.15	43.15	-	30.40	30.40	-	31.06	31.06	-
1 A 1 solid	61.40	61.40	-	3.86	3.86	-	NO	NO	-
1 A 1 gaseous	76.48	76.48	-	90.17	90.17	-	97.25	96.28	0.97
1 A 1 other	3.39	4.66	-1.27	11.25	22.63	-11.38	11.69	23.05	-11.36
1 A 1 peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 biomass	2.93	1.66	1.27	69.35	57.97	11.38	69.37	57.95	11.42
1 A 1 a Public Electricity and Heat Production	142.78	142.78	-	161.28	161.28	-	163.51	162.87	0.64
1 A 1 a liquid	15.63	15.63	-	0.83	0.83	-	1.57	1.57	-
1 A 1 a solid	61.40	61.40	-	3.86	3.86	-	NO	NO	-
1 A 1 a gaseous	59.46	59.46	-	76.03	76.03	-	80.93	80.34	0.59
1 A 1 a other	3.39	4.66	-1.27	11.25	22.63	-11.38	11.69	23.05	-11.36
1 A 1 a peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 a biomass	2.90	1.63	1.27	69.31	57.93	11.38	69.33	57.91	11.42
1 A 1 b Petroleum refining	35.34	35.34	-	38.51	38.51	-	39.07	39.07	-
1 A 1 b liquid	27.46	27.46	-	29.57	29.57	-	29.49	29.49	-
1 A 1 b solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 b gaseous	7.88	7.88	-	8.94	8.94	-	9.58	9.58	-
1 A 1 b other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 b peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 b biomass	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	9.23	9.23	-	5.24	5.24	-	6.78	6.40	0.38
1 A 1 c liquid	0.06	0.06	-	NO	NO	-	NO	NO	-
1 A 1 c solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c gaseous	9.13	9.13	-	5.20	5.20	-	6.74	6.36	0.38
1 A 1 c other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c biomass	0.03	0.03	-	0.04	0.04	-	0.04	0.04	-
1 A 1 c 1 Manufacture of Solid Fuels	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 1 liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 1 solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 1 gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 1 other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 1 peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 1 biomass	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 2 Oil and gas extraction	6.73	6.73	-	2.34	2.34	-	3.81	3.43	0.38
1 A 1 c 2 liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 2 solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 2 gaseous	6.73	6.73	-	2.34	2.34	-	3.81	3.43	0.38
1 A 1 c 2 other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 2 peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 2 biomass	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 3 Other Energy Industries	2.50	2.50	-	2.91	2.91	-	2.97	2.97	-
1 A 1 c 3 liquid	0.06	0.06	-	NO	NO	-	NO	NO	-
1 A 1 c 3 solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 3 gaseous	2.41	2.41	-	2.86	2.86	-	2.93	2.93	-
1 A 1 c 3 other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 3 peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 1 c 3 biomass	0.03	0.03	-	0.04	0.04	-	0.04	0.04	-
1 A 2 Manufacturing Industries and Construction	169.63	169.63	-	229.97	229.93	0.04	235.34	235.60	-0.26
1 A 2 liquid	36.10	36.10	-	21.34	21.34	-0.00	23.23	23.48	-0.25
1 A 2 solid	23.87	23.87	-	14.79	14.76	0.04	13.59	13.53	0.06

IPCC Category / Fuel Group	Fuel Consumption [PJ]								
	1990			2020			2021		
	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence
1 A 2 gaseous	76.99	76.99	-	119.07	119.07	0.00	123.07	122.29	0.78
1 A 2 other	3.22	3.22	-	11.64	11.64	-	11.41	12.25	-0.84
1 A 2 peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 biomass	29.45	29.45	-	63.11	63.11	0.00	64.04	64.04	-0.00
1 A 2 a Iron and Steel	24.44	24.44	-	27.10	27.10	0.00	26.34	26.17	0.17
1 A 2 a liquid	1.01	1.01	-	0.09	0.09	-	0.25	0.26	-0.01
1 A 2 a solid	11.69	11.69	-	7.54	7.54	-	8.02	8.02	-
1 A 2 a gaseous	11.73	11.73	-	19.45	19.45	0.00	18.05	17.88	0.17
1 A 2 a other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 a peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 a biomass	NO	NO	-	0.01	0.01	-	0.01	0.01	-
1 A 2 b Non-Ferrous Metals	2.08	2.08	-	4.73	4.73	0.00	5.27	5.22	0.05
1 A 2 b liquid	0.51	0.51	-	0.13	0.13	-	0.15	0.15	-0.00
1 A 2 b solid	0.21	0.21	-	0.13	0.13	-	0.09	0.09	0.00
1 A 2 b gaseous	1.35	1.35	-	4.42	4.42	0.00	4.98	4.94	0.05
1 A 2 b other	NO	NO	-	0.01	0.01	-	0.00	0.00	-
1 A 2 b peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 b biomass	NO	NO	-	0.04	0.04	-	0.04	0.04	-
1 A 2 c Chemicals	16.29	16.29	-	28.19	27.31	0.88	29.44	30.08	-0.64
1 A 2 c liquid	1.27	1.27	-	0.99	0.99	-	0.47	0.52	-0.05
1 A 2 c solid	1.09	1.09	-	0.44	0.40	0.04	0.36	0.32	0.04
1 A 2 c gaseous	9.36	9.36	-	20.35	20.35	-	22.14	21.94	0.21
1 A 2 c other	1.67	1.67	-	3.24	2.40	0.84	3.02	3.86	-0.84
1 A 2 c peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 c biomass	2.90	2.90	-	3.17	3.17	0.00	3.46	3.46	0.00
1 A 2 d Pulp, Paper and Print	55.31	55.31	-	67.42	67.42	-0.00	66.97	66.80	0.17
1 A 2 d liquid	10.94	10.94	-	0.17	0.18	-0.00	0.19	0.26	-0.07
1 A 2 d solid	4.13	4.13	-	3.31	3.31	-	2.33	2.33	-
1 A 2 d gaseous	17.01	17.01	-	26.61	26.61	-	28.66	28.42	0.25
1 A 2 d other	0.19	0.19	-	0.09	0.09	-	0.01	0.01	-
1 A 2 d peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 d biomass	23.03	23.03	-	37.23	37.23	-	35.78	35.78	-0.00
1 A 2 e Food Processing, Beverages and Tobacco	13.91	13.91	-	14.46	14.46	-	14.42	14.35	0.07
1 A 2 e liquid	4.45	4.45	-	0.41	0.41	-	0.48	0.52	-0.05
1 A 2 e solid	0.18	0.18	-	0.11	0.11	-	0.13	0.13	-
1 A 2 e gaseous	9.15	9.15	-	13.46	13.46	-	13.49	13.37	0.12
1 A 2 e other	NO	NO	-	0.00	0.00	-	NO	NO	-
1 A 2 e peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 e biomass	0.13	0.13	-	0.48	0.48	-	0.33	0.33	-0.00
1 A 2 f Non-Metallic Minerals	23.34	23.34	-	27.24	27.24	-	28.22	28.22	-
1 A 2 f liquid	6.26	6.26	-	0.88	0.88	-	1.61	1.61	-
1 A 2 f solid	5.69	5.69	-	3.27	3.27	-	2.64	2.64	-
1 A 2 f gaseous	10.09	10.09	-	12.57	12.57	-	11.96	11.96	-
1 A 2 f other	1.31	1.31	-	7.17	7.17	-	7.99	7.99	-
1 A 2 f peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 f biomass	NO	NO	-	3.35	3.35	-	4.02	4.02	-
1 A 2 g Other (please specify)	34.27	34.27	-	60.84	61.68	-0.84	64.68	64.75	-0.07
1 A 2 g liquid	11.65	11.65	-	18.67	18.67	0.00	20.09	20.16	-0.07
1 A 2 g solid	0.88	0.88	-	0.00	0.00	-	0.03	0.01	0.02
1 A 2 g gaseous	18.30	18.30	-	22.21	22.21	-	23.78	23.79	-0.01
1 A 2 g other	0.05	0.05	-	1.13	1.97	-0.84	0.39	0.39	0.00
1 A 2 g peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 g biomass	3.39	3.39	-	18.83	18.83	0.00	20.39	20.40	-0.00
1 A 2 g 7 Off-road vehicles and other machinery	3.45	3.45	-	17.53	17.53	-	19.30	19.15	0.15
1 A 2 g 7 liquid	3.45	3.45	-	16.58	16.58	-	18.22	18.07	0.15

IPCC Category / Fuel Group	Fuel Consumption [PJ]								
	1990			2020			2021		
	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence
1 A 2 g 7 solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 g 7 gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 g 7 other	NO	NO	-	0.05	0.05	-	0.06	0.06	0.00
1 A 2 g 7 peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 g 7 biomass	NO	NO	-	0.91	0.91	-	1.03	1.02	0.01
1 A 2 g 8 Other Manufacturing Industries	30.82	30.82	-	43.30	44.14	-0.84	45.38	45.61	-0.23
1 A 2 g 8 liquid	8.20	8.20	-	2.09	2.09	0.00	1.87	2.09	-0.22
1 A 2 g 8 solid	0.88	0.88	-	0.00	0.00	-	0.03	0.01	0.02
1 A 2 g 8 gaseous	18.30	18.30	-	22.21	22.21	-	23.78	23.79	-0.01
1 A 2 g 8 other	0.05	0.05	-	1.08	1.92	-0.84	0.33	0.33	-
1 A 2 g 8 peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 2 g 8 biomass	3.39	3.39	-	17.92	17.92	0.00	19.36	19.38	-0.01
1 A 3 Transport	183.58	183.62	-0.03	296.70	296.70	-0.01	306.91	307.07	-0.16
1 A 3 liquid	179.46	179.50	-0.03	272.68	272.68	0.00	284.10	284.24	-0.14
1 A 3 solid	0.07	0.07	-	0.00	0.00	-	0.00	0.00	-
1 A 3 gaseous	4.05	4.05	-	9.29	9.29	-	7.50	7.50	-
1 A 3 other	NO	NO	-	0.75	0.75	0.00	0.77	0.77	-0.00
1 A 3 biomass	NO	NO	-	13.97	13.98	-0.01	14.54	14.55	-0.02
1 A 3 a Domestic Aviation	0.52	0.52	-	0.32	0.32	-	0.33	0.33	-
1 A 3 a aviation gasoline	0.10	0.10	-	0.08	0.08	-	0.08	0.08	-
1 A 3 a jet kerosene	0.42	0.42	-	0.24	0.24	-	0.24	0.24	-
1 A 3 a biomass	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b Road Transportation	176.19	176.22	-0.03	286.32	286.33	-0.02	298.10	298.26	-0.16
1 A 3 b gasoline	103.53	103.53	-	52.49	52.49	0.00	55.82	55.82	0.00
1 A 3 b diesel oil	72.25	72.28	-0.03	218.26	218.27	-0.01	226.15	226.29	-0.14
1 A 3 b LPG	0.41	0.41	-	0.13	0.13	-	0.16	0.16	-
1 A 3 b other liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b gaseous	NO	NO	-	0.80	0.80	-	0.76	0.76	-
1 A 3 b other	NO	NO	-	0.74	0.74	-0.00	0.77	0.77	-0.00
1 A 3 b biomass	NO	NO	-	13.90	13.91	-0.01	14.45	14.47	-0.02
1 A 3 b 1 Cars	116.88	116.97	-0.09	157.88	157.95	-0.07	163.35	163.08	0.27
1 A 3 b 1 gasoline	97.28	97.36	-0.08	49.84	49.84	0.00	53.22	53.25	-0.02
1 A 3 b 1 diesel oil	19.20	19.22	-0.01	100.02	100.09	-0.07	102.01	101.72	0.29
1 A 3 b 1 LPG	0.39	0.39	-0.00	0.12	0.12	-	0.15	0.15	-0.00
1 A 3 b 1 other liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 1 gaseous	NO	NO	-	0.07	0.07	-0.00	0.07	0.08	-0.01
1 A 3 b 1 other	NO	NO	-	0.31	0.31	-0.00	0.32	0.32	0.00
1 A 3 b 1 biomass	NO	NO	-	7.51	7.51	0.00	7.58	7.56	0.02
1 A 3 b 2 Light duty trucks	13.64	13.64	-0.00	22.40	22.40	0.00	24.16	23.82	0.34
1 A 3 b 2 gasoline	3.35	3.35	-	0.62	0.62	-	0.66	0.65	0.02
1 A 3 b 2 diesel oil	10.28	10.28	-0.00	20.62	20.62	0.00	22.22	21.91	0.31
1 A 3 b 2 LPG	0.01	0.01	-0.00	0.00	0.00	-	0.00	0.00	0.00
1 A 3 b 2 other liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 2 gaseous	NO	NO	-	0.02	0.02	-	0.02	0.02	0.00
1 A 3 b 2 other	NO	NO	-	0.06	0.06	-	0.07	0.07	0.00
1 A 3 b 2 biomass	NO	NO	-	1.08	1.08	0.00	1.19	1.17	0.02
1 A 3 b 3 Heavy duty trucks and buses	44.84	44.78	0.06	103.91	103.84	0.07	108.58	109.35	-0.77
1 A 3 b 3 gasoline	2.07	1.99	0.08	NO	0.00	-	NO	0.00	-
1 A 3 b 3 diesel oil	42.77	42.79	-0.02	97.62	97.55	0.07	101.92	102.65	-0.73
1 A 3 b 3 LPG	0.01	0.01	0.00	0.00	0.00	-	0.00	0.00	0.00
1 A 3 b 3 other liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 3 gaseous	NO	NO	-	0.71	0.71	0.00	0.68	0.67	0.01
1 A 3 b 3 other	NO	NO	-	0.37	0.37	0.00	0.37	0.38	-0.00
1 A 3 b 3 biomass	NO	NO	-	5.21	5.21	0.00	5.60	5.64	-0.04
1 A 3 b 4 Motorcycles	0.84	0.84	-0.00	2.13	2.15	-0.01	2.02	2.02	-0.00

IPCC Category / Fuel Group	Fuel Consumption [PJ]								
	1990			2020			2021		
	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence
1 A 3 b 4 gasoline	0.84	0.84	-0.00	2.03	2.03	-0.00	1.93	1.92	0.01
1 A 3 b 4 diesel oil	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 4 LPG	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 4 other liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 4 gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 4 other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 4 biomass	NO	NO	-	0.10	0.11	-0.01	0.08	0.09	-0.01
1 A 3 b 5 Other (please specify)	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 5 gasoline	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 5 diesel oil	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 5 LPG	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 5 other liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 5 gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 5 other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 b 5 biomass	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 c Railways	2.38	2.38	-	1.15	1.14	0.01	1.14	1.14	0.00
1 A 3 c liquid	2.31	2.31	-	1.09	1.08	0.01	1.08	1.08	0.00
1 A 3 c solid	0.07	0.07	-	0.00	0.00	-	0.00	0.00	-
1 A 3 c gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 c other	NO	NO	-	0.00	0.00	0.00	0.00	0.00	-
1 A 3 c biomass	NO	NO	-	0.05	0.05	0.00	0.06	0.06	-
1 A 3 d Domestic Navigation	0.37	0.37	-	0.33	0.33	-0.00	0.50	0.50	-0.00
1 A 3 d residual oil	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 d gas/diesel oil	0.25	0.25	-	0.22	0.22	-	0.38	0.38	-
1 A 3 d gasoline	0.13	0.13	-	0.09	0.09	-0.00	0.09	0.09	-0.00
1 A 3 d other liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 d gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 d other	NO	NO	-	0.00	0.00	-	0.00	0.00	-
1 A 3 d biomass	NO	NO	-	0.02	0.02	-0.00	0.03	0.03	-0.00
1 A 3 e Other Transportation	4.11	4.11	-	8.58	8.58	-	6.84	6.84	-
1 A 3 e liquid	0.06	0.06	-	0.09	0.09	-	0.10	0.10	-
1 A 3 e solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 e gaseous	4.05	4.05	-	8.49	8.49	-	6.73	6.73	-
1 A 3 e other	NO	NO	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e biomass	NO	NO	-	0.00	0.00	-	0.01	0.01	-
1 A 3 e 1 Pipeline Transport	4.05	4.05	-	8.49	8.49	-	6.73	6.73	-
1 A 3 e 1 liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 e 1 solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 e 1 gaseous	4.05	4.05	-	8.49	8.49	-	6.73	6.73	-
1 A 3 e 1 other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 e 1 biomass	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 e 2 Other (please specify)	0.06	0.06	-	0.09	0.09	-	0.11	0.11	-
1 A 3 e 2 liquid	0.06	0.06	-	0.09	0.09	-	0.10	0.10	-
1 A 3 e 2 solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 3 e 2 gaseous	NO	NO	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 2 other	NO	NO	-	0.00	0.00	-	0.00	0.00	-
1 A 3 e 2 biomass	NO	NO	-	0.00	0.00	-	0.01	0.01	-
1 A 4 Other Sectors	249.32	249.32	-	216.75	216.75	-0.00	245.53	242.51	3.02
1 A 4 liquid	109.16	109.16	-	58.35	58.35	-	62.01	63.97	-1.96
1 A 4 solid	28.12	28.12	-	0.60	0.60	-	0.49	0.66	-0.17
1 A 4 gaseous	46.46	46.46	-	76.11	76.11	-0.00	83.99	85.74	-1.75
1 A 4 other	1.11	1.11	-	0.04	0.04	-	0.04	0.04	-
1 A 4 peat	0.00	0.00	-	NO	NO	-	NO	NO	-
1 A 4 biomass	64.46	64.46	-	81.66	81.66	-0.00	98.99	92.11	6.89
1 A 4 a Commercial/Institutional	35.39	35.39	-	25.13	25.13	-0.00	29.23	29.60	-0.37
1 A 4 a liquid	18.66	18.66	-	6.00	6.00	-	7.85	8.45	-0.60
1 A 4 a solid	0.96	0.96	-	NO	NO	-	NO	NO	-

IPCC Category / Fuel Group	Fuel Consumption [PJ]								
	1990			2020			2021		
	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence
1 A 4 a gaseous	12.60	12.60	-	15.15	15.15	-0.00	16.88	16.60	0.29
1 A 4 a other	1.11	1.11	-	0.01	0.01	-	0.01	0.01	-
1 A 4 a peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 a biomass	2.06	2.06	-	3.97	3.97	-0.00	4.50	4.55	-0.05
1 A 4 a 1 Stationary combustion	35.39	35.39	-	25.13	25.13	-0.00	29.23	29.60	-0.37
1 A 4 a 1 liquid	18.66	18.66	-	6.00	6.00	-	7.85	8.45	-0.60
1 A 4 a 1 solid	0.96	0.96	-	NO	NO	-	NO	NO	-
1 A 4 a 1 gaseous	12.60	12.60	-	15.15	15.15	-0.00	16.88	16.60	0.29
1 A 4 a 1 other	1.11	1.11	-	0.01	0.01	-	0.01	0.01	-
1 A 4 a 1 peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 a 1 biomass	2.06	2.06	-	3.97	3.97	-0.00	4.50	4.55	-0.05
1 A 4 b Residential	193.30	193.30	-	172.68	172.68	-	196.36	193.41	2.96
1 A 4 b liquid	74.79	74.79	-	41.20	41.20	-	43.30	44.65	-1.35
1 A 4 b solid	26.62	26.62	-	0.58	0.58	-	0.48	0.64	-0.16
1 A 4 b gaseous	33.50	33.50	-	60.05	60.05	-	66.14	68.18	-2.04
1 A 4 b other	NO	NO	-	0.00	0.00	-	0.00	0.00	-
1 A 4 b peat	0.00	0.00	-	NO	NO	-	NO	NO	-
1 A 4 b biomass	58.40	58.40	-	70.85	70.85	-	86.44	79.93	6.51
1 A 4 b 1 Stationary combustion	191.02	191.02	-	171.20	171.20	-	194.90	191.94	2.96
1 A 4 b 1 liquid	72.50	72.50	-	39.80	39.80	-	41.91	43.26	-1.35
1 A 4 b 1 solid	26.62	26.62	-	0.58	0.58	-	0.48	0.64	-0.16
1 A 4 b 1 gaseous	33.50	33.50	-	60.05	60.05	-	66.14	68.18	-2.04
1 A 4 b 1 other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 b 1 peat	0.00	0.00	-	NO	NO	-	NO	NO	-
1 A 4 b 1 biomass	58.40	58.40	-	70.78	70.78	-	86.38	79.86	6.51
1 A 4 b 2 Mobile combustion	2.29	2.29	-	1.48	1.48	-	1.46	1.46	-0.00
1 A 4 b 2 liquid	2.29	2.29	-	1.41	1.41	-	1.39	1.39	-0.00
1 A 4 b 2 biomass	NO	NO	-	0.00	0.07	-0.07	0.00	0.07	-0.07
1 A 4 b 2 other	NO	NO	-	0.07	0.00	0.07	0.07	0.00	0.07
1 A 4 c Agriculture/Forestry/ Fishing	20.63	20.63	-	18.94	18.94	-	19.93	19.51	0.42
1 A 4 c liquid	15.71	15.71	-	11.14	11.14	-	10.87	10.87	-0.01
1 A 4 c solid	0.55	0.55	-	0.02	0.02	-	0.01	0.02	-0.00
1 A 4 c gaseous	0.37	0.37	-	0.91	0.91	-	0.97	0.96	0.01
1 A 4 c other	NO	NO	-	0.03	0.03	-	0.03	0.03	-
1 A 4 c peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 c biomass	4.01	4.01	-	6.84	6.84	-	8.05	7.63	0.42
1 A 4 c 1 Stationary combustion	10.26	10.26	-	7.35	7.35	-	8.63	8.20	0.42
1 A 4 c 1 liquid	5.34	5.34	-	0.17	0.17	-	0.18	0.18	-0.01
1 A 4 c 1 solid	0.55	0.55	-	0.02	0.02	-	0.01	0.02	-0.00
1 A 4 c 1 gaseous	0.37	0.37	-	0.91	0.91	-	0.97	0.96	0.01
1 A 4 c 1 other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 c 1 peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 c 1 biomass	4.01	4.01	-	6.26	6.26	-	7.47	7.04	0.42
1 A 4 c 2 Mobile combustion	10.37	10.37	-	11.59	11.59	-	11.31	11.31	-
1 A 4 c 2 gasoline	0.42	0.42	-	0.36	0.36	-	0.38	0.38	-
1 A 4 c 2 diesel oil	9.95	9.95	-	10.62	10.62	-	10.31	10.31	-
1 A 4 c 2 LPG	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 c 2 other liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 c 2 gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 4 c 2 other	NO	NO	-	0.03	0.03	-	0.03	0.03	-
1 A 4 c 2 biomass	NO	NO	-	0.58	0.58	-	0.59	0.59	-
1 A 5 Other	0.51	0.48	0.03	0.39	0.46	-0.07	0.38	0.39	-0.00
1 A 5 liquid	0.51	0.48	0.03	0.39	0.45	-0.07	0.38	0.38	-0.00
1 A 5 solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 other	NO	NO	-	0.00	0.00	-0.00	0.00	0.00	-0.00

IPCC Category / Fuel Group	Fuel Consumption [PJ]								
	1990			2020			2021		
	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence	Subm. 2024	Subm. 2023	Differ- ence
1 A 5 peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 biomass	NO	NO	-	0.00	0.00	-0.00	0.00	0.00	-0.00
1 A 5 a Stationary combustion	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 a liquid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 a solid	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 a gaseous	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 a other	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 a peat	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 a biomass	NO	NO	-	NO	NO	-	NO	NO	-
1 A 5 b Mobile combustion – Military	0.51	0.48	0.03	0.39	0.46	-0.07	0.38	0.39	-0.00
1 A 5 b liquid	0.51	0.48	0.03	0.39	0.45	-0.07	0.38	0.38	-0.00
1 A 5 b biomass	NO	NO	-	0.00	0.00	-0.00	0.00	0.00	-0.00
1 A 5 b other	NO	NO	-	NO	0.00	-0.00	NO	0.00	-0.00
Memo - International Aviation	12.10	12.10	-	14.38	14.38	-	16.91	16.91	-
aviation gasoline	NO	NO	-	NO	NO	-	NO	NO	-
jet kerosene	12.10	12.10	-	14.38	14.38	-	16.91	16.91	-
biomass	NO	NO	-	NO	NO	-	NO	NO	-
Memo - International Navigation	0.62	0.62	-	0.57	0.57	-	0.52	0.82	-0.30
residual oil	NO	NO	-	NO	NO	-	NO	NO	-
gas/diesel oil	0.62	0.62	-	0.57	0.57	-	0.52	0.82	-0.30
gasoline	NO	NO	-	NO	NO	-	NO	NO	-
other liquid	NO	NO	-	NO	NO	-	NO	NO	-
gaseous	NO	NO	-	NO	NO	-	NO	NO	-
other	NO	NO	-	NO	NO	-	NO	NO	-
biomass	NO	NO	-	NO	NO	-	NO	NO	-

A “-” indicates that no recalculations were carried out or recalculations are lower than ± 0.005 TJ (mostly due to rounding).

Methodology

CO₂ emissions from *1.A Fuel Combustion* have been calculated using the IPCC Tier 2 methodology while for N₂O and CH₄ emissions the Tier 1 methodology has been applied. The fuel consumption based on the energy balance is multiplied with source specific emission factors for CO₂, CH₄ and N₂O. Sector specific considerations and emission factors are described in the related sub chapters of Chapter 3 *Energy* of the NIR.

Activity data is taken from the national energy balance as described in the following sub chapters. Data of the national energy balance is presented in Annex 4.

The National Energy Balance

There are five different IEA questionnaires for each of: oil; natural gas; coal; renewable fuels; electricity and heat. Table A 53 shows the unified categories of the IEA questionnaires with ISIC codes and the corresponding SNAP and IPCC categories to which the fuel consumption is assigned to.

Data of the national energy balance is presented in Annex 4.

Table A 53: Categories of the national energy balance (JQ 2020) and their correspondence to IPCC categories.

IEA-Category and ISIC Codes ⁽²⁾	Comments	SNAP	IPCC-Category
Production			Reference Approach: Production
Imports			Reference Approach: Import

IEA-Category and ISIC Codes ⁽²⁾	Comments	SNAP	IPCC-Category
Exports			Reference Approach: Export
Bunkers	No consumption ⁽¹⁾		
Stock Changes			Reference Approach: Stock Change
Refinery Fuel		0103	1 A 1 b Petroleum Refining
Transformation Sector, of which:			
Public Electricity plants	In the inventory plant specific data are considered.	0101	1 A 1 a Public Electricity and Heat Production
Public CHP plants		0102	
Public Heat plants			
Auto Producer Electricity plants	For autoproducers by sectors see table below.		
Auto Producer CHP plants			
Auto Producer Heat plants			
Coke Ovens	Transformation from <i>Coking Coal</i> to <i>Coke Oven Coke</i> .		
Blast furnaces	Coke Oven Coke.	030326	1 A 2 a Iron and Steel
Gas Works	Transformation of <i>Other Oil Products</i> to <i>Gas Works Gas</i> .		
Petrochemical Industry	No consumption ⁽¹⁾		
Patent Fuel Plants	No consumption ⁽¹⁾		
Not Elsewhere Specified	No consumption ⁽¹⁾		
Energy Sector, of which (ISIC 10, 11, 12, 23, 40):			
Coal Mines	No consumption ⁽¹⁾		
Oil and Gas Extraction		0105	1 A 1 c Manufacture of Solid fuels and Other Energy Industries
Inputs to oil refineries		0103	1 A 1 b Petroleum Refining
Coke Ovens	<i>Coke Oven Gas</i> and <i>Blast Furnace Gas</i> .	0301	1 A 2 a Iron and Steel
Blast furnaces	<i>Coke Oven Coke</i> .	030326	1 A 2 a Iron and Steel
Gas Works	<i>Natural Gas</i> . <i>Other liquid fuels</i> .	0105	1 A 1 c Manufacture of Solid fuels and Other Energy Industries
Electricity, CHP and Heat Plants		0101	1 A 1 a Public Electricity and Heat Production
Liquefaction Plants	No consumption ⁽¹⁾		
Not Elsewhere Specified	No consumption ⁽¹⁾		
Distribution Losses	Includes statistical differences and therefore it may be less than zero.		
Final Energy Consumption			
Total Transport, of which (ISIC 60, 61, 62):			
Domestic Air Transport	Division to SNAP categories is performed by means of studies.		1 A 2 f Manuf. Ind. and Constr. -Other
Road		07	1 A 3 Transport
Rail		08	1 A 4 b Residential
Inland Waterways		0201	1 A 4 c Agriculture/ Forestry/ Fisheries
Pipeline Transport	<i>Natural Gas</i> .	010506	1 A 3 e Transport-Other
Non Specified	<i>Other biofuels</i> and <i>Lubricants</i> .	0201	1 A 4 a Commercial/ Institutional
Total Industry, of which:			
Iron and Steel (ISIC 271, 2731)		0301 030301 030326	1 A 2 a Iron and Steel
Chemical incl. Petro-Chemical (ISIC 24)		0301	1 A 2 c Chemicals
Non ferrous Metals (ISIC 272, 2732)		0301	1 A 2 b Non-ferrous Metals
Non metallic Mineral Products (ISIC 26)		0301 030311 030317 030319	1 A 2 Non-metallic minerals
Transportation Equipment (ISIC 34, 35)		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Machinery (ISIC 28, 29, 30, 31, 32)		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Mining and Quarrying (ISIC 13, 14)		0105	1 A 2 g Manuf. Ind. and Constr. -Other
Food, Beverages and Tobacco (ISIC 15, 16)		0301	1 A 2 e Food Processing, Beverages and Tobacco

IEA-Category and ISIC Codes ⁽²⁾	Comments	SNAP	IPCC-Category
Pulp, Paper and Printing (ISIC 21, 22)		0301	1 A 2 d Pulp, Paper and Print
Wood and Wood Products (ISIC 20)		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Construction (ISIC 45)		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Textiles and Leather (ISIC 17, 18, 19)		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Non Specified (ISIC 25, 33, 36, 37)		0301	1 A 2 g Manuf. Ind. and Constr. -Other
Total Other sectors, of which:			
Commercial and Public Services (ISIC 41, 50, 51, 52, 55, 63, 64, 65, 66, 67, 70, 71, 72, 73, 74, 75, 80, 85, 90, 91, 92, 93, 99)		0201	1 A 4 a Commercial/ Institutional
Residential (ISIC 95)		0202	1 A 4 b Residential
Agriculture (ISIC 01, 02, 05)		0203	1 A 4 c Agriculture/Forestry/ Fisheries
Non Specified	No consumption ⁽¹⁾		

⁽¹⁾ Indicates that no fuel consumption is reported in the energy balance for the specific category. In some cases this may be interpreted as "included elsewhere" if the energy statistic has lack of detailed sectoral data.

⁽²⁾ Sector names may differ to original IEA questionnaire naming convention. Note that the ISIC Revised 4 codes cited in this table are consistent with the NACE Revision 2 nomenclature.

Table A 54: Categories of the national energy balance (since 2013) and their correspondence to IPCC categories: Autoproducers by sector.

Auto Producers (Electricity + CHP + Heat), of which:			
Energy Sector, of which:			
Coal Mines	No consumption ⁽¹⁾		
Oil and Gas Extraction	0105	1 A 1 c Manufacture of Solid fuels and Other Energy Industries	
Inputs to oil refineries	0103	1 A 1 b Petroleum Refining	
Coke Ovens	No consumption ⁽¹⁾		
Gas Works	No consumption ⁽¹⁾		
Liquefaction Plants	No consumption ⁽¹⁾		
Not Elsewhere Specified	No consumption ⁽¹⁾		
Industrie, of which:			
Iron and Steel	030326	1 A 2 a Iron and Steel	
Chemical (incl. Petro-Chemical)	0301	1 A 2 c Chemicals	
Non ferrous Metals	0301	1 A 2 b Non-ferrous Metals	
Non metallic Mineral Products	0301	1 A 2 f Non-metallic minerals	
Transportation Equipment	0301	1 A 2 g Manuf. Ind. and Constr. -Other	
Machinery	0301	1 A 2 g Manuf. Ind. and Constr. -Other	
Mining and Quarrying	0301	1 A 2 g Manuf. Ind. and Constr. -Other	
Food, Beverages and Tobacco	0301	1 A 2 e Food Processing, Beverages and Tobacco	
Pulp, Paper and Printing	0301	1 A 2 d Pulp, Paper and Print	
Wood and Wood Products	0301	1 A 2 g Manuf. Ind. and Constr. -Other	
Construction	0301	1 A 2 g Manuf. Ind. and Constr. -Other	
Textiles and Leather	0301	1 A 2 g Manuf. Ind. and Constr. -Other	
Non Specified (Industry)	0301	1 A 2 g Manuf. Ind. and Constr. -Other	
Total Transport, of which			
Pipeline Transport	No consumption ⁽¹⁾		
Non Specified	No consumption ⁽¹⁾		
Other Sectors, of which			
Commercial and Public Services	0201	1 A 4 a Commercial/ Institutional	
Residential	No consumption ⁽¹⁾		
Agriculture	No consumption ⁽¹⁾		
Non Specified	No consumption ⁽¹⁾		

⁽¹⁾ Indicates that no fuel consumption is reported in the energy balance for the specific category. In some cases this may be interpreted as "included elsewhere" if the energy statistic has lack of detailed sectoral data.

Fuels and Fuel Categories

The units used in the national fuel statistics are: *ton* for solid or liquid fuels and *cubic meter* for gaseous fuels. To convert these units into the caloric unit *Joule* the calorific value of each fuel category has to be quantified. These calorific values are specified in the unit *Joule per Mass or Volume Unit*, e.g. MJ/kg, MJ/m³ gas.

Each fuel has chemical and physical characteristics which influence its burning performance e.g. calorific value or carbon and sulphur content. Fuel categories are formed to pool fuels of the same characteristics in fuel groups. Limitations are given by the fuel categories of the energy balance. A list of the inventory fuel categories and their correspondence to IPCC-fuel categories is shown in Table A 55.

Table A 55: Fuel categories used for the inventory and correspondence to IPCC fuel categories.

Inventory Fuel Category		IEA Fuel Category	Average Net Calorific Value ⁽²⁾	IPCC Fuel Category ⁽³⁾
Code ⁽¹⁾	Category	Category		
102 A	Hard Coal	Bituminous Coal and Anthracite	29.90	Solid (coal)
104 A	Hard Coal Briquettes	Patent Fuel	31.00	Solid (coal)
105 A	Brown Coal	Lignite/Brown Coal	21.52	Solid (coal)
106 A	Brown Coal Briquettes	BKB/PB	19.80	Solid (coal)
107 A	Coke	Coke Oven Coke	28.22	Solid (coal)
113 A	Peat	Peat	0.00	Solid
304 A	Coke Oven Gas	Coke Oven Gas	17.02	Solid
305 A	Blast Furnace Gas	Blast Furnace Gas	3.58	Solid
110 A	Petrol Coke	Petrol Coke	31.13	Liquid
203 B	Light Fuel Oil Sulphur Content < 0,2 %	Residual Fuel Oil	42.40	Liquid (residual oil)
203 C	Medium Fuel Oil Sulphur Content < 0,4%			
203 D	Heavy Fuel Oil Sulphur Content >= 1%			
204 A	Gasoil	Heating and other Gasoil		Liquid (gas/diesel oil)
205 0	Diesel	Transport Diesel		Liquid (diesel oil; gas/diesel oil)
206 A	Petroleum	Other Kerosene		Liquid
206 B	Kerosene	Kerosene Type Jet Fuel	43.37	Liquid (jet kerosene)
207 A	Aviation Gasoline	Gasoline Type Jet Fuel	42.37	Liquid (aviation gasoline)
208 0	Motor Gasoline	Motor Gasoline	43.35	Liquid (gasoline)
224 A	Other Petroleum Products	Other Products	43.30	Liquid
303 A	Liquified Petroleum Gas (LPG)	LPG	44.10	Liquid
308 A	Refinery Gas	Refinery Gas	41.81	Liquid
301 A	Natural Gas	Natural Gas	45.44	Gaseous (natural gas)
114 B	Municipal Waste	Municipal Solid Waste- Renewable	⁽⁴⁾ 10.41	Other Fuels
		Municipal Solid Waste-Non Renewable	⁽⁴⁾ 10.40	Biomass
115 A	Industrial Waste	Industrial Wastes	17.04	Other Fuels
111 A	Fuel Wood	Wood/Wood wastes/Other Solid Wastes, of which: Wood	14.31	Biomass
112 A	Char Coal	Char coal	29.50	Biomass
116 A	Wood Wastes, Wood Chips, Pellets, Straw.	Wood/Wood wastes/Other Solid Wastes, of which: Other vegetal materials and waste (including straw, sawdust, wood chips)	6.41	Biomass

Inventory Fuel Category		IEA Fuel Category	IPCC Fuel Category ⁽³⁾	
Code ⁽¹⁾	Category	Category	Average Net Calorific Value ⁽²⁾	
118 A	Sewage Sludge (dry substance)	Wood/Wood wastes/Other Solid Wastes, of which: Other vegetal materials and waste (including straw, sawdust, wood chips)	12.00	Biomass
215 A	Black Liquor	Wood/Wood wastes/Other Solid Wastes, of which: Black Liquor	⁽⁴⁾ 8.79	Biomass
309 A	Biogas	Biogas	⁽⁴⁾ 10.85	Biomass
309 B	Sewage Sludge Gas	Sewage Sludge Gas	⁽⁴⁾ 25.82	Biomass
310 A	Landfill Gas	Landfill Gas	⁽⁴⁾ 16.73	Biomass

⁽¹⁾ First three digits are based on CORINAIR / NAPFUE 94–Code

⁽²⁾ Units: [MJ / kg] or [MJ / m³ Gas] respectively, for the Year 2022. Note that for some fuels sector specific calorific values are taken. The energy balance reports some fuels (e.g. renewables) in [TJ] so that unit conversion by means of calorific values is not necessary.

⁽³⁾ Fuel subcategories are shown in parenthesis

⁽⁴⁾ Heating value of transformation input.

Energy Consumption and CO₂ Emissions by Sectors and Fuel Types

The following tables show detailed data on fuel consumption and CO₂ emissions for each fuel type and each sector of *1 A Fuel Combustion* for certain years. For information on completeness, in particular on CO₂ emissions included elsewhere, please refer to the documentation boxes of the CRF and to Chapter 3.2.8 chapter *Completeness* of the NIR.

Table A 56: 2022 energy consumption and CO₂ emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO ₂ emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Transport	Other Sectors	Total	Energy Ind.	Industry	Transport	Other Sectors	Total
Total Solid			13.40	0.00	0.37	13.77		1.27	0.00	0.03	1.30
102A	Hard Coal		2.76	0.00	0.01	2.77		0.25	0.00	0.00	0.25
104A	Hard Coal Briquettes				0.06	0.06				0.01	0.01
105A	Brown Coal		1.46		0.01	1.47		0.14		0.00	0.14
106A	Brown Coal Briquettes				0.16	0.16				0.02	0.02
107A	Coke		0.38		0.12	0.50		0.04		0.01	0.05
113A	Peat										
304A	Coke Oven Gas		8.81			8.81		0.83			0.83
Total Liquid		30.27	25.56	270.98	54.78	381.58	2.19	1.92	20.25	4.09	28.45
110A	Petrol Coke	1.73	1.58			3.31	0.17	0.15			0.32
203B	Light Fuel Oil	0.22	1.08		0.00	1.30	0.02	0.08		0.00	0.10
203C	Medium Fuel Oil										
203D	Heavy Fuel Oil	0.49	0.28			0.78	0.04	0.02			0.06
204A	Gasoil	2.40	1.18		41.32	44.90	0.18	0.09		3.10	3.37
2050	Diesel	0.00	19.39	212.22	11.02	242.63	0.00	1.44	15.79	0.82	18.06
206A	Other Kerosene										
206B	Jet Kerosene			0.69		0.69			0.05		0.05
207A	Aviation Gasoline			0.07		0.07			0.01		0.01
2080	Motor Gasoline		0.14	57.89	0.96	58.99		0.01	4.40	0.07	4.48
224A	Other Petroleum Products	10.89	0.10			10.99	0.85	0.01			0.86
303A	Liquefied Petroleum Gas (LPG)	2.64	1.81	0.11	1.47	6.03	0.17	0.12	0.01	0.09	0.39
308A	Refinery Gas	11.89				11.89	0.76				0.76
301A	Total Gaseous (Natural Gas)	92.53	113.86	3.46	68.26	278.11	5.14	6.33	0.19	3.80	15.46
Total Other Fuel		22.56	13.09	0.73	0.04	36.42	1.03	0.96	0.06	0.00	2.05
114A	MSW non renewable	9.95				9.95	0.91				0.91
114C	MSW renewable	11.10				11.10					
115A	Industrial Waste	1.52	13.03		0.01	14.55	0.11	0.96		0.00	1.07
225A	FAME		0.06	0.73	0.04	0.83		0.00	0.06	0.00	0.06
Total Biomass⁽¹⁾		57.01	71.19	13.77	79.38	221.36	(6.12)	(7.32)	(0.98)	(8.83)	(23.25)
111A	Fuel Wood				54.19	54.19				6.07	6.07
112A	Char Coal	0.03			0.36	0.39				0.04	0.04
116A	Wood Wastes	52.06	38.20		23.67	113.94	5.83	4.28		2.65	12.76
118A	Sewage Sludge	0.33	0.73			1.06	0.04	0.08			0.12
215A	Black Liquor		28.93			28.93		2.76			2.76
250A	Liquid Biofuels		1.10	13.75	0.65	15.50		0.08	0.97	0.05	1.10
309A	Biogas	4.42	0.78	0.03	0.30	5.53	0.24	0.04	0.00	0.02	0.30
309B	Sewage Sludge Gas	0.11	1.44		0.18	1.73	0.01	0.08		0.01	0.09
310A	Landfill Gas	0.06			0.03	0.09	0.00			0.00	0.00
Total⁽¹⁾		202.38	237.10	288.94	202.83	931.25	8.36	10.48	20.50	7.92	47.26

⁽¹⁾ CO₂ emissions of Biomass are not included in Total.

Table A 57: 2021 energy consumption and CO₂ emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO ₂ emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Trans- port	Other Sectors	Total	Energy Ind.	Industry	Trans- port	Other Sectors	Total
Total Solid			13.59	0.00	0.49	14.08		1.28	0.00	0.05	1.33
102A	Hard Coal		4.11	0.00	0.04	4.15		0.38	0.00	0.00	0.38
104A	Hard Coal Briquettes				0.03	0.03				0.00	0.00
105A	Brown Coal		1.24		0.01	1.25		0.12		0.00	0.12
106A	Brown Coal Briquettes				0.24	0.24				0.02	0.02
107A	Coke		0.31		0.16	0.46		0.03		0.01	0.05
113A	Peat										
304A	Coke Oven Gas		7.93			7.93		0.75			0.75
Total Liquid		31.06	23.23	284.48	62.01	400.78	2.34	1.75	21.23	4.62	29.94
110A	Petrol Coke	2.34	1.40			3.74	0.24	0.13			0.37
203B	Light Fuel Oil	0.53	1.54		0.06	2.13	0.04	0.12		0.00	0.17
203C	Medium Fuel Oil										
203D	Heavy Fuel Oil		0.35			0.35		0.03			0.03
204A	Gasoil	1.04	0.48		48.02	49.55	0.08	0.04		3.60	3.72
2050	Diesel	0.00	18.09	227.72	11.11	256.91	0.00	1.35	16.95	0.83	19.12
206A	Other Kerosene										
206B	Jet Kerosene			0.60		0.60			0.04		0.04
207A	Aviation Gasoline			0.08		0.08			0.01		0.01
2080	Motor Gasoline		0.13	55.92	0.97	57.02		0.01	4.22	0.07	4.30
224A	Other Petroleum Products	17.39	0.09			17.47	1.36	0.01			1.36
303A	Liquified Petroleum Gas (LPG)	0.80	1.16	0.16	1.85	3.97	0.05	0.07	0.01	0.12	0.25
308A	Refinery Gas	8.96				8.96	0.57				0.57
301A	Total Gaseous (Natural Gas)	97.25	123.07	7.50	83.99	311.81	5.41	6.84	0.42	4.67	17.34
Total Other Fuel		23.05	11.41	0.77	0.04	35.28	1.05	0.89	0.06	0.00	2.00
114A	MSW non renewable	10.18				10.18	0.94				0.94
114C	MSW renewable	11.36				11.36					
115A	Industrial Waste	1.51	11.36		0.01	12.87	0.11	0.88		0.00	0.99
225A	FAME		0.06	0.77	0.04	0.87		0.00	0.06	0.00	0.07
Total Biomass⁽¹⁾		58.01	64.04	14.54	98.99	235.58	(6.23)	(6.57)	(1.03)	(11.03)	(24.86)
111A	Fuel Wood				67.92	67.92				7.61	7.61
112A	Char Coal	0.04			0.46	0.50				0.05	0.05
116A	Wood Wastes	53.03	33.25		29.47	115.75	5.94	3.72		3.30	12.96
118A	Sewage Sludge	0.34	0.73			1.07	0.04	0.08			0.12
215A	Black Liquor		27.16			27.16		2.59			2.59
250A	Liquid Biofuels		1.03	14.53	0.65	16.21		0.07	1.03	0.05	1.15
309A	Biogas	4.46	0.66	0.01	0.28	5.42	0.24	0.04	0.00	0.02	0.30
309B	Sewage Sludge Gas	0.09	1.21		0.18	1.47	0.00	0.07		0.01	0.08
310A	Landfill Gas	0.05			0.03	0.07	0.00			0.00	0.00
Total⁽¹⁾		209.36	235.34	307.29	245.53	997.52	8.79	10.76	21.70	9.34	50.60

⁽¹⁾ CO₂ emissions of Biomass are not included in Total.

Table A 58: 2020 energy consumption and CO₂ emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO ₂ emissions (Mt)				
		1 A 1		1 A 3 + 1 A 5		1 A 4	1 A	1 A 1		1 A 3 + 1 A 5	
		1 A 2		1 A 4		1 A	1 A	1 A 2		1 A 4	
		Energy Ind.	Industry	Trans-port	Other Sectors	Total	Energy Ind.	Industry	Trans-port	Other Sectors	Total
Total Solid		3.86	14.79	0.00	0.60	19.25	0.36	1.39	0.00	0.06	1.80
102A	Hard Coal	3.86	5.67	0.00	0.08	9.61	0.36	0.52	0.00	0.01	0.88
104A	Hard Coal Briquettes				0.03	0.03				0.00	0.00
105A	Brown Coal		1.35		0.03	1.38		0.13		0.00	0.13
106A	Brown Coal Briquettes				0.20	0.20				0.02	0.02
107A	Coke		0.32		0.25	0.58		0.03		0.02	0.06
113A	Peat										
304A	Coke Oven Gas		7.46			7.46		0.71			0.71
Total Liquid		30.40	21.34	273.07	58.35	383.16	2.30	1.60	20.37	4.35	28.62
110A	Petrol Coke	2.25	0.63			2.88	0.23	0.06			0.29
203B	Light Fuel Oil	0.57	1.55		0.01	2.13	0.04	0.12		0.00	0.17
203C	Medium Fuel Oil										
203D	Heavy Fuel Oil	0.13	0.28			0.41	0.01	0.02			0.03
204A	Gasoil	0.14	1.08		44.23	45.45	0.01	0.08		3.32	3.41
2050	Diesel	0.00	16.46	219.67	11.41	247.54	0.00	1.23	16.35	0.85	18.42
206A	Other Kerosene										
206B	Jet Kerosene			0.61		0.61			0.04		0.04
207A	Aviation Gasoline			0.08		0.08			0.01		0.01
2080	Motor Gasoline		0.12	52.59	0.97	53.68		0.01	3.97	0.07	4.05
224A	Other Petroleum Products	18.48	0.09			18.57	1.44	0.01			1.45
303A	Liquified Petroleum Gas (LPG)	0.21	1.13	0.13	1.73	3.20	0.01	0.07	0.01	0.11	0.20
308A	Refinery Gas	8.61				8.61	0.55				0.55
301A	Total Gaseous (Natural Gas)	90.17	119.07	9.29	76.11	294.64	5.01	6.62	0.52	4.23	16.38
Total Other Fuel		22.63	11.64	0.75	0.04	35.06	1.02	0.86	0.06	0.00	1.93
114A	MSW non renewable	10.20				10.20	0.94				0.94
114C	MSW renewable	11.38				11.38					
115A	Industrial Waste	1.05	11.59		0.01	12.65	0.08	0.85		0.00	0.93
225A	FAME		0.05	0.75	0.04	0.83		0.00	0.06	0.00	0.06
Total Biomass⁽¹⁾		57.97	63.11	13.98	81.66	216.72	(6.10)	(6.45)	(0.99)	(9.09)	(22.63)
111A	Fuel Wood		0.01		57.52	57.54		0.00		6.44	6.44
112A	Char Coal	0.04			0.45	0.49				0.05	0.05
116A	Wood Wastes	50.49	30.61		22.55	103.65	5.65	3.43		2.53	11.61
118A	Sewage Sludge	0.59	0.81			1.40	0.07	0.09			0.16
215A	Black Liquor		29.20			29.20		2.78			2.78
250A	Liquid Biofuels		0.91	13.96	0.65	15.52		0.06	0.99	0.05	1.10
309A	Biogas	6.73	0.75	0.01	0.29	7.78	0.37	0.04	0.00	0.02	0.43
309B	Sewage Sludge Gas	0.08	0.84		0.17	1.09	0.00	0.05		0.01	0.06
310A	Landfill Gas	0.03			0.01	0.05	0.00			0.00	0.00
Total⁽¹⁾		205.03	229.97	297.08	216.75	948.83	8.69	10.46	20.95	8.64	48.74

⁽¹⁾ CO₂ emissions of Biomass are not included in Total.

Table A 59: 2015 energy consumption and CO₂ emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO ₂ emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Transport	Other Sectors	Total	Energy Ind.	Industry	Transport	Other Sectors	Total
Total Solid		24.98	11.47	0.00	0.94	37.39	2.34	1.07	0.00	0.09	3.50
102A	Hard Coal	24.98	6.25	0.00	0.06	31.29	2.34	0.57	0.00	0.01	2.91
104A	Hard Coal Briquettes				0.21	0.21				0.02	0.02
105A	Brown Coal		1.89		0.04	1.93		0.18		0.00	0.19
106A	Brown Coal Briquettes				0.20	0.20				0.02	0.02
107A	Coke		0.44		0.42	0.86		0.05		0.04	0.09
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		2.90			2.90		0.27			0.27
Total Liquid		35.91	22.16	292.16	61.32	411.55	2.72	1.68	21.80	4.58	30.78
110A	Petrol Coke	1.86	1.48			3.34	0.19	0.14			0.33
203B	Light Fuel Oil	0.12	3.02		0.90	4.04	0.01	0.24		0.07	0.31
203C	Medium Fuel Oil										
203D	Heavy Fuel Oil	2.99	1.65			4.64	0.24	0.13			0.37
204A	Gasoil	0.12	0.29		47.38	47.79	0.01	0.02		3.55	3.58
2050	Diesel	0.00	14.20	227.17	10.49	251.86	0.00	1.06	16.89	0.78	18.73
206A	Other Kerosene										
206B	Jet Kerosene			1.03		1.03			0.08		0.08
207A	Aviation Gasoline			0.11		0.11			0.01		0.01
2080	Motor Gasoline		0.11	63.29	1.20	64.60		0.01	4.79	0.09	4.89
224A	Other Petroleum Products	21.64	0.30			21.94	1.69	0.02			1.71
303A	Liquified Petroleum Gas (LPG)	0.76	1.11	0.56	1.35	3.78	0.05	0.07	0.04	0.09	0.24
308A	Refinery Gas	8.42				8.42	0.54				0.54
301A	Total Gaseous (Natural Gas)	76.58	116.85	11.29	72.71	277.43	4.24	6.47	0.63	4.03	15.37
Total Other Fuel		22.57	10.97	1.13	0.12	34.80	1.08	0.83	0.09	0.01	2.01
114A	MSW non renewable	9.14				9.14	0.84				0.84
114C	MSW renewable	10.20				10.20					
115A	Industrial Waste	3.23	10.92		0.08	14.23	0.24	0.83		0.01	1.08
225A	FAME		0.05	1.13	0.04	1.22		0.00	0.09	0.00	0.09
Total Biomass⁽¹⁾		61.39	68.48	18.35	83.15	231.37	(6.29)	(7.03)	(1.30)	(9.25)	(23.88)
111A	Fuel Wood	0.03	0.00		60.59	60.63	0.00	0.00		6.79	6.79
112A	Char Coal	0.04			0.43	0.47				0.05	0.05
116A	Wood Wastes	50.44	36.46		20.90	107.80	5.65	4.08		2.34	12.07
118A	Sewage Sludge	0.72	0.53			1.25	0.08	0.06			0.14
215A	Black Liquor		28.40			28.40		2.71			2.71
250A	Liquid Biofuels		0.96	18.33	0.76	20.05		0.07	1.30	0.05	1.42
309A	Biogas	9.94	0.79	0.02	0.28	11.04	0.54	0.04	0.00	0.02	0.60
309B	Sewage Sludge Gas	0.11	1.34		0.09	1.54	0.01	0.07		0.00	0.08
310A	Landfill Gas	0.09			0.09	0.19	0.01			0.01	0.01
Total⁽¹⁾		221.44	229.93	322.94	218.23	992.54	10.38	10.07	22.51	8.70	51.66

⁽¹⁾ CO₂ emissions of Biomass are not included in Total.

Table A 60: 2010 energy consumption and CO₂ emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO ₂ emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Transport	Other Sectors	Total	Energy Ind.	Industry	Transport	Other Sectors	Total
Total Solid		41.47	9.39	0.00	2.89	53.75	3.87	0.88	0.00	0.27	5.02
102A	Hard Coal	41.47	6.07	0.00	0.28	47.82	3.87	0.56	0.00	0.03	4.45
104A	Hard Coal Briquettes				0.40	0.40				0.04	0.04
105A	Brown Coal		1.57		0.10	1.68		0.15		0.01	0.16
106A	Brown Coal Briquettes				0.59	0.59				0.06	0.06
107A	Coke		0.35		1.51	1.86		0.04		0.14	0.18
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		1.40			1.40		0.13			0.13
Total Liquid		38.90	29.66	293.05	77.98	439.59	2.90	2.24	21.87	5.80	32.80
110A	Petrol Coke	1.75	1.44			3.20	0.18	0.14			0.32
203B	Light Fuel Oil	0.15	4.91		1.79	6.86	0.01	0.38		0.14	0.53
203C	Medium Fuel Oil	1.79				1.79	0.14				0.14
203D	Heavy Fuel Oil	6.43	3.03			9.46	0.51	0.24			0.75
204A	Gasoil	0.11	3.21		59.67	62.98	0.01	0.24		4.47	4.72
2050	Diesel	0.00	14.37	221.34	10.70	246.40	0.00	1.07	16.41	0.79	18.27
206A	Other Kerosene		0.01			0.01		0.00			0.00
206B	Jet Kerosene			1.30		1.30			0.09		0.09
207A	Aviation Gasoline			0.12		0.12			0.01		0.01
2080	Motor Gasoline		0.11	69.40	1.38	70.88		0.01	5.29	0.11	5.41
224A	Other Petroleum Products	15.34	0.52			15.85	1.20	0.04			1.23
303A	Liquified Petroleum Gas (LPG)	1.30	2.07	0.89	4.45	8.71	0.08	0.13	0.06	0.28	0.56
308A	Refinery Gas	12.02				12.02	0.77				0.77
301A	Total Gaseous (Natural Gas)	107.76	128.68	8.74	83.50	328.68	5.97	7.13	0.48	4.63	18.21
Total Other Fuel		17.86	11.21	0.92	0.10	30.09	0.89	0.79	0.07	0.01	1.75
114A	MSW non renewable	6.80				6.80	0.62				0.62
114C	MSW renewable	7.58				7.58					
115A	Industrial Waste	3.48	11.16		0.06	14.70	0.26	0.79		0.00	1.05
225A	FAME		0.05	0.92	0.04	1.01		0.00	0.07	0.00	0.08
Total Biomass⁽¹⁾		55.34	66.51	15.77	86.53	224.15	(5.89)	(6.88)	(1.12)	(9.64)	(23.53)
111A	Fuel Wood	0.04	0.65		69.13	69.82	0.00	0.07		7.74	7.82
112A	Char Coal	0.04			0.37	0.41				0.04	0.04
116A	Wood Wastes	49.83	34.77		15.93	100.53	5.58	3.89		1.78	11.26
118A	Sewage Sludge	0.22	0.69			0.92	0.03	0.08			0.10
215A	Black Liquor		28.53			28.53		2.72			2.72
250A	Liquid Biofuels		0.80	15.77	0.66	17.23		0.06	1.12	0.05	1.22
309A	Biogas	4.78	0.51	0.00	0.10	5.39	0.26	0.03	0.00	0.01	0.29
309B	Sewage Sludge Gas	0.32	0.55		0.27	1.13	0.02	0.03		0.01	0.06
310A	Landfill Gas	0.12			0.07	0.19	0.01			0.00	0.01
Total⁽¹⁾		261.32	245.46	318.47	251.00	1 076.25	13.62	11.04	22.42	10.70	57.78

⁽¹⁾ CO₂ emissions of Biomass are not included in Total.

Table A 61: 2005 energy consumption and CO₂ emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO ₂ emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Trans- port	Other Sectors	Total	Energy Ind.	Industry	Trans- port	Other Sectors	Total
Total Solid		61.63	18.43	0.01	4.81	84.88	5.84	1.72	0.00	0.45	8.01
102A	Hard Coal	51.51	7.65	0.01	1.37	60.54	4.81	0.71	0.00	0.13	5.64
104A	Hard Coal Briquettes				0.03	0.03				0.00	0.00
105A	Brown Coal	10.12	2.54		0.16	12.82	1.04	0.22		0.02	1.27
106A	Brown Coal Briquettes		0.00		1.01	1.01		0.00		0.10	0.10
107A	Coke		1.15		2.23	3.38		0.12		0.21	0.32
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		7.09			7.09		0.67			0.67
Total Liquid		45.18	30.94	326.96	105.60	508.67	3.42	2.37	24.41	7.87	38.07
110A	Petrol Coke	2.07	2.05			4.12	0.21	0.19			0.40
203B	Light Fuel Oil	0.17	7.14		9.23	16.53	0.01	0.56		0.71	1.28
203C	Medium Fuel Oil	2.29	0.00			2.29	0.18	0.00			0.18
203D	Heavy Fuel Oil	11.39	4.14			15.53	0.90	0.32			1.23
204A	Gasoil	0.19	4.94		77.61	82.73	0.01	0.37		5.82	6.21
2050	Diesel	0.01	10.80	240.59	11.74	263.14	0.00	0.80	17.84	0.87	19.52
206A	Other Kerosene		0.02			0.02		0.00			0.00
206B	Jet Kerosene			1.37		1.37			0.10		0.10
207A	Aviation Gasoline			0.12		0.12			0.01		0.01
2080	Motor Gasoline		0.11	83.96	1.65	85.72		0.01	6.40	0.13	6.54
224A	Other Petroleum Products	17.28	0.17			17.45	1.35	0.01			1.36
303A	Liquified Petroleum Gas (LPG)	2.29	1.56	0.93	5.37	10.15	0.15	0.10	0.06	0.34	0.65
308A	Refinery Gas	9.49				9.49	0.61				0.61
301A	Total Gaseous (Natural Gas)	111.68	119.92	6.49	89.65	327.73	6.19	6.64	0.36	4.97	18.16
Total Other Fuel		10.33	7.89	0.17	1.08	19.47	0.49	0.48	0.01	0.08	1.07
114A	MSW non renewable	4.20				4.20	0.39				0.39
114C	MSW renewable	4.68				4.68					
115A	Industrial Waste	1.45	7.88		1.07	10.41	0.11	0.48		0.08	0.67
225A	FAME		0.01	0.17	0.01	0.18		0.00	0.01	0.00	0.01
Total Biomass⁽¹⁾		20.46	58.24	2.20	67.64	148.53	(2.08)	(6.00)	(0.16)	(7.55)	(15.79)
111A	Fuel Wood	0.04	1.14		57.69	58.87	0.00	0.13		6.46	6.59
112A	Char Coal	0.03			0.36	0.39				0.04	0.04
116A	Wood Wastes	16.55	29.10		9.09	54.74	1.85	3.26		1.02	6.13
118A	Sewage Sludge	0.25	0.04			0.29	0.03	0.00			0.03
215A	Black Liquor		26.65			26.65		2.54			2.54
250A	Liquid Biofuels		0.10	2.20	0.11	2.40		0.01	0.16	0.01	0.17
309A	Biogas	2.85	0.43		0.14	3.42	0.16	0.02		0.01	0.19
309B	Sewage Sludge Gas	0.69	0.64		0.06	1.39	0.04	0.04		0.00	0.08
310A	Landfill Gas	0.04	0.15		0.19	0.38	0.00	0.01		0.01	0.02
Total⁽¹⁾		249.28	235.41	335.83	268.77	1 089.29	15.95	11.21	24.79	13.37	65.31

⁽¹⁾ CO₂ emissions of Biomass are not included in Total.

Table A 62: 2000 energy consumption and CO₂ emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO ₂ emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Trans- port	Other Sectors	Total	Energy Ind.	Industry	Trans- port	Other Sectors	Total
Total Solid		49.16	15.21	0.03	10.33	74.72	4.82	1.45	0.00	0.97	7.25
102A	Hard Coal	37.36	10.31	0.03	2.16	49.85	3.53	0.97	0.00	0.20	4.70
104A	Hard Coal Briquettes				0.12	0.12				0.01	0.01
105A	Brown Coal	11.80	1.90		0.64	14.34	1.29	0.18		0.07	1.55
106A	Brown Coal Briquettes		0.00		2.06	2.06		0.00		0.20	0.20
107A	Coke		1.19		5.35	6.54		0.12		0.49	0.62
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		1.81			1.81		0.17			0.17
Total Liquid		41.55	24.71	244.94	106.01	417.21	3.04	1.88	18.32	7.94	31.18
110A	Petrol Coke	1.63	0.81			2.44	0.16	0.08			0.25
203B	Light Fuel Oil	1.81	5.52		15.69	23.02	0.14	0.43		1.21	1.78
203C	Medium Fuel Oil				1.47	1.47				0.11	0.11
203D	Heavy Fuel Oil	13.04	6.59		0.14	19.77	1.04	0.51		0.01	1.56
204A	Gasoil	0.01	1.61		71.98	73.59	0.00	0.12		5.40	5.52
2050	Diesel	0.04	7.32	162.80	11.06	181.22	0.00	0.54	12.07	0.82	13.44
206A	Other Kerosene				0.26	0.26				0.02	0.02
206B	Jet Kerosene			1.37		1.37			0.10		0.10
207A	Aviation Gasoline			0.08		0.08			0.01		0.01
2080	Motor Gasoline		0.11	80.02	1.72	81.84		0.01	6.10	0.13	6.24
224A	Other Petroleum Products	9.74	0.21			9.96	0.76	0.01			0.77
303A	Liquified Petroleum Gas (LPG)	0.94	2.54	0.67	3.70	7.85	0.06	0.16	0.04	0.24	0.50
308A	Refinery Gas	14.33				14.33	0.87				0.87
301A	Total Gaseous (Natural Gas)	74.27	111.77	6.10	73.11	265.25	4.11	6.19	0.34	4.05	14.69
Total Other Fuel		5.46	6.25		0.56	12.27	0.29	0.38		0.04	0.71
114A	MSW non renewable	2.19				2.19	0.23				0.23
114C	MSW renewable	2.45				2.45					
115A	Industrial Waste	0.82	6.25		0.56	7.63	0.06	0.38		0.04	0.49
225A	FAME										
Total Biomass⁽¹⁾		8.08	40.83		69.27	118.18	(0.90)	(4.13)		(7.73)	(12.76)
111A	Fuel Wood		0.95		59.22	60.17		0.11		6.63	6.74
112A	Char Coal	0.03			0.31	0.34				0.03	0.03
116A	Wood Wastes	7.67	15.15		9.24	32.05	0.86	1.70		1.03	3.59
118A	Sewage Sludge	0.28				0.28	0.03				0.03
215A	Black Liquor		24.06			24.06		2.29			2.29
250A	Liquid Biofuels										
309A	Biogas	0.00	0.31		0.05	0.36	0.00	0.02		0.00	0.02
309B	Sewage Sludge Gas	0.08	0.36		0.03	0.47	0.00	0.02		0.00	0.03
310A	Landfill Gas	0.01			0.43	0.44	0.00			0.02	0.02
Total⁽¹⁾		178.52	198.78	251.06	259.28	887.64	12.26	9.90	18.66	13.01	53.83

⁽¹⁾ CO₂ emissions of Biomass are not included in Total.

Table A 63: 1995 energy consumption and CO₂ emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO ₂ emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Trans- port	Other Sectors	Total	Energy Ind.	Industry	Trans- port	Other Sectors	Total
Total Solid		45.49	15.72	0.06	18.59	79.86	4.53	1.50	0.01	1.75	7.78
102A	Hard Coal	29.90	7.45	0.06	4.11	41.52	2.82	0.70	0.01	0.38	3.91
104A	Hard Coal Briquettes										
105A	Brown Coal	15.58	2.29		1.14	19.00	1.71	0.22		0.12	2.05
106A	Brown Coal Briquettes		0.28		3.05	3.32		0.03		0.30	0.32
107A	Coke		0.78		10.30	11.08		0.08		0.95	1.03
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		4.93			4.93		0.47			0.47
Total Liquid		46.34	33.87	205.75	107.92	393.87	3.73	2.59	15.46	8.09	29.86
110A	Petrol Coke	1.87	0.37			2.24	0.19	0.04			0.23
203B	Light Fuel Oil	1.39	11.55		17.79	30.73	0.11	0.90		1.37	2.38
203C	Medium Fuel Oil	0.11	0.00		2.32	2.43	0.01	0.00		0.18	0.19
203D	Heavy Fuel Oil	17.70	13.77		0.46	31.93	1.41	1.07		0.04	2.52
204A	Gasoil	0.09	0.20		70.50	70.80	0.01	0.02		5.29	5.31
2050	Diesel	0.28	4.82	106.98	10.61	122.69	0.02	0.36	7.93	0.79	9.10
206A	Other Kerosene				0.26	0.26				0.02	0.02
206B	Jet Kerosene			1.05		1.05			0.08		0.08
207A	Aviation Gasoline			0.09		0.09			0.01		0.01
2080	Motor Gasoline		0.07	97.13	1.80	99.00		0.01	7.41	0.14	7.55
224A	Other Petroleum Products	8.88	0.21		0.01	9.10	0.69	0.01		0.00	0.71
303A	Liquified Petroleum Gas (LPG)	1.06	2.88	0.49	4.18	8.61	0.07	0.18	0.03	0.27	0.55
308A	Refinery Gas	14.95				14.95	1.23				1.23
301A	Total Gaseous (Natural Gas)	80.70	99.58	4.09	74.06	258.43	4.47	5.52	0.23	4.10	14.32
Total Other Fuel		5.13	5.27		0.52	10.92	0.28	0.37		0.04	0.69
114A	MSW non renewable	1.85				1.85	0.19				0.19
114C	MSW renewable	2.06				2.06					
115A	Industrial Waste	1.22	5.27		0.52	7.01	0.09	0.37		0.04	0.50
225A	FAME										
Total Biomass⁽¹⁾		4.05	35.65		69.85	109.55	(0.45)	(3.63)		(7.79)	(11.86)
111A	Fuel Wood		1.07		66.28	67.35		0.12		7.42	7.54
112A	Char Coal	0.03			0.28	0.31				0.03	0.03
116A	Wood Wastes	3.77	13.04		2.63	19.44	0.42	1.46		0.29	2.18
118A	Sewage Sludge	0.21				0.21	0.02				0.02
215A	Black Liquor		21.39			21.39		2.04			2.04
250A	Liquid Biofuels										
309A	Biogas		0.04			0.04		0.00			0.00
309B	Sewage Sludge Gas	0.01	0.00		0.61	0.62	0.00	0.00		0.03	0.03
310A	Landfill Gas	0.03	0.12		0.05	0.20	0.00	0.01		0.00	0.01
Total⁽¹⁾		181.70	190.09	209.90	270.95	852.64	13.01	9.97	15.69	13.98	52.65

⁽¹⁾ CO₂ emissions of Biomass are not included in Total.

Table A 64: 1990 energy consumption and CO₂ emissions from category 1 A Fuel Combustion by fuel type and sector.

		Consumption (PJ)					CO ₂ emissions (Mt)				
		1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A	1 A 1	1 A 2	1 A 3 + 1 A 5	1 A 4	1 A
		Energy Ind.	Industry	Trans- port	Other Sectors	Total	Energy Ind.	Industry	Trans- port	Other Sectors	Total
Total Solid		61.40	23.87	0.07	28.13	113.46	6.25	2.28	0.01	2.65	11.18
102A	Hard Coal	38.44	7.17	0.07	5.28	50.96	3.85	0.67	0.01	0.49	5.03
104A	Hard Coal Briquettes										
105A	Brown Coal	22.73	2.19		2.36	27.28	2.37	0.21		0.26	2.84
106A	Brown Coal Briquettes	0.23	1.24		4.45	5.91	0.02	0.12		0.43	0.57
107A	Coke		1.66		16.04	17.69		0.17		1.48	1.65
113A	Peat				0.00	0.00				0.00	0.00
304A	Coke Oven Gas		11.61			11.61		1.10			1.10
Total Liquid		43.15	36.10	179.98	109.16	368.39	3.19	2.78	13.56	8.23	27.76
110A	Petrol Coke	1.96	0.96			2.92	0.20	0.10			0.29
203B	Light Fuel Oil	1.61	10.99		33.54	46.14	0.13	0.86		2.58	3.57
203C	Medium Fuel Oil	0.29	0.01		4.47	4.77	0.02	0.00		0.35	0.37
203D	Heavy Fuel Oil	13.67	17.40		1.63	32.71	1.08	1.36		0.13	2.56
204A	Gasoil	0.00	0.06		52.94	53.00	0.00	0.00		3.97	3.97
2050	Diesel	0.01	3.40	74.93	10.80	89.14	0.00	0.25	5.56	0.80	6.61
206A	Other Kerosene				0.74	0.74				0.06	0.06
206B	Jet Kerosene			0.87		0.87			0.06		0.06
207A	Aviation Gasoline			0.10		0.10			0.01		0.01
2080	Motor Gasoline		0.05	103.66	1.85	105.56		0.00	7.91	0.14	8.05
224A	Other Petroleum Products	6.93	0.24		0.87	8.03	0.54	0.02		0.06	0.61
303A	Liquified Petroleum Gas (LPG)	0.41	2.99	0.41	2.32	6.14	0.03	0.19	0.03	0.15	0.39
308A	Refinery Gas	18.28				18.28	1.20				1.20
301A	Total Gaseous (Natural Gas)	76.48	76.99	4.05	46.46	203.98	4.24	4.27	0.22	2.57	11.30
Total Other Fuel		4.66	3.22		1.11	8.99	0.29	0.21		0.08	0.58
114A	MSW non renewable	1.14				1.14	0.12				0.12
114C	MSW renewable	1.27				1.27					
115A	Industrial Waste	2.25	3.22		1.11	6.58	0.17	0.21		0.08	0.46
225A	FAME										
Total Biomass⁽¹⁾		1.66	29.45		64.46	95.57	(0.18)	(3.00)		(7.22)	(10.40)
111A	Fuel Wood		0.66		62.46	63.12		0.07		7.00	7.07
112A	Char Coal	0.03			0.22	0.25				0.02	0.02
116A	Wood Wastes	1.44	10.99		1.79	14.22	0.16	1.23		0.20	1.59
118A	Sewage Sludge	0.19				0.19	0.02				0.02
215A	Black Liquor		17.80			17.80		1.70			1.70
250A	Liquid Biofuels										
309A	Biogas										
309B	Sewage Sludge Gas										
310A	Landfill Gas										
Total⁽¹⁾		187.35	169.63	184.10	249.32	790.39	13.96	9.53	13.79	13.54	50.83

⁽¹⁾ CO₂ emissions of Biomass are not included in Total.

Annex 3.2 – CRF 3 Agriculture – Austria's N-flow model

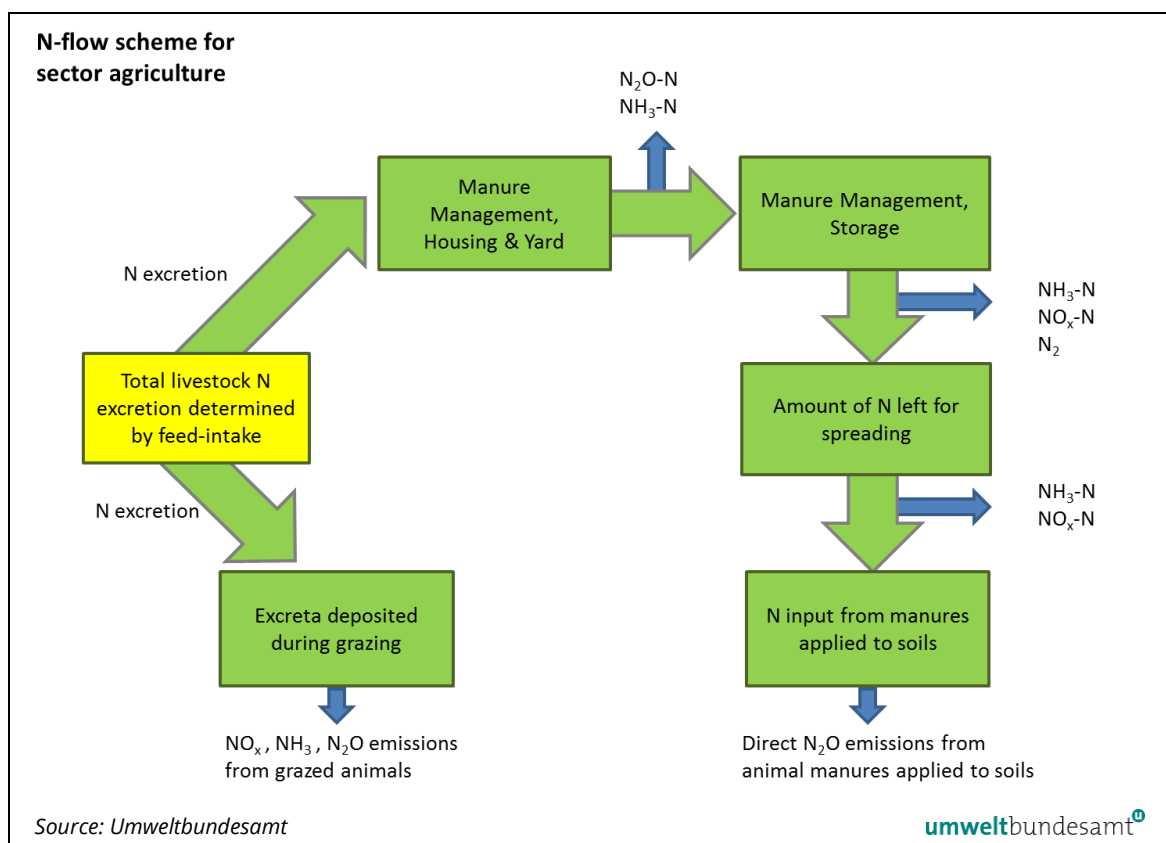
For the calculation of N₂O emissions from agricultural soils Austria uses country specific methods which are consistent with the N-flow approach. The approach used by Austria is more complex than the IPCC method in order to allow for the consideration of the management practices in Austria as those may differ from other countries.

As recommended in the EMEP/EEA Emission Inventory Guidebook 2023 for higher tier methods, NH₃ 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 NH₃ 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 NH₃, NO_x, N₂O and N₂ 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. Detailed information on parameters and methods used is provided in Austria's Informative Inventory Report 2024, chapter 5 (UMWELTBUNDESAMT 2024).

The N-flux model used by Austria was developed by the University of Natural Resources and Applied Life Sciences, Vienna, on behalf of the Environment Agency Austria in 2001 and has been regularly further developed (AMON et al. 2002, 2008 & 2010), (AMON & HÖRTENHUBER 2014) and (AMON & HÖRTENHUBER 2019). In submission 2020 the N flow model has been further enhanced according to the EMEP/EEA Guidebook 2019; in the current submission the EMEP/EEA GB 2023 was applied. However, there were no significant changes regarding N-flow in the new EMEP/EEA GB 2023 compared to the 2019 version.

The following figure illustrates the pathways of N in the calculation of N-species emissions from the N excreted by livestock.

Figure 1: Schematic diagram of the Austrian N flow (animal manure)



For the calculation of N_2O emissions occurring from N-input from manures applied to soils, the chain beginning with the feeding, the housing, the transfer to the storage, the transfer to the application machine and finally the spreading to the fields is relevant. All those emissions are accounted at the appropriate stage of the process.

Feeding

In the first step, N excretion for a given animal category is determined on the basis of national feed-intake data.

Grazing

In the second step the resulting N amount relating to the share excreted on pasture is subtracted based on the proportion of time spent on pasture. Following the 2006 IPCC Guidelines, N_2O emissions resulting from nitrogen input through excretions of grazing animals (directly dropped onto the soil) are calculated under *Manure Management* but reported under *Agricultural Soils*.

Housing:

For each animal category, the amount of N accruing from the housing is split based on the relative share of animal-housing systems used in Austria. These systems vary in terms of their emission behaviour (e.g. tied and loose housing systems, liquid versus solid manure systems).

Indirect N₂O emissions from manure management systems

Nitrogen losses begin at the point of excretion and continue through on-site management in storage and treatment systems. Further nitrogen can be lost through runoff and leaching into soils from the solid storage of manure at outdoor areas (not occurring in Austria). The indirect N₂O emissions from volatilization of N in forms of NH₃ and NO_x are estimated following the IPCC Tier 2 methodology. The country specific value of $Frac_{GasMS}$ includes NH₃-N losses from housing, storage, yard and NO_x-N losses from manure management calculated within the Austrian N-flow model.

Storage:

The remaining N is then transferred to the different storage systems used in Austria (e.g. covered or uncovered storage).

For all stages of manure NH₃ emissions are calculated in proportion to the available TAN amount. Emission factors for cattle and swine were derived from the Swiss DYNAMO-model, peer reviewed by the EAGER group and published in (REIDY et al. 2008, 2009). For the non-key livestock categories sheep, goats, horses, poultry and deer the EMEP/EEA default Tier 2 NH₃-N EF and associated parameters have been applied (EEA 2023).

N losses from manure management resulting from emissions of N₂O, NO_x and N₂ are calculated on the basis of N excretion per AWMS, jointly for housing and storage, as recommended by the IPCC guidelines. Throughout the inventory the same MMS distribution is used.

Application on agricultural soils

Remaining amounts of animal manure nitrogen ("N left for spreading") are available for soil application.

Direct N₂O-emissions

Following the 2006 IPCC guidelines for calculation of direct N₂O emissions from soils amounts of applied fertilizers are no longer adjusted for the amounts of NH₃ and NO_x volatilization after application to soils (see below).

NH₃ and NO_x emissions

NH₃ and NO_x emissions are calculated according to different application procedures (broadcast spreading, band spreading) resulting in different N-losses. In particular, volatile NH₃-N losses of cattle and swine manure are subtracted from the TAN content per animal category; volatile losses from NO_x are subtracted from the N amount per animal category available for spreading.

Indirect N₂O emissions from leaching and run-off from managed soils

Calculation basis is the nitrogen amount available for application on soils ("N left for spreading") as a result from the Austrian N-flow model. This amount is multiplied with the country-specific value of $Frac_{LEACH}$.

Results of a country specific study of the Institute for Land & Water Management Research Petzenkirchen (Federal Agency for Water Management) in cooperation with the Institute of Hydraulic Engineering and Water Resources Management (Vienna University of Technology) (EDER et al. 2015) determine a value of 15.154% for the fraction of leaching and run-off from nitrogen additions to Austria's managed soils. The peer reviewed study used 22 lysimeters covering a wide

range of soils, climatic conditions and management practices in Austria to evaluate an Austria-specific value of $\text{Frac}_{\text{LEACH}}$.

Indirect N₂O emissions from atmospheric deposition of N volatilised from managed soils

Basis for emission calculation are the country specific volatilization losses ($\text{NH}_3\text{-N}$ and $\text{NO}_x\text{-N}$) occurring during animal grazing and manure application.

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Annex 3.3 – CO₂ Reference Approach

This annex presents the results, methodology and detailed data for the CO₂ reference approach.

Methodology

The default methodology is applied.

Emission factors

Carbon emission factors

For estimation of emissions that arise from combustion of fossil fuels, the default carbon emission factors described in chapter 1.4.1.1 of the IPCC 1996 Reference Manual have been used (IPCC Workbook 1.6 table 1-2) except for natural gas and coal, where country specific values have been used.

Fraction of carbon oxidised

Default values of table 1-6 of the IPCC 1996 Reference Manual have been used for coal and biomass. For liquid fuels and natural gas 100% combustion efficiency is assumed. Selected values are presented Table A 71.

Activity data

Production, Imports, Exports, Stock Change

Activity data are taken from the national energy balance (IEA JQ 2023) (see Annex 3.1 and Annex 4). The reference approach requires more detailed fuel categories than provided in the national energy balance. Some fuel categories are aggregations of the detailed fuel categories the reference approach asks for. The following fuel types are included elsewhere:

- Ethane is included in Refinery Feedstocks.

Conversion factors

For the most important solid and liquid fuels country specific conversion factors in the unit TJ/Gg are selected. Selected values are presented below.

International Bunkers

International bunkers are relevant for aviation and international navigation on rivers (mostly Danube), the Neusiedler Lake and the Lake Constance.

Fuel consumption of international bunkers is consistent with memo item international bunkers as described in the relevant chapter for Category 1.A.3.

Carbon Stored (C excluded)

A high amount of residual fuel oil is considered as a reductant in blast furnaces (CRF 2.C.1).

Naphta is used as feedstock for ethylen production in petrochemical plants.

Non-energy use of Bitumen is considered to be 100% stored (e.g. as Asphalt concrete).

The share of Petroleum coke which is used for calcium carbide production is considered to be 100% stored.

Non energy use of other oil products is considered to be 100% stored.

A high amount of other bituminous coal is considered as a reductant in blast furnaces (CRF 2.C.1).

A high amount of Coke oven coke is considered as a reductant in blast furnaces (CRF 2.C.1).

Coal tar imports are considered as a reductant in blast furnaces (CRF 2.C.1).

Natural gas used for Ammonia production is excluded from the RA and emissions are reported under CRF 2.B.1

A share of waste plastics are considered as a reductant in blast furnaces (CRF 2.C.1).

In the Sectoral Approach, the release of stored carbon as emissions is considered as quoted in the NIR, chapter 3.4 *Feedstock*.

Recalculations

Activity data

Imports, Exports and Production are updated according to the new version of the energy balance (IEA JQ 2023). Changes of activity data are based on energy balance recalculations.

Revised Methodology

Since submission 2021, the reference approach considers energy balance data of pure fossil diesel and gasoline while in previous submissions blended biofuels were included in those fuel data.

Because of the exclusion of blended biofuels from motor diesel and gasoline, these fuels are now included in 'liquid biomass'.

The carbon content of waste non-biomass fraction in the reference approach has been harmonized with the sectoral approach.

Results of the Reference Approach

Table A 65 to Table A 70 present calculation results, apparent fuel consumption, carbon stored, international bunker fuels, conversion factors, carbon emission factors and the fraction of carbon oxidised for all fuel types of the Reference Approach.

Table A 65 presents the calculation results for each fuel type of the Reference Approach for selected years.

Table A 65: Actual CO₂ emissions (kt CO₂) for selected years.

Fuel Type	1990	2000	2005	2010	2015	2018	2019	2020	2021	2022
Crude Oil	24 784	25 694	27 249	24 056	27 591	27 956	28 438	25 456	25 690	17 505
Orimulsion	0	0	0	0	0	0	0	0	0	0
Natural Gas Liquids	110	287	209	360	141	48	43	39	31	30
Gasoline	-248	488	910	1 012	-349	-832	-1 054	-1 097	-1 082	399
Jet Kerosene	-846	-1 588	-1 737	-1 398	-1 920	-2 267	-2 683	-1 062	-1 023	-1 297
Other Kerosene	-44	16	-2	-1	-1	-1	-1	-1	0	-1
Shale Oil	0	0	0	0	0	0	0	0	0	0
Gas / Diesel Oil	1 755	7 093	13 476	12 954	10 676	12 005	11 585	10 727	11 763	14 902

Fuel Type	1990	2000	2005	2010	2015	2018	2019	2020	2021	2022
Residuel Fuel Oil	650	399	-373	-539	-1 494	-1 224	-1 124	-1 214	-978	-866
LPG	249	398	329	296	-163	-104	-152	-140	-186	72
Ethane	0	0	0	0	0	0	0	0	0	0
Naphtha	-1 357	-1 828	-1 474	-2 257	-2 974	-3 255	-3 155	-3 296	-3 410	-2 577
Bitumen	-907	-1 207	-1 234	-986	-979	-1 244	-1 332	-1 431	-1 483	-794
Lubricants	155	-173	-216	-182	55	53	53	48	74	98
Petroleum Coke	97	82	207	140	149	123	95	64	141	172
Refinery Feedstocks	3 019	1 620	873	357	-211	132	978	358	398	1 181
OtherOil	432	-26	-193	-620	43	41	36	-49	-48	-5
Liquid Fossil Totals	27 849	31 254	38 023	33 193	30 564	31 432	31 727	28 402	29 887	28 820
Anthracite	40	7	12	8	10	164	55	57	73	5
Coking Coal	7 004	5 626	5 625	4 709	4 615	4 637	4 631	4 617	4 640	4 693
Other Bit. Coal	4 713	4 809	5 808	4 559	2 984	1 877	1 682	1 001	308	165
Sub- Bit. Coal	0	79	137	141	171	144	138	124	113	133
Lignite	2 729	1 319	1 205	13	11	15	3	5	7	6
Oil Shale	0	0	0	0	0	0	0	0	0	0
BKB & Patent Fuel	548	198	96	78	31	73	21	22	24	19
Coke Oven / Gas Coke	-3 269	-3 383	-3 565	-3 923	-3 664	-3 650	-3 269	-3 484	-3 807	-3 775
Coal Tar	0	-143	-1	-2	-140	-121	-122	-83	-129	-129
Solid Fossil Totals	11 766	8 512	9 318	5 583	4 018	3 140	3 139	2 260	1 230	1 115
Gaseous Fossil	11 417	14 791	18 293	18 366	15 523	16 720	17 350	16 547	17 498	15 620
Waste (non-biomass fraction)	580	714	1 059	1 678	1 919	1 964	1 879	1 870	1 931	1 985
Peat	0	0	0	0	0	0	0	0	0	0
Fossil Totals	51 612	55 270	66 693	58 820	52 024	53 256	54 095	49 078	50 545	47 540
Biomass Totals	9 270	11 550	14 694	22 203	23 125	21 954	21 832	21 736	23 827	22 281
Solid Biomass	9 197	11 254	13 584	19 354	19 035	18 708	18 640	18 823	21 046	19 524
Liquid Biomass	19	51	382	1 775	2 286	1 748	1 735	1 471	1 530	1 411
Gas Biomass	0	140	544	730	1 353	1 042	985	963	739	845
Other non-fossil fuels (biogenic waste)	55	105	184	344	450	456	472	479	513	501

Table A 66 presents the apparent fuel consumption for each fuel type of the Reference Approach.

Table A 66: Apparent Consumption (TJ) for selected years.

Fuel Type	1990	2000	2005	2010	2015	2018	2019	2020	2021	2022
Crude Oil	337 960	350 367	371 572	328 037	376 237	381 225	387 788	347 127	350 323	238 710
Orimulsion	0	0	0	0	0	0	0	0	0	0
Natural Gas Liquids	1 743	4 550	3 315	5 711	2 238	754	684	615	488	473
Gasoline	-3 203	7 140	13 229	14 663	-4 992	-11 963	-15 170	-15 774	-15 565	5 802
Jet Kerosene	-11 826	-22 204	-24 294	-19 558	-26 852	-31 710	-37 521	-14 858	-14 304	-18 135
Other Kerosene	-610	217	110	50	24	30	24	13	21	20
Shale Oil	0	0	0	0	0	0	0	0	0	0
Gas / Diesel Oil	23 699	95 763	181 950	174 902	144 138	162 087	156 411	144 823	158 814	201 191
Residuel Fuel Oil	13 243	14 769	4 898	1 420	-18 355	-15 822	-14 532	-15 696	-12 639	-11 190
LPG	3 943	6 307	5 210	4 696	-1 420	-1 012	-1 740	-1 521	-2 339	2 093
Ethane	0	0	0	0	0	0	0	0	0	0
Naphtha	90	0	1 230	89	-6 515	-8 657	190	-65	-253	474
Bitumen	11 328	10 643	7 878	7 219	5 993	5 250	4 326	977	860	6 210
Lubricants	5 506	-84	-1 278	-972	1 506	1 443	1 432	1 317	2 005	2 671
Petroleum Coke	2 881	2 069	3 313	3 246	1 918	1 922	1 188	637	1 434	2 268
Refinery Feedstocks	41 163	22 090	11 900	4 873	-2 876	1 802	13 332	4 882	5 427	16 103
OtherOil	6 646	393	-1 487	-7 462	2 449	2 687	2 612	1 430	1 416	1 180
Liquid Fossil Totals	432 562	492 018	577 546	516 913	473 493	488 037	499 025	453 907	475 687	447 870
Anthracite	448	84	142	99	131	1 749	612	605	784	72
Coking Coal	67 937	54 564	55 252	53 630	51 356	50 841	50 979	50 608	50 953	51 482
Other Bit. Coal	50 568	51 604	62 304	53 439	55 150	40 400	39 020	30 408	28 447	23 161
Sub- Bit. Coal	0	844	1 451	1 499	1 811	1 527	1 465	1 320	1 197	1 409

Fuel Type	1990	2000	2005	2010	2015	2018	2019	2020	2021	2022
Lignite	27 294	13 188	11 861	132	114	159	30	49	68	57
Oil Shale	0	0	0	0	0	0	0	0	0	0
BKB & Patent Fuel	5 912	2 134	1 032	838	333	792	226	237	259	200
Coke Oven / Gas Coke	19 304	30 110	36 977	33 751	29 222	21 730	29 943	22 107	27 411	26 704
Coal Tar	0	-1 810	91	36	-1 759	-1 526	-1 409	-1 038	-1 586	-1 512
Solid Fossil Totals	171 462	150 718	169 112	143 424	136 357	115 670	120 865	104 296	107 533	101 574
Gaseous Fossil	219 239	275 836	338 534	340 091	289 239	308 256	321 403	306 427	323 717	288 460
Waste (non-biomass fraction)	8 073	10 509	16 654	25 649	27 899	27 142	26 372	27 981	27 618	28 936
Peat	4	4	4	4	4	0	0	0	0	0
Fossil Totals	831 340	929 086	1 101 850	1 026 082	926 992	939 105	967 666	892 611	934 556	866 840
Biomass Totals	96 503	120 409	153 723	236 337	246 781	233 978	232 789	231 233	253 460	237 226
Solid Biomass	95 324	116 649	140 804	200 603	197 301	193 909	193 204	195 104	218 142	202 369
Liquid Biomass	262	720	4 882	23 313	29 600	22 933	22 701	19 327	19 997	18 764
Gas Biomass	0	1 275	4 961	6 663	12 341	9 505	8 983	8 787	6 743	7 710
Other non-fossil fuels (biogenic waste)	917	1 765	3 076	5 758	7 540	7 631	7 901	8 016	8 578	8 383

Table A 67 presents the carbon stored for each fuel type of the Reference Approach.

Table A 67: Carbon Stored (kt C) for selected years

Fuel Type	1990	2000	2005	2010	2015	2018	2019	2020	2021	2022
Crude Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orimulsion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas Liquids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gasoline	7.05	1.79	1.75	1.18	0.88	0.84	0.81	0.95	0.85	0.83
Jet Kerosene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Kerosene	0.00	0.00	2.60	1.13	0.70	0.77	0.65	0.44	0.55	0.53
Shale Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas / Diesel Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residual Fuel Oil	102.08	202.84	204.95	177.08	20.12	0.00	0.00	0.00	0.00	0.00
LPG	0.00	0.00	0.00	0.00	20.15	10.84	11.61	11.96	10.40	16.34
Ethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Naphtha	372.01	498.58	426.63	617.38	680.87	714.51	864.19	897.48	924.92	712.19
Bitumen	496.58	563.27	509.96	427.64	398.92	454.79	458.37	411.66	423.42	353.28
Lubricants	67.90	45.56	33.44	30.26	15.00	14.37	14.29	13.17	20.05	26.71
Petroleum Coke	52.82	34.51	34.69	50.98	12.07	19.25	6.67	0.16	1.05	15.37
Refinery Feedstocks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Oil	15.05	15.05	23.01	19.92	37.13	42.67	42.45	41.93	41.36	24.96
Liquid Fossil Totals	1 113.49	1 361.59	1 237.04	1 325.57	1 185.85	1 258.03	1 399.04	1 377.76	1 422.60	1 150.20
Anthracite	0.75	0.38	0.36	0.35	0.65	1.17	1.20	0.42	0.61	0.65
Coking Coal	37.10	29.59	56.04	51.63	37.94	19.10	25.98	24.83	23.18	21.84
Other Bit. Coal	0.00	0.00	0.00	116.01	597.08	512.23	535.10	500.08	644.51	541.79
Sub- Bit. Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lignite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil Shale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB & Patent Fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Oven / Gas Coke	1 474.97	1 823.38	2 066.73	2 092.32	1 903.61	1 676.32	1 822.25	1 643.37	1 889.33	1 855.41
Coal Tar	0.00	0.00	2.31	1.40	0.17	0.18	2.88	0.20	0.98	2.63
Solid Fossil Totals	1 512.83	1 853.35	2 123.13	2 260.30	2 539.28	2 208.82	2 384.54	2 168.69	2 557.62	2 419.69
Gaseous Fossil	198.77	133.78	125.93	129.61	136.62	97.40	141.79	133.83	136.49	114.01
Waste (non-biomass fraction)	0.00	0.00	0.00	51.06	30.81	10.14	19.40	30.31	32.20	30.17
Peat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fossil Totals	2 825.08	3 348.72	3 486.10	3 715.48	3 861.75	3 564.25	3 925.36	3 680.28	4 116.71	3 683.90
Biomass Totals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Biomass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquid Biomass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Fuel Type	1990	2000	2005	2010	2015	2018	2019	2020	2021	2022
Gas Biomass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other non-fossil fuels (biogenic waste)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 68 presents international bunker fuels for the relevant fuel types of the Reference Approach.

Table A 68: International Bunkers [kt fuel].

Fuel Type	1990	2000	2005	2010	2015	2018	2019	2020	2021	2022
Jet Kerosene	279	538	622	650	627	627	675	803	923	331
Diesel	15	21	24	21	20	19	15	13	14	13

Table A 69 presents conversion factors, carbon emission factors and the fraction of carbon oxidised for all fuel types of the Reference Approach. Country specific values are provided only where relevant.

Table A 69: Conversion factor, carbon emission factor and fraction of carbon oxidised for the year 2022.

Fuel Type	Conversion Factor [TJ/kt]		Carbon emission factor [t C/TJ]		Fraction of carbon oxidised [t C/t C]
	Default value	Country specific value 2021	Default value	Country specific value 2021	
Crude Oil	42.75	42.50	20.00	-	1.00
Orimulsion	-	-	-	-	-
Natural Gas Liquids	45.22	42.50	17.20	-	1.00
Gasoline	44.80	41.52	18.90	-	1.00
Jet Kerosene	44.59	43.30	19.50	-	1.00
Other Kerosene	44.75	43.30	19.60	-	1.00
Shale Oil	-	-	-	-	1.00
Gas / Diesel Oil	43.33	42.37	20.20	-	1.00
Residual Fuel Oil	40.19	41.66	21.10	-	1.00
LPG	47.31	46.12	17.20	-	1.00
Ethane	-	-	-	-	1.00
Naphtha	45.01	45.01	20.00	-	1.00
Bitumen	40.19	41.80	22.00	-	1.00
Lubricants	40.19	41.80	20.00	-	1.00
Petroleum Coke	31.00	31.13	27.50	-	1.00
Refinery Feedstocks	42.50	41.98	20.00	-	1.00
Other Oil	40.19	45.44	20.00	-	1.00
Anthracite	28.00	28.00	26.80	-	0.98
Coking Coal	28.00	29.91	25.80	25.79	0.98
Other Bit. Coal	28.00	29.90	25.80	25.37	0.98
Sub- Bit. Coal	22.20	21.79	26.20	-	0.98
Lignite	10.90	16.51	27.60	27.07	0.98
Oil Shale	-	-	-	-	-
BKB & Patent Fuel	19.30	19.30	25.80	-	0.98
Coke Oven / Gas Coke	28.20	28.22	29.50	30.14	0.98
Coal Tar	-	36.90	22.01	-	0.98
Natural Gas	-	-	15.30	15.16	1.00
Waste (non-biomass fraction)	-	-	-	19.75	1.00
Peat	8.80	-	28.90	-	1.00
Solid Biomass	-	-	29.90	29.90	0.88
Liquid Biomass	-	37.14	-	20.50	1.00
Gas Biomass	-	-	29.90	29.90	1.00
Other non-fossil fuels (biogenic waste)	-	-	27.30	16.29	1.00

Table A 70 presents selected country specific conversion factors. From 2007 on the conversion factor of lignite is higher because indigenous production and use of lignite with a comparable low calorific value (high water content) has been suspended.

Table A 70: Country specific conversion factors for selected fuels [TJ/kt]

Fuel Type	1990	2000	2005	2010	2015	2018	2019	2020	2021	2022
Other Bit. Coal	28.00	27.99	29.10	28.15	28.50	28.53	28.85	28.42	28.93	28.46
Sub Bit. Coal	22.20	22.20	22.18	21.84	21.85	21.91	22.08	21.81	22.23	21.83
Lignite	10.90	9.82	9.83	9.80	9.70	9.86	9.70	16.76	16.16	14.14
Coke	28.50	28.67	28.88	28.75	28.57	29.01	28.84	27.90	28.73	28.77

ANNEX 4: NATIONAL ENERGY BALANCE

The following tables present the data of the national energy balance by IEA categories. Calorific values for unit conversion are presented at the end of this Annex. Data was submitted to the Umweltbundesamt by STATISTIK AUSTRIA in November 2023.

Please note that for reasons of confidentiality energy consumption of autoproducers by sub sectors are not public available and therefore not presented in this ANNEX.

Annex 4.1 – Coal

Table A 71: National Energy Balance 1990–2022. Coking Coal [1000 tons].

101A Coking Coal	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	2 376	1 778	1 738	2 063	1 907	1 786	1 689	1 797	1 751	1 760	1 837	1 732	1 711	1 688
Total Exports (Balance)	0	0	0	0	0	0	5	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-39	130	139	-164	-69	12	48	19	12	-16	-79	16	28	33
Gross Inland Deliveries (Obs.)	2 337	1 908	1 877	1 899	1 838	1 799	1 731	1 816	1 764	1 745	1 758	1 748	1 739	1 721
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	2 337	1 908	1 877	1 899	1 838	1 799	1 731	1 816	1 764	1 745	1 758	1 748	1 739	1 721
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	2 337	1 908	1 877	1 899	1 838	1 799	1 731	1 816	1 764	1 745	1 758	1 748	1 739	1 721
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

101A Coking Coal	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 72: National Energy Balance 1990–2022. Bituminous Coal & Anthracite [1000 tons].

102A Bituminous Coal & Anthracite (hard coal)	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	1 233	1 216	1 671	2 260	1 727	1 851	1 339	1 485	1 636	1 327	1 241	976	1 060	791
Total Exports (Balance)	0	1	0	3	1	2	6	0	1	3	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	589	268	176	-111	176	-151	583	230	-17	159	129	114	-50	-14
Gross Inland Deliveries (Obs.)	1 822	1 484	1 847	2 146	1 902	1 698	1 916	1 715	1 617	1 484	1 370	1 090	1 010	777
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	1 421	1 082	1 422	1 885	1 576	1 399	967	675	584	622	532	196	34	11
Public Electricity	964	550	1 203	1 694	1 396	1 225	718	438	363	421	313	59	0	0
Public Combined Heat and Power	409	518	161	148	144	140	207	195	176	153	179	97	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	10	7	0	0	0	0	0	0	0	0	3	0
Auto Producers for CHP	48	14	48	36	36	34	41	43	45	47	40	40	31	11
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	33	0	143	121	750	806	838	676	702	705	818	681
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	143	121	750	806	838	676	702	705	818	681
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	33	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	399	401	391	260	181	177	197	231	192	183	133	187	157	84
Total Transport	3	0	1	0	0	0	0	0	0	0	0	0	0	0
Rail	3	0	1	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

102A Bituminous Coal & Anthracite (hard coal)	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Total Industry	208	252	313	213	171	168	195	226	183	173	123	184	155	83
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	7	45	57	35	20	19	31	28	40	34	5	12	12	14
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	199	164	170	86	56	43	32	20	23	28	30	86	49	27
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	2	43	86	87	94	106	132	178	121	111	88	85	94	42
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	188	149	77	47	10	9	2	5	9	10	10	3	2	0
Commerce - Public Services	11	10	8	9	0	0	0	0	0	0	0	0	0	0
Residential	176	137	69	38	9	9	2	5	8	10	10	3	2	0
Agriculture	1	2	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	2	1	1	1	1	1	2	3	3	3	3	1	2	2

Table A 73: National Energy Balance 1990–2022. Patent Fuel [1000 tons].

104A Patent Fuel (hard coal briquettes)	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	0	0	4	1	13	7	7	4	4	28	2	2	1	2
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	0	0	4	1	13	7	7	4	4	28	2	2	1	2
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	0	0	4	1	13	7	7	4	4	28	2	2	1	2
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0

104A Patent Fuel (hard coal briquettes)	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	26	1	1	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	26	1	1	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	4	1	13	7	7	4	4	2	1	1	1	2
Commerce - Public Services	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	3	1	13	7	7	4	4	2	1	1	1	2
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 74: National Energy Balance 1990–2022. Lignite and Brown Coal [1000 tons].

105A Lignite and brown coal	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	2 448	1 297	1 249	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	36	29	54	113	90	88	94	79	76	80	68	64	59	68
Total Exports (Balance)	3	0	0	0	8	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	23	417	78	1 158	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	2 503	1 743	1 381	1 272	82	88	94	79	76	79	68	64	59	68
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	2 133	1 524	1 230	1 136	0	0	0	0	0	0	0	0	0	0
Public Electricity	1 182	1 081	1 168	1 068	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	881	339	26	48	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	16	9	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	54	95	35	20	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	6	0	2	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	6	0	2	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

105A Lignite and brown coal	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	364	219	149	136	82	88	94	79	76	79	68	63	59	68
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	147	115	105	126	77	86	92	78	74	78	66	61	58	68
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	11	4	39	70	77	86	92	78	74	78	66	61	58	68
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	132	111	66	56	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	217	104	43	10	5	2	2	1	2	1	1	1	1	1
Commerce - Public Services	9	5	3	1	0	0	0	0	0	0	0	0	0	0
Residential	208	99	41	9	5	2	2	1	2	1	1	1	1	1
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Table A 75: National Energy Balance 1990–2022. Brown Coal Briquettes [1000 tons].

106A BKB-PB	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	295	173	95	53	31	17	10	9	14	13	10	10	12	8
Total Exports (Balance)	0	1	0	2	0	1	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	12	1	11	2	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	306	172	107	52	31	17	10	9	13	13	10	10	12	8
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	12	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	7	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0

106A BKB-PB	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	295	172	107	52	31	17	10	9	13	13	10	10	12	8
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	64	14	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	63	14	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	230	158	107	52	31	17	10	9	13	13	10	10	12	8
Commerce - Public Services	8	6	34	17	8	0	0	0	0	0	0	0	0	0
Residential	214	146	70	32	22	16	10	9	13	12	10	10	12	8
Agriculture	8	6	3	4	1	1	0	0	1	1	0	1	1	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 76: National Energy Balance 1990–2022. Coke Oven Coke [1000 tons].

107A Coke Oven Coke	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	1 725	1 448	1 385	1 404	1 381	1 329	1 329	1 352	1 355	1 316	1 316	1 327	1 319	1 271
Total Imports (Balance)	815	718	981	1 402	1 252	1 191	1 004	929	1 167	823	951	816	921	962
Total Exports (Balance)	1	1	1	4	3	0	1	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-136	189	71	-117	-75	1	10	-20	9	-43	91	-48	42	-16
Gross Inland Deliveries (Obs.)	2 402	2 354	2 435	2 684	2 555	2 521	2 343	2 260	2 530	2 095	2 359	2 095	2 281	2 217
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	623	711	909	1 162	1 200	1 195	1 214	1 177	1 276	1 069	1 136	1 084	1 220	1 128
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	623	711	909	1 162	1 200	1 195	1 214	1 177	1 276	1 069	1 136	1 084	1 220	1 128
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	913	1 076	1 076	1 167	1 067	1 049	856	828	972	810	936	716	751	800
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	913	1 076	1 076	1 167	1 067	1 049	856	828	972	810	936	716	751	800
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

107A Coke Oven Coke	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	853	557	436	339	268	252	244	237	230	182	255	264	256	254
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	290	196	247	262	215	218	229	223	218	173	245	255	250	249
Iron and Steel	235	178	207	229	206	208	217	213	209	167	236	247	243	239
Chemical (incl.Petro-Chemical)	14	6	15	9	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	7	3	6	4	4	4	4	5	3	3	4	4	3	5
Non metallic Mineral Products	23	4	10	14	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	5	2	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Food, Beverages and Tobacco	5	2	7	6	5	6	7	5	6	4	4	4	4	6
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	563	361	190	77	53	34	15	15	11	8	11	9	6	4
Commerce - Public Services	13	9	6	4	2	0	0	0	0	0	0	0	0	0
Residential	537	345	180	72	50	33	14	14	11	8	10	9	5	4
Agriculture	12	8	4	2	1	1	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	13	10	14	16	20	25	28	18	52	34	31	30	54	36

Table A 77: National Energy Balance 1990–2022. Peat [1000 tons].

113A Peat	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Total Imports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

113A Peat	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 78: National Energy Balance 1990–2022. Coke Oven Gas [TJ].

304A Coke Oven Gas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	13 117	10 906	10 466	10 854	10 716	10 696	10 337	9 954	10 154	10 321	10 428	10 217	10 250	9 721
Total Imports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	13 117	10 906	10 466	10 854	10 716	10 696	10 337	9 954	10 154	10 321	10 428	10 217	10 250	9 721
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	3 385	6 228	3 592	2 332	2 584	2 592	4 328	3 352	3 367	3 165	2 961	3 290	3 045	2 461
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	3 256	2 127	2 346	2 316	4 013	3 063	3 105	2 953	2 744	3 020	2 773	2 195
Auto Producers for CHP	3 385	6 228	286	205	238	276	315	289	262	213	217	270	272	266
Auto Producer Heat Plants	0	0	50	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	4 136	3 439	3 300	4 944	4 799	5 226	3 515	3 156	3 074	3 920	3 917	4 100	3 272	3 762
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0

304A Coke Oven Gas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	1 072	892	856	316	536	370	382	2 048	1 661	2 342	1 771	2 050	1 358	1 958
Blast Furnaces (Energy)	3 064	2 547	2 444	4 628	4 264	4 856	3 133	1 108	1 414	1 577	2 146	2 050	1 914	1 804
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	5 596	1 239	3 574	3 514	3 266	2 875	2 476	3 439	3 704	3 230	3 540	2 815	3 925	3 488
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	5 596	1 239	3 574	3 514	3 266	2 875	2 476	3 439	3 704	3 230	3 540	2 815	3 925	3 488
Iron and Steel	5 596	1 239	3 574	3 514	3 266	2 875	2 476	3 439	3 704	3 230	3 540	2 815	3 925	3 488
Chemical (incl. Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 79: National Energy Balance 1990–2022. Blast Furnace Gas [TJ].

305A Blast Furnace Gas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	17 094	19 503	25 385	32 220	33 119	32 951	33 626	32 631	35 082	28 633	31 341	29 429	34 082	31 240
Total Imports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	17 094	19 503	25 385	32 220	33 119	32 951	33 626	32 631	35 082	28 633	31 341	29 429	34 082	31 240
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	4 822	6 213	6 014	12 095	14 468	14 233	15 529	14 552	17 051	14 473	15 709	14 540	17 036	15 254
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	5 011	11 292	13 502	12 898	14 584	13 640	15 595	13 580	14 351	12 918	15 311	13 603
Auto Producers for CHP	4 822	6 213	1 003	802	966	1 335	945	912	1 456	893	1 358	1 622	1 725	1 651
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

305A Blast Furnace Gas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Total Energy Sector	9 682	11 685	15 254	16 723	16 002	16 509	15 979	16 049	16 175	12 646	14 203	13 546	15 307	14 525
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	2 391	2 641	3 675	4 169	3 442	3 931	3 378	4 468	4 954	3 964	3 320	2 911	3 460	3 006
Blast Furnaces (Energy)	7 291	9 044	11 579	12 554	12 560	12 577	12 601	11 581	11 222	8 681	10 883	10 634	11 847	11 519
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum refineries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	2 590	1 605	4 117	836	1 262	1 192	1 145	1 089	1 054	783	828	871	1 152	1 003
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	2 590	1 605	4 117	836	1 262	1 192	1 145	1 089	1 054	783	828	871	1 152	1 003
Iron and Steel	2 590	1 605	4 117	836	1 262	1 192	1 145	1 089	1 054	783	828	871	1 152	1 003
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Annex 4.2 – Oil

Table A 80: National Energy Balance 1990–2022. Crude Oil [1000 tons].

201A Crude Oil	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	1 149	1 035	971	855	903	840	854	786	698	670	634	548	550	505
Refinery Losses	254	177	157	36	97	46	139	169	158	116	111	166	157	125
Refinery Intake (Calculated)	7 952	8 619	8 240	8 743	7 719	8 349	8 853	8 184	8 064	8 970	9 124	8 168	8 243	5 617
Refinery Intake (Observed)	7 952	8 619	8 240	8 743	7 719	8 349	8 853	8 184	8 064	8 970	9 124	8 168	8 243	5 617
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	6 797	7 590	7 314	7 833	6 795	7 472	8 079	7 332	7 219	8 333	8 592	7 610	7 567	5 138
Total Exports (Balance)	0	0	61	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	6	-6	16	55	20	37	-80	66	148	-34	-102	10	125	-26
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 81: National Energy Balance 1990–2022. Natural Gas Liquids [1000 tons].

302A Natural Gas Liquids	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	41	43	101	78	134	79	21	6	37	18	16	14	11	11
Refinery Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Refinery Intake (Calculated)	41	43	107	78	134	123	53	6	37	18	16	14	11	11
Refinery Intake (Observed)	41	43	107	78	134	123	53	6	37	18	16	14	11	11
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	0	0	6	0	0	44	31	0	0	0	0	0	0	0
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 82: National Energy Balance 1990–2022. Refinery Feedstocks [1000 tons].

217A Refinery Feedstocks	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Refinery Intake (Calculated)	1 069	582	540	362	325	430	371	531	552	293	501	421	268	658
Refinery Intake (Observed)	1 069	582	540	362	325	430	371	531	552	293	501	421	268	658
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	1 009	600	627	265	218	190	63	204	296	101	224	143	186	428
Total Exports (Balance)	0	39	125	18	2	2	47	39	52	95	64	30	44	40
Stock Change (National Territory)	-26	-28	-10	35	-101	-57	-131	156	-61	-4	118	-25	-55	-45

Table A 83: National Energy Balance 1990–2022. Residual Fuel Oil [1000 tons].

203X; Residual Fuel Oil	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	1 913	1 596	1 075	1 360	934	954	1 154	898	839	710	735	737	645	778
Refinery Fuel	131	233	133	186	143	107	60	42	73	88	76	41	29	147
Total Imports (Balance)	602	532	261	182	173	58	11	16	68	65	44	67	32	38
Total Exports (Balance)	185	38	152	72	244	220	525	576	437	467	455	471	370	266
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-94	-100	247	7	102	1	67	119	71	17	56	24	33	-40
Gross Inland Deliveries (Obs.)	2 155	1 757	1 298	1 237	823	547	397	344	275	188	218	222	244	156
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	725	721	611	506	390	251	243	194	177	140	164	187	203	127
Public Electricity	28	88	109	84	32	2	10	1	11	0	0	2	1	1
Public Combined Heat and Power	253	316	162	174	144	28	37	78	35	1	1	5	3	12
Public Heat Plants	99	70	87	81	35	36	30	30	26	24	10	10	8	4
Auto Producers of Electricity	0	0	5	72	38	1	1	12	8	50	44	64	107	2
Auto Producers for CHP	227	97	15	95	140	184	166	73	97	66	110	105	83	108
Auto Producer Heat Plants	1	1	1	0	2	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	117	149	232	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	421	345	219	83	54	73	88	76	41	29	147
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	235	202	112	23	12	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	1 430	1 036	687	496	231	184	131	138	98	47	53	36	41	29

203X; Residual Fuel Oil	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	517	549	277	263	187	160	110	100	81	39	53	35	40	29
Iron and Steel	19	23	21	15	8	5	2	2	1	1	0	0	1	1
Chemical (incl. Petro-Chemical)	23	27	11	13	30	16	14	15	14	7	5	10	6	5
Non ferrous Metals	4	7	9	6	5	6	5	2	1	0	0	0	0	0
Non metallic Mineral Products	115	135	51	45	39	17	23	21	16	7	19	11	9	4
Transportation Equipment	13	17	4	5	2	3	1	2	1	1	0	0	0	1
Machinery	29	32	30	32	23	33	12	11	9	5	6	3	6	4
Mining and Quarrying	6	7	12	12	4	4	2	2	2	1	1	0	1	0
Food, Beverages and Tobacco	78	89	38	42	31	26	16	13	10	5	5	3	5	5
Pulp, Paper and Printing	126	108	41	39	18	9	9	7	4	3	3	2	2	3
Wood and Wood Products	15	21	9	13	6	6	7	7	6	3	3	1	1	0
Construction	32	22	16	16	4	24	13	13	12	6	8	4	5	6
Textiles and Leather	27	25	12	11	7	5	2	2	1	0	0	0	0	0
Non Specified (Industry)	30	36	23	15	9	6	4	3	3	1	2	1	3	1
Total Other Sectors	913	487	410	233	44	23	22	38	17	8	1	0	1	0
Commerce - Public Services	315	240	118	92	5	11	13	27	15	8	1	0	1	0
Residential	471	194	232	112	30	6	0	0	0	0	0	0	0	0
Agriculture	127	53	60	29	8	6	8	11	2	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 84: National Energy Balance 1990–2022. Heating and Other Gas Oil [1000 tons].

204A Heating and Other Gas Oil	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	1 239	1 454	1 062	997	795	688	642	635	662	581	476	592	387	261
Refinery Fuel	0	0	0	0	0	1	0	0	0	0	4	0	0	0
Total Imports (Balance)	0	165	533	926	725	605	592	580	597	555	599	722	571	644
Total Exports (Balance)	0	0	1	20	14	51	31	12	10	10	13	15	17	7
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	5	39	125	59	12	64	23	-49	-9	20	25	-106	258	153
Gross Inland Deliveries (Obs.)	1 244	1 658	1 719	1 933	1 471	1 206	1 113	1 085	1 152	1 041	1 044	1 061	1 160	1 033
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	2	0	5	4	5	3	1	3	4	3	4	21	28
Public Electricity	0	0	0	1	0	1	1	0	1	1	1	0	1	1
Public Combined Heat and Power	0	2	0	3	1	1	1	0	2	2	2	2	2	1
Public Heat Plants	0	0	0	1	1	1	1	0	0	0	0	0	17	23
Auto Producers of Electricity	0	0	0	0	1	1	0	0	0	0	0	0	0	1
Auto Producers for CHP	0	0	0	0	0	0	1	1	0	0	1	1	1	2
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	1	0	0	0	0	4	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

204A Heating and Other Gas Oil	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	1 244	1 656	1 719	1 928	1 468	1 201	1 109	1 084	1 149	1 038	1 040	1 058	1 139	1 005
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	1	5	38	115	75	79	7	7	7	21	25	25	15	53
Iron and Steel	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Chemical (incl. Petro-Chemical)	0	0	2	2	1	3	0	0	0	3	5	5	2	6
Non ferrous Metals	0	0	2	1	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	1	2	6	6	7	1	2	2	5	6	8	3	5
Transportation Equipment	0	0	0	1	1	1	0	0	0	0	0	0	0	1
Machinery	0	1	5	13	9	18	1	1	1	2	2	2	2	5
Mining and Quarrying	0	0	1	4	1	2	1	1	1	1	1	1	1	1
Food, Beverages and Tobacco	0	1	10	29	26	18	1	1	1	3	3	3	2	19
Pulp, Paper and Printing	0	0	1	2	1	1	0	0	0	1	1	1	1	4
Wood and Wood Products	0	0	1	7	1	3	0	0	0	1	1	1	0	1
Construction	0	1	10	41	23	19	1	1	1	3	3	3	2	8
Textiles and Leather	0	0	1	4	2	3	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	2	6	3	3	0	0	0	1	1	1	1	2
Total Other Sectors	1 243	1 651	1 682	1 813	1 393	1 122	1 103	1 077	1 142	1 017	1 016	1 033	1 124	952
Commerce - Public Services	26	92	264	474	150	126	122	101	159	142	137	132	173	146
Residential	1 216	1 558	1 416	1 337	1 241	996	980	975	982	873	878	900	950	805
Agriculture	1	1	1	1	1	1	1	1	1	3	1	1	1	1
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 85: National Energy Balance 1990–2022. Diesel [1000 tons].

2050 Diesel	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	1 531	1 920	2 662	2 931	2 741	3 318	3 453	3 166	3 319	3 472	3 703	3 202	3 329	1 883
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	576	937	2 075	4 129	4 428	3 814	3 949	4 477	4 511	4 509	4 577	4 201	4 256	4 779
Total Exports (Balance)	3	83	415	889	858	961	861	829	954	998	1 064	1 003	1 246	636
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-7	112	-59	89	46	-81	-42	-67	70	5	-185	-154	156	90
Gross Inland Deliveries (Obs.)	2 097	2 886	4 263	6 260	6 228	6 090	6 499	6 748	6 945	6 989	7 030	6 245	6 494	6 116
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	8	1	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	6	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

2050 Diesel	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Total Energy Sector	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	2 096	2 877	4 262	6 260	6 228	6 090	6 499	6 748	6 945	6 989	7 030	6 245	6 494	6 116
Total Transport	1 766	2 507	3 830	5 658	5 644	5 513	6 024	6 303	6 473	6 510	6 552	5 801	6 038	5 607
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	1 691	2 436	3 757	5 568	5 556	5 434	5 958	6 234	6 400	6 442	6 479	5 753	5 979	5 540
Rail	54	45	42	52	52	45	32	32	35	33	33	29	29	29
Inland Waterways	20	26	31	38	36	34	34	36	38	36	40	19	29	38
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	81	113	172	338	316	329	212	190	214	222	223	198	206	260
Iron and Steel	0	0	0	0	0	0	1	1	1	1	1	0	1	8
Chemical (incl. Petro-Chemical)	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	1	1	1	1	4	4	4	4	4	4	4	1
Transportation Equipment	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Machinery	0	0	0	0	0	0	7	6	6	7	7	6	6	2
Mining and Quarrying	2	2	3	4	4	4	4	4	5	5	5	4	4	18
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	1	1	1	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	1	1	1	1	1	6	3	3	3	3	3	3	3
Construction	77	108	165	331	308	321	189	171	194	201	203	180	187	227
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	250	257	260	264	268	248	263	256	258	256	254	246	250	249
Commerce - Public Services	9	13	19	27	35	16	32	26	30	30	30	30	30	30
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	241	245	241	237	233	231	231	230	228	226	225	216	220	219
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 86: National Energy Balance 1990–2022. Other Kerosene [1000 tons].

206A Other Kerosene	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Refinery Gross Output	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Fuel	31	8	1	1	3	16	28	21	15	26	15	13	9	27
Total Imports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Exports (Balance)	14	4	5	3	1	1	1	0	1	1	1	0	1	1
International Marine Bunkers	21	6	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	-7	0	0	0	0	0	0	0	0	0	0	0	0	0
Statistical Difference	17	6	6	3	2	1	1	1	1	1	1	1	1	1
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

206A Other Kerosene	1990	1995	2000	2005	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transport	17	6	6	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	17	6	6	0	0	0	0	0	0	0	0	0	0	0
Residential	17	6	6	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 87: National Energy Balance 1990–2022. Kerosene Type Jet Fuel [1000 tons].

206B Kerosene Type Jet Fuel	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	291	420	544	592	476	616	648	651	613	760	893	362	344	404
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	13	23	35	85	193	92	109	137	144	83	50	53	39	217
Total Exports (Balance)	5	0	5	2	6	24	37	24	29	19	29	9	5	2
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	4	-5	-22	12	2	-17	1	11	7	37	-56	26	-10
Gross Inland Deliveries (Obs.)	299	447	569	653	675	687	703	765	739	831	951	322	404	610
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0

206B Kerosene Type Jet Fuel	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	299	447	569	653	675	687	703	765	739	831	951	322	404	610
Total Transport	299	447	569	653	675	687	703	765	739	831	951	322	404	610
International Civil Aviation	281	421	537	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	18	26	32	653	675	687	703	765	739	831	951	322	404	610
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl.Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 88: National Energy Balance 1990–2022. Gasoline Type Jet Fuel [1000 tons].

207A Gasoline Type Jet Fuel	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	3	4	3	6	4	3	4	3	4	1	2	1	1	1
Total Exports (Balance)	0	0	1	3	2	1	1	1	1	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	-2	0	0	0	1	0	1	-1	1	0	0	0	0

207A Gasoline Type Jet Fuel	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Gross Inland Deliveries (Obs.)	3	2	2	3	3	3	3	3	2	2	2	2	2	2
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	3	2	2	3	3	3	3	3	2	2	2	2	2	2
Total Transport	3	2	2	3	3	3	3	3	2	2	2	2	2	2
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	3	2	2	3	3	3	3	3	2	2	2	2	2	2
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 89: National Energy Balance 1990–2022. Motor Gasoline [1000 tons].

2080 Motor Gasoline	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	2 631	2 276	1 815	1 798	1 589	1 636	1 812	1 759	1 782	2 030	2 075	1 805	1 870	1 389
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	271	710	680	1 107	873	903	844	822	771	730	671	566	570	821
Total Exports (Balance)	281	596	473	770	665	778	976	875	865	1 060	978	984	996	606
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-53	18	-32	-14	106	28	29	-36	-13	49	-56	48	42	-61
Gross Inland Deliveries (Obs.)	2 567	2 409	1 990	2 121	1 872	1 732	1 661	1 659	1 639	1 678	1 669	1 396	1 463	1 520
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	2 549	2 399	1 985	2 117	1 869	1 729	1 659	1 657	1 637	1 676	1 667	1 394	1 461	1 518
Total Transport	2 546	2 393	1 979	2 109	1 859	1 719	1 652	1 650	1 631	1 670	1 661	1 388	1 454	1 511
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	3	3	2	3	3	3	3	3	2	2	2	2	2	2
Road	2 540	2 387	1 974	2 103	1 854	1 714	1 647	1 644	1 627	1 665	1 656	1 383	1 450	1 507
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	3	3	3	3	2	2	2	2	2	2	2	2	2	2
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	2	1	2	3	5	5	1	2	2	3	3	2	2	2
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	1	1	1	0	0	0	0	0	0	1	1	1	1	2
Machinery	0	0	0	0	0	0	0	1	1	1	1	1	1	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	1	3	5	5	1	1	1	1	1	1	1	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	2	5	4	4	5	5	6	5	4	4	4	4	5	5
Commerce - Public Services	0	0	0	0	1	1	1	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	2	4	4	4	4	4	4	5	4	4	4	4	5	5
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

2080 Motor Gasoline	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Total Non-Energy Use	18	10	4	4	3	3	2	3	2	2	2	2	2	2

Table A 90: National Energy Balance 1990–2022. Lubricants [1000 tons].

219A Lubricants	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	31	73	111	111	96	56	0	0	0	0	0	0	0	0
Refinery Fuel	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	177	51	57	53	45	48	73	110	141	144	121	97	93	92
Total Exports (Balance)	32	41	58	85	71	45	37	69	96	109	86	65	45	30
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-12	4	-1	1	2	1	0	0	0	0	-1	-1	0	2
Gross Inland Deliveries (Obs.)	164	86	109	80	72	59	36	41	45	34	34	31	48	64
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	18	9	12	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	5	3	4	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	2	1	1	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	9	5	6	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	146	77	97	0	0	0	0	0	0	0	0	0	0	0
Total Transport	67	35	44	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	66	34	43	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Total Industry	76	40	51	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	15	9	9	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	6	3	4	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	2	1	2	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	10	5	7	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	2	1	1	0	0	0	0	0	0	0	0	0	0	0
Machinery	3	2	2	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	3	2	2	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	10	5	7	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	8	4	5	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	3	1	2	0	0	0	0	0	0	0	0	0	0	0
Construction	2	1	1	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	4	2	3	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	8	4	6	0	0	0	0	0	0	0	0	0	0	0

219A Lubricants	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Total Other Sectors	3	2	2	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	3	2	2	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	164	86	109	80	72	59	36	41	45	34	34	31	48	64

Table A 91: National Energy Balance 1990–2022. White Spirit [1000 tons].

220A White Spirit	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	0	5	0	0	70	0	0	0	0	0	0	0	0	0
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	11	8	7	11	12	15	19	19	19	18	18	16	17	15
Total Exports (Balance)	0	0	0	0	65	0	1	1	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	-1	0	0	-3	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	11	12	7	12	15	15	18	18	18	18	17	16	17	15
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	11	12	7	7	12	11	16	16	16	16	15	13	15	13
Total Transport	0	1	1	4	7	6	13	13	14	13	13	11	12	11
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	4	7	6	13	13	14	13	13	11	12	11
Rail	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	11	11	6	3	5	5	1	2	2	3	3	2	2	2
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	11	10	4	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	1	1	0	0	0	0	0	0	1	1	1	1	2
Machinery	0	0	0	0	0	0	0	1	1	1	1	1	1	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0

220A White Spirit	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	1	3	5	5	1	1	1	1	1	1	1	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	1	1	1	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	1	1	1	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	11	11	5	4	3	3	2	3	2	2	2	2	2	2

Table A 92: National Energy Balance 1990–2022. Bitumen [1000 tons].

222A Bitumen	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	269	254	343	366	292	366	290	333	306	369	395	424	440	236
Refinery Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	284	187	292	335	346	270	271	278	289	313	304	290	262	284
Total Exports (Balance)	1	5	45	147	182	205	131	145	144	187	201	239	240	135
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-12	4	-3	0	10	0	3	0	-4	0	0	-28	-2	0
Gross Inland Deliveries (Obs.)	540	440	587	555	465	431	434	467	447	495	498	448	460	384
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	540	440	587	0	0	0	0	0	0	0	0	0	0	0
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	540	440	587	0	0	0	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0

222A Bitumen	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	540	440	587	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	540	440	587	555	465	431	434	467	447	495	498	448	460	384

Table A 93: National Energy Balance 1990–2022. Other Oil Products [1000 tons].

224A Other Oil Products	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	7	29	15	87	172	61	19	26	27	21	23	45	46	26
Refinery Fuel	70	0	0	6	8	0	0	0	0	0	0	0	0	0
Total Imports (Balance)	182	29	149	54	33	5	45	50	41	46	41	13	17	15
Total Exports (Balance)	3	39	139	96	144	10	3	3	1	6	1	1	1	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	-31	36	-8	-5	-12	0	-1	2	-2	0	-1	3	-2	-4
Gross Inland Deliveries (Obs.)	35	15	18	35	40	55	60	74	66	62	62	60	60	37
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	22	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	22	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	6	8	0	0	0	0	0	0	0	0	0
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	0	0	0	4	11	12	3	3	3	2	3	2	2	2
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0

224A Other Oil Products	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	0	4	11	12	3	3	3	2	3	2	2	2
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	0	0	0	4	11	12	3	3	3	2	3	2	2	2
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	13	15	18	31	29	44	57	71	63	60	59	58	58	35

Table A 94: National Energy Balance 1990–2022. LPG [1000 tons].

303A LPG	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	47	60	34	107	87	67	139	122	102	111	137	117	150	106
Refinery Fuel	0	0	20	49	28	4	16	25	21	6	18	5	17	57
Total Imports (Balance)	97	149	159	133	114	81	54	53	62	62	61	64	64	96
Total Exports (Balance)	14	42	17	20	11	22	83	68	62	86	89	92	110	64
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	2	20	-5	0	-1	1	-3	-2	3	1	-9	-5	-4	13
Gross Inland Deliveries (Obs.)	133	186	150	171	161	123	91	80	83	83	81	80	82	94
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	1	3	0	0	0	0	0	0	0	0	0	0	0	0
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	1	3	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers for CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	8	19	20	49	28	4	16	25	21	6	18	5	17	57
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	124	163	150	171	161	92	66	64	75	69	67	65	69	73
Total Transport	9	11	15	20	19	20	12	11	11	7	5	3	2	2
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0

303A LPG	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	9	11	15	20	19	20	12	11	11	7	5	3	2	2
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	65	62	55	34	45	42	24	24	26	26	25	25	26	39
Iron and Steel	4	3	1	0	0	0	0	0	0	0	0	0	0	9
Chemical (incl. Petro-Chemical)	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Non ferrous Metals	8	6	4	4	1	1	1	0	0	2	2	3	3	3
Non metallic Mineral Products	12	23	15	3	9	9	2	2	2	2	1	1	1	1
Transportation Equipment	1	3	1	2	1	1	1	1	1	1	1	1	1	1
Machinery	11	13	14	10	12	10	9	10	11	11	10	9	10	11
Mining and Quarrying	1	1	1	1	1	1	2	2	2	1	2	2	1	1
Food, Beverages and Tobacco	3	3	4	5	7	6	4	4	4	4	3	4	4	5
Pulp, Paper and Printing	1	1	2	1	1	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	1	1	2	2	2	1	1	1	1	1	1	1
Construction	23	9	13	6	9	10	4	4	3	4	3	4	5	7
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	1	0	0	1	1	0	0	0	0	1	0	0	0
Total Other Sectors	50	90	80	117	97	31	30	29	39	36	37	37	40	32
Commerce - Public Services	32	61	24	69	60	4	3	3	7	6	7	7	8	6
Residential	16	26	51	43	33	25	24	24	29	27	27	28	29	24
Agriculture	2	3	5	4	3	3	2	2	3	3	3	3	3	2
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	31	25	16	8	14	15	15	13	21

Table A 95: National Energy Balance 1990–2022. Refinery Gas [1000 tons].

308A Refinery Gas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Refinery Gross Output	373	305	312	309	392	311	282	218	262	281	316	284	296	389
Refinery Fuel	373	305	310	277	356	286	250	94	110	108	277	245	191	349
Total Imports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Exports (Balance)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Marine Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Change (National Territory)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Inland Deliveries (Obs.)	0	0	2	32	35	25	32	124	152	173	39	39	105	40
Statistical Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transformation Sector	0	0	0	30	31	22	31	124	152	173	39	39	105	40
Public Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Combined Heat and Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Producers of Electricity	0	0	0	0	0	0	0	17	10	72	11	15	62	0
Auto Producers for CHP	0	0	0	30	31	22	31	108	142	101	28	24	43	40
Auto Producer Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrochemical Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patent Fuel Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transformation)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Sector	0	0	0	277	356	286	250	94	110	108	277	245	191	349
Coal Mines	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Consumption	0	0	2	2	4	3	0	0	0	0	0	0	0	0

308A Refinery Gas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Civil Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inland Waterways	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Transport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Industry	0	0	2	2	4	3	0	0	0	0	0	0	0	0
Iron and Steel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical (incl. Petro-Chemical)	0	0	2	2	4	3	0	0	0	0	0	0	0	0
Non ferrous Metals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non metallic Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food, Beverages and Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulp, Paper and Printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and Wood Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles and Leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Industry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce - Public Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non Specified (Others)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Annex 4.3 – Natural Gas

Table A 96: National Energy Balance 1990–2022. Natural Gas [PJ NCV].

301A Natural Gas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	46.4	53.3	64.8	55.7	58.5	61.9	43.4	40.8	43.7	36.0	32.2	26.5	23.7	22.4
Total Imports (Balance)	187.9	229.1	222.8	299.4	256.0	267.8	210.0	260.5	293.7	271.8	394.8	224.9	165.1	430.1
Total Exports (Balance)	0.0	0.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock Change (National Territory)	-15.1	-12.3	-11.3	-16.6	25.6	-23.0	35.8	2.0	-11.8	0.5	-105.7	55.1	134.8	-164.1
Gross Inland Deliveries (Obs.)	219.2	269.6	275.8	338.5	340.1	306.7	289.2	303.2	325.6	308.3	321.4	306.4	323.7	288.5
Statistical Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Transformation Sector	74.7	95.8	83.3	115.2	113.7	89.1	75.2	82.5	102.4	91.2	96.2	87.4	93.7	89.6
Public Electricity	28.1	21.7	25.4	46.7	35.2	14.1	16.0	15.9	38.6	25.8	31.7	22.1	14.8	26.4
Public Combined Heat and Power	23.8	30.8	27.7	39.2	48.9	48.1	37.9	45.2	41.7	43.9	45.3	46.6	57.1	48.1
Public Heat Plants	7.6	9.6	9.2	9.1	10.2	12.0	11.3	11.1	12.1	9.1	7.6	7.1	8.8	6.2
Auto Producers of Electricity	9.6	21.2	12.0	9.0	7.5	5.0	2.7	2.9	2.8	5.5	4.6	4.8	5.5	2.2
Auto Producers for CHP	5.7	12.5	8.6	10.6	11.9	9.7	6.9	6.9	7.2	6.5	6.9	6.7	7.5	6.6
Auto Producer Heat Plants	0.0	0.0	0.4	0.6	0.1	0.2	0.4	0.5	0.1	0.4	0.1	0.1	0.1	0.0
Gas Works (Transformation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coke Ovens (Transformation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blast Furnaces (Transformation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conversion to Liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non Specified (Transformation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Energy Sector	15.8	18.8	11.9	14.7	12.0	13.7	9.0	8.4	8.8	10.4	10.5	9.0	10.2	7.9
Coal Mines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oil and Gas Extraction	6.6	10.8	4.3	6.8	3.8	3.2	3.6	3.4	3.1	2.9	2.6	2.5	2.9	3.4
Inputs to Oil Refineries	6.8	7.6	6.5	5.5	5.8	4.6	3.6	3.4	3.8	4.7	5.2	4.8	5.2	3.0
Coke Ovens (Energy)	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.2	0.2	0.2
Blast furnace (Energy)	0.0	0.0	0.8	2.0	2.1	5.6	1.6	1.3	1.5	2.2	2.0	1.3	1.5	1.1

301A Natural Gas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Gas Works (Energy)	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Power Plants	0.0	0.0	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2
Non Specified (Energy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Distribution Losses	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Final Consumption	113.5	144.2	167.3	195.4	198.5	190.6	191.0	198.0	200.4	194.9	199.7	195.8	206.0	178.6
Total Transport	4.1	4.1	6.1	6.5	8.7	8.8	11.3	10.9	12.2	11.3	10.5	9.3	7.5	3.5
Road	0.0	0.0	0.0	0.0	0.5	0.5	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8
Pipeline Transport	4.1	4.1	6.1	6.5	8.3	8.3	10.6	10.1	11.5	10.6	9.7	8.5	6.7	2.7
Non Specified (Transport)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Industry	69.0	73.5	88.3	99.2	106.3	105.4	107.0	109.3	110.7	112.2	113.5	111.0	115.3	107.1
Iron and Steel	10.5	11.2	13.5	14.1	14.6	16.1	17.7	17.0	17.6	17.7	17.6	17.2	15.7	16.6
Chemical (incl.Petro-Chemical)	7.7	8.3	14.4	16.0	16.5	16.8	16.7	18.6	19.1	18.4	19.5	18.8	20.5	16.5
Non ferrous Metals	1.4	2.2	2.3	3.1	3.8	3.9	4.5	4.9	4.8	5.6	5.0	4.4	5.0	5.0
Non metallic Mineral Products	10.1	11.1	11.6	14.0	13.5	12.9	14.3	14.9	15.3	15.1	15.0	16.4	18.7	16.2
Transportation Equipment	1.5	2.6	1.3	2.2	1.9	2.0	1.3	1.5	1.7	1.8	1.6	1.7	1.8	1.9
Machinery	4.3	6.1	4.8	6.5	8.8	9.0	6.1	6.3	6.0	6.2	6.2	6.0	6.6	6.2
Mining and Quarrying	2.6	2.5	2.3	2.8	2.0	2.0	5.6	6.2	7.2	6.7	6.0	5.9	4.1	2.6
Food, Beverages and Tobacco	8.9	9.4	11.4	11.5	12.4	12.8	13.3	12.4	12.1	11.9	12.1	12.8	13.1	13.6
Pulp, Paper and Printing	12.9	9.8	19.5	20.3	24.2	21.8	20.9	20.5	20.1	21.8	23.8	21.7	22.9	20.5
Wood and Wood Products	1.7	2.0	1.7	3.3	2.9	2.7	2.4	2.3	2.5	2.6	2.3	2.1	2.5	2.3
Construction	0.7	1.5	1.4	1.6	1.8	1.8	1.2	1.3	1.2	1.4	1.3	1.2	1.1	2.5
Textiles and Leather	3.5	3.4	2.9	2.1	1.8	1.7	1.4	1.7	1.4	1.4	1.6	1.4	1.6	1.4
Non Specified (Industry)	3.1	3.4	1.2	1.6	2.0	1.9	1.6	1.6	1.7	1.6	1.6	1.5	1.8	1.8
Total Other Sectors	40.4	66.6	72.9	89.6	83.5	76.5	72.6	77.8	77.5	71.4	75.8	75.5	83.2	68.0
Commerce - Public Services	6.5	21.9	23.4	23.2	17.2	16.8	15.2	14.3	15.0	14.2	15.2	14.5	16.0	12.6
Residential	33.5	44.3	48.9	65.7	65.5	59.2	56.8	62.8	61.5	56.3	59.5	60.0	66.1	54.5
Agriculture	0.4	0.5	0.5	0.8	0.8	0.5	0.6	0.7	1.0	0.9	1.1	0.9	1.0	0.8
Non Specified (Others)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Non-Energy Use	14.9	10.5	13.3	13.2	15.8	13.2	13.9	14.3	13.8	11.6	14.9	14.2	13.8	12.3

Annex 4.4 – Renewable Fuels

Table A 97: National Energy Balance 1990–2022. Fuel Wood [PJ].

111A Fuel Wood	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	61.40	65.76	58.63	56.30	63.02	58.81	52.35	55.54	56.73	50.06	52.71	55.23	65.99	52.08
Total Imports (Balance)	2.30	1.62	1.80	3.50	7.87	9.41	8.55	6.83	5.76	7.01	5.07	2.55	2.20	2.34
Total Exports (Balance)	0.04	0.22	0.18	0.84	0.98	0.74	0.17	0.15	0.18	0.27	0.23	0.14	0.17	0.15
Stock Change (National Territory)	-0.55	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Deliveries (Obs.)	63.12	67.35	60.25	58.95	69.91	67.49	60.73	62.22	62.31	56.80	57.54	57.64	68.03	54.27
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	0.00	0.00	0.08	0.13	0.13	0.15	0.14	0.14	0.09	0.10	0.10	0.10	0.10	0.08
Public Electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Combined Heat and Power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Heat Plants	0.00	0.00	0.00	0.04	0.04	0.04	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producers of Electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producers for CHP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producer Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-

111A Fuel Wood	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	63.12	67.35	60.17	58.82	69.78	67.34	60.59	62.08	62.22	56.71	57.44	57.54	67.92	54.19
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	0.66	1.07	0.95	1.14	0.65	0.58	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical (incl.Petro-Chemical)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non metallic Mineral Products	0.05	0.06	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.05	0.06	0.03	0.06	0.10	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.12	0.09	0.02	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pulp, Paper and Printing	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Wood Products	0.23	0.30	0.71	0.36	0.37	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Construction	0.00	0.29	0.11	0.27	0.09	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles and Leather	0.02	0.02	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Industry)	0.19	0.25	0.08	0.36	0.02	0.02	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Total Other Sectors	62.46	66.28	59.22	57.69	69.13	66.76	60.59	62.07	62.21	56.69	57.43	57.52	67.92	54.19
Commerce - Public Services	1.33	1.17	0.34	0.59	0.60	0.18	0.10	0.09	0.21	0.19	0.21	0.21	0.24	0.19
Residential	57.50	61.25	55.38	53.04	64.46	62.64	56.91	58.30	58.32	53.15	53.82	53.92	63.67	50.80
Agriculture	3.63	3.86	3.49	4.06	4.06	3.95	3.59	3.68	3.68	3.35	3.40	3.40	4.01	3.20
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 98: National Energy Balance 1990-2022. Wood Waste [PJ].

116A Wood waste and other biomass	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	14.34	19.78	35.70	61.63	101.12	111.22	109.68	108.00	113.23	109.52	109.23	112.65	121.46	121.67
Total Imports (Balance)	2.14	2.49	3.14	7.41	12.83	10.82	8.47	8.31	8.80	7.98	7.35	8.14	8.80	6.92
Total Exports (Balance)	2.08	2.62	6.51	13.84	12.95	11.46	10.29	11.15	12.38	14.09	14.72	15.08	15.54	13.03
Stock Change (National Territory)	0.00	0.00	0.00	0.00	1.16	0.67	0.31	0.25	-0.33	0.04	0.34	-1.24	1.20	-0.73
Gross Inland Deliveries (Obs.)	14.41	19.65	32.34	55.20	102.16	111.25	108.18	105.41	109.32	103.45	102.19	104.47	115.92	114.83
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	3.19	10.12	12.50	20.71	58.00	64.62	59.90	58.02	60.43	59.39	56.81	59.49	61.96	60.83
Public Electricity	0.00	0.00	0.01	2.86	10.86	11.07	9.15	7.24	7.18	6.67	4.71	5.24	3.96	5.69
Public Combined Heat and Power	0.00	0.00	0.35	4.10	17.27	20.43	18.06	16.25	17.51	17.62	17.96	16.97	17.56	17.71
Public Heat Plants	1.63	3.98	7.59	9.81	21.92	21.83	23.96	25.38	26.91	26.42	25.95	28.88	31.86	29.00
Auto Producers of Electricity	0.00	0.19	1.51	1.32	2.99	5.30	2.16	1.38	1.42	2.53	2.68	2.79	2.56	2.08
Auto Producers for CHP	1.56	5.95	2.96	2.60	4.88	5.95	6.52	7.68	7.29	6.06	5.43	5.55	5.93	6.25
Auto Producer Heat Plants	0.00	0.00	0.08	0.02	0.08	0.04	0.06	0.09	0.11	0.09	0.08	0.07	0.10	0.10
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	11.22	9.53	19.84	34.49	44.16	46.64	48.28	47.39	48.89	44.06	45.21	44.81	53.76	53.84
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

116A Wood waste and other biomass	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	9.43	6.90	11.62	25.52	28.61	29.55	27.39	26.39	26.13	22.29	22.82	22.25	24.30	30.18
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.07
Chemical (incl.Petro-Chemical)	2.90	1.72	2.52	1.61	2.15	2.20	1.48	1.65	1.87	1.89	2.43	1.89	2.04	2.55
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.02	0.03	0.00	0.04	0.04	0.05
Non metallic Mineral Products	0.00	0.00	0.00	2.06	3.47	3.85	4.28	3.93	3.56	2.30	2.13	2.19	2.65	3.76
Transportation Equipment	0.00	0.00	0.00	0.01	0.02	0.06	0.04	0.03	0.03	0.04	0.04	0.07	0.09	0.08
Machinery	0.00	0.00	0.05	0.31	1.37	1.21	0.26	0.25	0.26	0.30	0.24	0.26	0.34	0.43
Mining and Quarrying	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.01	0.01	0.21	0.31	0.47	0.43	0.16	0.28	0.26	0.35	0.32	0.30	0.18	0.61
Pulp, Paper and Printing	3.66	3.90	1.95	7.06	4.55	4.47	3.86	4.87	4.89	4.68	6.01	5.32	5.73	7.35
Wood and Wood Products	2.76	1.16	6.00	13.85	13.21	14.41	16.82	14.81	14.61	12.09	11.13	11.58	12.69	14.53
Construction	0.04	0.03	0.36	0.16	1.35	1.24	0.15	0.23	0.27	0.24	0.21	0.26	0.29	0.44
Textiles and Leather	0.00	0.00	0.00	0.00	0.03	0.03	0.01	0.02	0.00	0.01	0.00	0.01	0.02	0.04
Non Specified (Industry)	0.07	0.07	0.52	0.15	1.96	1.61	0.30	0.30	0.34	0.35	0.30	0.31	0.21	0.26
Total Other Sectors	1.79	2.63	8.22	8.97	15.55	17.09	20.89	21.00	22.76	21.77	22.39	22.55	29.46	23.66
Commerce - Public Services	0.64	0.60	2.27	1.67	2.55	1.46	2.20	1.63	2.77	2.89	3.21	3.10	3.58	2.76
Residential	0.77	1.40	4.50	5.61	10.69	12.93	15.39	16.00	16.30	15.55	16.37	16.59	22.43	18.02
Agriculture	0.38	0.63	1.46	1.69	2.30	2.69	3.29	3.37	3.69	3.33	2.80	2.86	3.45	2.87
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 99: National Energy Balance 1990–2022. Black Liquor [PJ].

215A Black Liquor	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	17.8	21.4	24.1	26.6	28.5	30.1	28.4	32.8	32.7	33.7	33.6	33.2	34.4	33.4
Total Imports (Balance)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Exports (Balance)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock Change (National Territory)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gross Inland Deliveries (Obs.)	17.8	21.4	24.1	26.6	28.5	30.1	28.4	32.8	32.7	33.7	33.6	33.2	34.4	33.4
Statistical Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Transformation Sector	5.3	9.3	7.6	8.8	7.3	9.8	8.5	8.1	7.9	8.3	8.5	9.4	8.6	8.5
Public Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Public Combined Heat and Power	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Public Heat Plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Auto Producers of Electricity	2.6	5.3	2.0	2.4	0.4	1.9	1.7	0.4	0.0	0.0	0.1	0.5	0.3	0.4
Auto Producers for CHP	2.6	4.0	5.6	6.4	6.8	7.9	6.7	7.8	7.9	8.2	8.4	8.9	8.3	8.1
Auto Producer Heat Plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Energy Sector	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal Mines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Patent Fuel Plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coke Ovens (Energy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blast Furnaces (Energy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gas Works (Energy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Power Plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non Specified (Energy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Distribution Losses	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Final Consumption	12.5	12.1	16.4	17.9	21.3	20.3	19.9	24.6	24.8	25.4	25.1	23.8	25.8	25.0
Total Transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inland Waterways	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non Specified (Transport)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Industry	12.5	12.1	16.4	17.9	21.3	20.3	19.9	24.6	24.8	25.4	25.1	23.8	25.8	25.0
Iron and Steel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemical (incl.Petro-Chemical)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

215A Black Liquor	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Non ferrous Metals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non metallic Mineral Products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Transportation Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Machinery	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mining and Quarrying	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Food, Beverages and Tobacco	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pulp, Paper and Printing	12.5	12.1	16.4	17.9	21.3	20.3	19.9	24.6	24.8	25.4	25.1	23.8	25.8	25.0
Wood and Wood Products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Textiles and Leather	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non Specified (Industry)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Sectors	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Commerce - Public Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non Specified (Others)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A 100: National Energy Balance 1990–2022. Biogas [PJ].

309A Biogas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	0.00	0.04	0.36	3.42	5.39	7.10	10.61	10.65	11.20	8.38	7.52	7.65	5.20	5.89
Total Imports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock Change (National Territory)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Deliveries (Obs.)	0.00	0.04	0.36	3.42	5.39	7.10	10.61	10.65	11.20	8.38	7.52	7.65	5.20	5.89
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	0.00	0.04	0.22	3.16	4.97	6.52	10.28	10.24	10.69	7.81	6.98	7.18	4.74	5.43
Public Electricity	0.00	0.00	0.00	2.65	4.36	5.94	9.77	9.50	10.18	7.17	6.47	6.58	4.26	4.21
Public Combined Heat and Power	0.00	0.00	0.00	0.20	0.33	0.28	0.10	0.27	0.16	0.15	0.14	0.12	0.14	0.16
Public Heat Plants	0.00	0.00	0.00	0.00	0.08	0.09	0.07	0.08	0.06	0.06	0.03	0.03	0.06	0.04
Auto Producers of Electricity	0.00	0.00	0.12	0.14	0.06	0.05	0.15	0.17	0.05	0.05	0.18	0.21	0.10	0.86
Auto Producers for CHP	0.00	0.04	0.10	0.18	0.13	0.16	0.18	0.22	0.24	0.38	0.16	0.24	0.17	0.15
Auto Producer Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	0.00	0.00	0.15	0.25	0.42	0.57	0.33	0.41	0.50	0.57	0.54	0.46	0.46	0.46
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
Total Industry	0.00	0.00	0.15	0.25	0.40	0.47	0.19	0.22	0.22	0.26	0.27	0.21	0.19	0.19
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.02	0.05	0.02	0.01	0.01	0.01
Chemical (incl. Petro-Chemical)	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.04	0.04	0.03	0.08	0.05	0.05	0.04
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Non metallic Mineral Products	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Transportation Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.01	0.02	0.01	0.01	0.01
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.00
Food, Beverages and Tobacco	0.00	0.00	0.00	0.01	0.02	0.04	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.04

309A Biogas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Pulp, Paper and Printing	0.00	0.00	0.12	0.24	0.34	0.33	0.04	0.04	0.04	0.06	0.05	0.04	0.03	0.03
Wood and Wood Products	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles and Leather	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Industry)	0.00	0.00	0.00	0.00	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total Other Sectors	0.00	0.00	0.00	0.00	0.02	0.10	0.12	0.18	0.27	0.29	0.26	0.24	0.25	0.25
Commerce - Public Services	0.00	0.00	0.00	0.00	0.02	0.08	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.01
Residential	0.00	0.00	0.00	0.00	0.01	0.03	0.10	0.15	0.25	0.27	0.23	0.21	0.23	0.23
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 101: National Energy Balance 1990–2022. Sewage Sludge Gas [PJ].

309B Sewage sludge gas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	0.00	0.62	0.47	1.17	1.08	1.18	1.54	1.71	1.72	1.05	1.41	1.09	1.47	1.73
Total Imports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock Change (National Territory)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Deliveries (Obs.)	0.00	0.62	0.47	1.17	1.08	1.18	1.54	1.71	1.72	1.05	1.41	1.09	1.47	1.73
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	0.00	0.62	0.11	0.75	0.59	0.40	0.20	0.37	0.29	0.27	0.41	0.37	0.41	0.44
Public Electricity	0.00	0.01	0.08	0.65	0.28	0.17	0.06	0.23	0.15	0.16	0.11	0.04	0.05	0.07
Public Combined Heat and Power	0.00	0.00	0.00	0.04	0.04	0.06	0.05	0.04	0.03	0.02	0.03	0.04	0.04	0.04
Public Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producers of Electricity	0.00	0.00	0.03	0.01	0.22	0.13	0.07	0.08	0.09	0.05	0.10	0.13	0.14	0.13
Auto Producers for CHP	0.00	0.61	0.00	0.05	0.05	0.05	0.02	0.02	0.01	0.03	0.17	0.16	0.19	0.19
Auto Producer Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	0.00	0.00	0.36	0.41	0.49	0.78	1.34	1.34	1.43	0.78	1.00	0.72	1.06	1.29
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	0.00	0.00	0.36	0.41	0.49	0.78	1.34	1.34	1.43	0.78	1.00	0.72	1.06	1.29
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical (incl. Petro-Chemical)	0.00	0.00	0.36	0.29	0.34	0.36	0.49	0.51	0.72	0.26	0.34	0.25	0.51	0.46
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non metallic Mineral Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.00	0.00	0.00	0.10	0.09	0.34	0.37	0.24	0.12	0.11	0.08	0.11	0.10	0.13
Pulp, Paper and Printing	0.00	0.00	0.00	0.02	0.07	0.07	0.48	0.59	0.59	0.41	0.58	0.35	0.45	0.70
Wood and Wood Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles and Leather	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Industry)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Other Sectors	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

309B Sewage sludge gas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Commerce - Public Services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 102: National Energy Balance 1990–2022. Landfill Gas [PJ].

310A Landfill Gas	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	0.00	0.20	0.44	0.38	0.19	0.16	0.19	0.16	0.10	0.08	0.05	0.05	0.07	0.09
Total Imports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock Change (National Territory)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Deliveries (Obs.)	0.00	0.20	0.44	0.38	0.19	0.16	0.19	0.16	0.10	0.08	0.05	0.05	0.07	0.09
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	0.00	0.15	0.44	0.23	0.19	0.16	0.19	0.16	0.10	0.08	0.05	0.05	0.07	0.09
Public Electricity	0.00	0.00	0.01	0.04	0.12	0.10	0.09	0.04	0.04	0.03	0.03	0.03	0.05	0.06
Public Combined Heat and Power	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producers of Electricity	0.00	0.12	0.43	0.19	0.07	0.06	0.09	0.11	0.07	0.05	0.02	0.01	0.02	0.03
Auto Producers for CHP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producer Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	0.00	0.05	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical (incl. Petro-Chemical)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non metallic Mineral Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pulp, Paper and Printing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Wood Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Construction	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles and Leather	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Industry)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Other Sectors	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commerce - Public Services	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 103: National Energy Balance 1990–2022. Municipal Solid Waste [PJ].

114B Municipal Solid Waste	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	2.41	3.91	4.64	8.88	14.38	15.55	19.35	21.17	18.62	19.44	19.80	21.58	21.54	21.05
Total Imports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.00	0.00	0.00	0.00	0.00
Total Exports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock Change (National Territory)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Deliveries (Obs.)	2.41	3.91	4.64	8.88	14.38	15.55	19.35	21.17	19.85	19.44	19.80	21.58	21.54	21.05
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	2.41	3.91	4.64	8.88	14.38	15.55	19.35	21.17	19.85	19.44	19.80	21.58	21.54	21.05
Public Electricity	0.00	0.00	0.72	2.19	2.82	4.25	5.17	5.34	4.20	4.72	4.37	4.51	4.31	3.98
Public Combined Heat and Power	1.72	2.32	2.23	3.14	3.01	2.44	3.17	4.03	3.90	4.20	4.40	6.29	6.56	6.41
Public Heat Plants	0.69	1.59	1.69	1.97	1.87	2.25	2.06	2.09	2.21	2.12	2.14	1.99	1.95	1.77
Auto Producers of Electricity	0.00	0.00	0.00	1.46	4.22	3.45	5.49	6.08	5.59	4.62	4.31	4.63	4.22	4.53
Auto Producers for CHP	0.00	0.00	0.00	0.10	2.46	3.16	3.46	3.63	3.96	3.78	4.58	4.15	4.49	4.36
Auto Producer Heat Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Energy Sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical (incl. Petro-Chemical)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non metallic Mineral Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pulp, Paper and Printing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Wood Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles and Leather	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Industry)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Other Sectors	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commerce - Public Services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 104: National Energy Balance 1990–2022. Industrial Waste [PJ].

115A Industrial Waste	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Indigenous Production	6.58	7.01	7.63	10.85	17.03	17.80	16.09	16.94	16.54	15.33	14.48	14.42	14.65	16.27
Total Imports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports (Balance)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock Change (National Territory)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

115A Industrial Waste	1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
Gross Inland Deliveries (Obs.)	6.58	7.01	7.63	10.85	17.03	17.80	16.09	16.94	16.54	15.33	14.48	14.42	14.65	16.27
Statistical Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Transformation Sector	2.54	1.93	1.46	2.61	5.15	5.95	4.31	3.93	3.81	3.27	3.18	2.14	2.45	2.58
Public Electricity	0.00	0.00	0.00	0.62	0.51	1.18	0.68	0.71	0.59	0.30	0.21	0.16	0.37	0.44
Public Combined Heat and Power	0.00	0.00	0.00	0.72	0.92	1.34	2.37	2.28	2.27	2.10	1.91	0.72	0.90	0.88
Public Heat Plants	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto Producers of Electricity	0.00	0.00	0.44	0.25	1.83	1.85	0.32	0.14	0.18	0.14	0.00	0.00	0.07	0.00
Auto Producers for CHP	2.54	1.93	1.02	0.91	1.70	1.36	0.76	0.64	0.61	0.58	0.89	1.09	0.88	1.07
Auto Producer Heat Plants	0.00	0.00	0.00	0.11	0.19	0.19	0.17	0.16	0.16	0.16	0.16	0.18	0.24	0.20
Total Energy Sector	0.00	0.00	0.00	0.44	2.32	2.14	1.87	1.82	1.65	0.60	1.12	1.77	1.79	1.73
Coal Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patent Fuel Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coke Ovens (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blast Furnaces (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Works (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BKB (Transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum refineries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution Losses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Consumption	4.03	5.08	6.18	7.80	9.55	9.71	9.92	11.19	11.08	11.46	10.18	10.51	10.42	11.96
Total Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Waterways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Industry	2.92	4.56	5.61	6.73	9.49	9.71	9.92	11.19	11.08	11.46	10.18	10.51	10.42	11.96
Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical (incl. Petro-Chemical)	1.57	1.91	1.64	3.16	3.26	3.19	2.45	2.79	2.52	2.64	1.92	2.51	2.44	2.54
Non ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.01	0.17	0.18	0.19	0.00	0.00	0.01	0.00	0.00
Non metallic Mineral Products	1.31	1.98	3.56	2.66	5.29	5.68	6.71	7.49	7.72	7.83	7.35	7.34	7.08	7.67
Transportation Equipment	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining and Quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food, Beverages and Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pulp, Paper and Printing	0.00	0.00	0.00	0.04	0.09	0.04	0.19	0.22	0.15	0.20	0.22	0.19	0.11	0.88
Wood and Wood Products	0.04	0.55	0.37	0.63	0.76	0.75	0.31	0.42	0.41	0.69	0.58	0.34	0.69	0.81
Construction	0.00	0.01	0.02	0.06	0.04	0.00	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.03
Textiles and Leather	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Non Specified (Industry)	0.01	0.09	0.02	0.10	0.05	0.03	0.06	0.09	0.08	0.09	0.10	0.10	0.06	0.00
Total Other Sectors	1.11	0.52	0.56	1.07	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commerce - Public Services	1.11	0.52	0.56	1.07	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non Specified (Others)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Annex 4.5 – Net Calorific Values

The selected net calorific values of each fuel are presented below.

Table A 105: Net calorific values for 1990-2022 in [MJ/kg], [MJ/m³] taken from (IEA JQ 2023).

Fuel Code	Fuel Name		1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
101A	Coking Coal	T	29.07	29.07	29.07	29.10	29.17	29.07	29.66	28.66	29.18	29.14	29.00	28.95	29.30	29.91
102A	Hard Coal	FC	28.00	28.00	27.99	29.08	27.57	27.77	27.53	27.37	27.49	28.42	28.83	27.79	28.43	29.89

Fuel Code	Fuel Name		1990	1995	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022
		T	28.00	28.00	26.74	29.10	28.14	28.29	28.73	28.29	28.67	28.60	28.97	28.82	29.28	29.91
104A	Hard Coal Briquettes	A	0.00	0.00	31.00	31.00	31.00	31.00	31.00	31.01	31.00	31.00	31.00	31.00	31.00	31.00
		FC	10.90	10.90	14.71	16.04	19.86	20.00	20.53	20.63	20.69	21.21	22.06	21.41	21.38	21.52
105A	Brown Coal	T	10.90	10.90	9.86	9.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A	19.30	19.30	19.30	19.30	19.30	19.30	19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80
106A	Brown Coal Briquettes	A	19.30	19.30	19.30	19.30	19.30	19.30	19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80
107A	Coke Oven Coke	T	28.50	28.50	29.00	28.88	28.75	28.72	28.84	28.88	28.64	27.90	28.73	28.77	28.48	28.22
113A	Peat	FC	8.80	8.80	8.80	8.80	8.80	8.80	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
304A	Coke Oven Gas	P	17.90	17.90	17.61	17.56	17.69	18.06	17.69	17.24	17.43	17.61	17.61	17.43	17.01	17.02
305A	Blast Furnace Gas	P	3.65	3.63	3.70	3.80	3.74	3.67	3.67	3.67	3.57	3.51	3.53	3.63	3.65	3.58
110A	Petrol Coke	A	34.30	28.40	33.92	31.33	29.92	32.83	30.86	30.84	31.02	30.26	30.98	30.94	31.56	31.13
201A	Crude Oil	A	42.50	42.50	42.52	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50
203X	Residual Fuel Oil	A	41.00	40.50	41.49	42.15	45.24	40.33	41.07	41.16	41.16	41.15	40.99	41.26	41.41	41.66
204A	Gasoil	A	42.60	42.70	42.80	42.80	42.80	42.79	42.94	42.80	42.80	42.80	42.81	42.81	42.70	43.37
2050	Diesel	A	42.60	42.70	42.80	42.80	42.80	42.52	42.40	42.39	42.39	42.39	42.37	42.37	42.37	42.37
206A	Petroleum	A	43.60	43.30	43.30	43.60	43.36	43.30	43.35	43.35	43.35	43.35	43.35	43.35	43.35	43.35
206B	Kerosene	A	43.60	43.30	43.30	43.30	43.36	43.32	43.35	43.30	43.30	43.30	43.38	43.38	43.38	43.30
207A	Aviation Gasoline	A	42.50	42.50	42.50	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10
2080	Motor Gasoline	A	42.50	42.50	42.50	42.68	41.98	41.10	41.31	40.53	40.73	41.61	41.64	41.65	41.64	41.81
217A	Refinery Feedstocks	A	41.87	42.56	42.56	42.59	42.47	41.86	42.34	42.65	42.29	42.96	42.51	42.57	42.91	42.31
219A	Lubricants	A	41.40	41.10	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80
220A	White Spirit	A	41.60	42.50	42.50	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10
222A	Bitumen	A	41.80	41.80	43.62	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80
		FC	34.30	28.40	33.92	45.87	45.97	45.85	46.02	46.22	45.93	46.01	46.26	46.17	46.13	45.44
224A	Other Petroleum Products	NE	41.80	41.80	43.62	39.69	37.91	40.73	41.59	41.61	41.62	46.01	46.26	46.17	46.13	45.44
302A	NGL	A	42.50	42.50	42.52	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50
303A	LPG	A	46.30	46.30	46.00	46.00	46.00	46.12	46.12	46.12	46.12	46.12	46.12	46.12	46.12	46.12
308A	Refinery Gas	A	49.00	49.00	37.18	30.68	30.68	32.00	29.87	29.87	32.44	30.32	29.78	30.32	30.32	30.60
301A	Natural Gas	A	36.00	36.00	35.85	36.00	36.26	36.26	36.48	36.64	36.61	36.61	36.61	36.71	36.64	37.23

Legend: A...Average; T...Transformation; FC...Final Consumption; P...Production; NE...Non Energy use;
NGL...Natural Gas Liquids; LPG...Liquified Petroleum Gas

Table A 106 presents the net calorific values from STATISTIK AUSTRIA, which are used for default unit conversion.

Table A 106: Default net calorific values from STATISTIK AUSTRIA.

Fuel Name	NCV	Unit
Municipal Waste / renewable	8.93	MJ/kg
Municipal Waste / non renewable	9.14	MJ/kg
Industrial Waste	15.76	MJ/kg
Fuel Wood	15.50	MJ/kg
Wood Wastes	11.36	MJ/kg
Bark	7.54	MJ/kg
Sewage Sludge (wet substance)	3.64	MJ/kg
Black Liquor	7.92	MJ/kg
Carcass meal	17.30	MJ/kg
Adipose	36.59	MJ/kg
Liquid Biofuels	42.00	MJ/kg

Fuel Name	NCV	Unit
Biogas	22.06	MJ/m ³
Gas from Waste Disposal Site	17.00	MJ/m ³

Table A 107 presents the IPCC default values of net calorific values of gaseous biofuels which are used for default unit conversion.

Table A 107: Default net calorific values from IPCC Guidelines.

Fuel Name	NCV	Unit
Sewage Sludge Gas	27.00	MJ/m ³

ANNEX 5: ADDITIONAL INFORMATION

Annex 5.1 – NISA

Austria's Obligations

Regarding Austria's obligations under the United Nations Framework Convention on Climate Change (UNFCCC) the relevant COP (Conference of the Parties) Decisions and Guidelines are:

- Decision 11/CP.4 National communications from Parties included in Annex I to the Convention.
- Decision 3/CP.5 Guidelines for the Preparation of National Communications by Parties included in Annex I to the Convention, Part I: UNFCCC Reporting Guidelines on Annual Inventories (referring to Document FCCC/CP/1999/7) revised with Decision 18/CP.8 (referring to Document FCCC/CP/2002/8).
- Decision 4/CP.5 Guidelines for the Preparation of National Communications by Parties included in Annex I to the Convention, Part II: UNFCCC Reporting Guidelines on National Communications (referring to Document FCCC/CP/1999/7) revised with Decision 19/CP.8 (referring to Document FCCC/CP/2002/8).
- Decision 20/CP.7 (19/CMP.1): Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol;
- Decision 21/CP.7 (20/CMP.1): Good practice guidance and adjustments under Article 5, paragraph 2, of the Kyoto Protocol;
- Decision 24/CP.19: Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention.

The relevant EU Regulations are:

- Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council; ("*Governance Regulation*"¹). The purpose of this regulation is to monitor anthropogenic greenhouse gas emissions and to evaluate the progress towards meeting the Union greenhouse gas reduction commitments in accordance with the Paris Agreement;
- Commission Implementing Regulation (EU) 2020/1208 Commission Implementing Regulation (EU) 2020/1208, specifying the reporting obligations and providing templates;
- Commission Delegated Regulation (EU) 2020/1044 of 8 May 2020 supplementing Regulation (EU) 2018/1999 of the European Parliament and of the Council with regard to values for global warming potentials and the inventory guidelines and with regard to the Union inventory system and repealing Commission Delegated Regulation (EU) No 666/2014.

¹ <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999&from=EN>

In addition to the obligation under the UNFCCC Austria has to comply with the following obligations regarding air emissions:

- Austria's annual obligation under the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) and its Protocols (1979) comprising the annual reporting of national emission data on SO₂, NO_x, NMVOCs, NH₃, CO, TSP, PM₁₀, and PM_{2.5} as well as on heavy metals (Pb, Cd, Hg), persistent organic pollutants (POPs), dioxins and furans, hexachlorobenzene (HCB) and polychlorinated biphenyls (PCB).
- Obligation under the Austrian Ambient Air Quality Law² concerning the reporting of national emission data on SO₂, NO_x, NMVOC, CO, heavy metals (Pb, Cd, Hg), benzene and particulate matter.
- Austria's obligation according to Article 15 of the European IPPC Directive 1996/61/EC is to implement a European Pollutant Emission Register (EPER). EPER was displaced and upgraded by regulation (EC) No 166/2006 concerning the establishment of a European Pollutant Release and Transfer Register (E-PRTR Regulation). EPER and E-PRTR are 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 of environmental issues.

History of NISA

As there are so many different obligations which are subject to continuous development, Austria's National Inventory System (NISA) has to be adapted to these changes. A brief history of the development and the activities of NISA are shown here:

- Austria established estimates for SO₂ under EMEP in 1978 (Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe).
- As an EFTA country Austria participated in CORINAIR 90, which was an air emission inventory for Europe. It was part of the CORINE (Coordination d'Information Environnementale) 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 pollutants: SO_x as SO₂, NO_x as NO₂, NMVOC, CH₄, CO, CO₂, N₂O and NH₃.
- Austria signed the UNFCCC on June 8, 1992 and subsequently submitted its instrument of ratification on February 28, 1994.
- 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 HM, POPs and FCs were included in the inventory.
- Inventory data for particulate matter were included in the inventory in 2001.
- In 2005: accreditation according to EN ISO/IEC 17020 as *Inspection Body for Emission Inventories*.
- Periodic external audits by "Accreditation Austria" in 2006, 2008 and 2009
- In 2011: first re-accreditation according to EN ISO/IEC 17020
- Periodic external audits by "Accreditation Austria" in 2012, 2013 and 2014

² AUSTRIAN AMBIENT AIR QUALITY LAW (1997): Immissionsschutzgesetz-Luft. Federal Law Gazette I 115/1997.

- In 2016: second re-accreditation according to EN ISO/IEC 17020
- Periodic external audits by "Accreditation Austria " in 2017 and 2018
- In 2020: third re-accreditation according to EN ISO/IEC 17020
- Periodic external audits by "Accreditation Austria" in 2022 and 2023

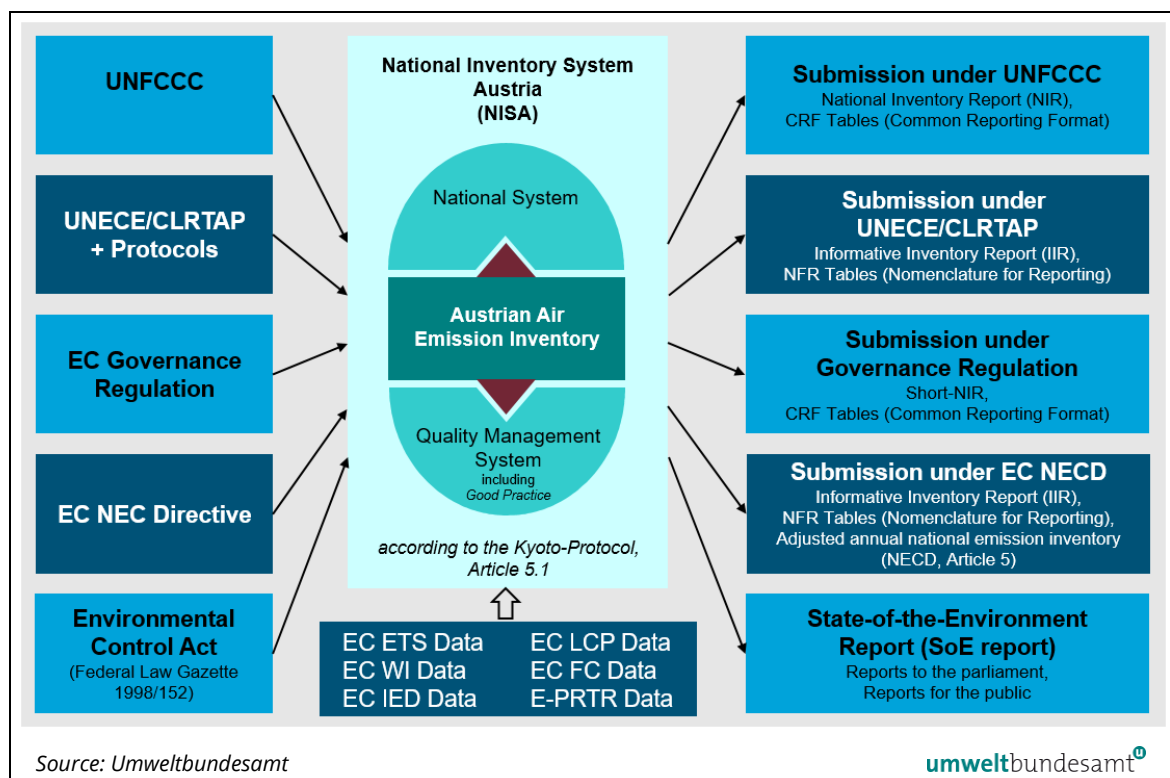
Adaptation of NISA according to the Kyoto Protocol

Regulations under the UNFCCC and the Kyoto Protocol defined new standards for national emission inventories. These standards include more stringent requirements related to transparency, consistency, comparability, completeness and accuracy of inventories. Each Party shall have in place a national system. This national system shall include all institutional, legal and procedural arrangements made within a Party for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and for reporting and archiving inventory information.

Austria's aim was to set up a national system that fulfils all the requirements of the Kyoto Protocol and also works as an efficient system to fulfil all the other obligations regarding air emission inventories Austria has to comply with.

The emission inventory system has a structure as illustrated in Figure 2.

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



The Austrian Air Emission Inventory, comprising all air pollutants stipulated in the various national and international obligations, is at the centre of NISA. The national system and the quality management system have been incorporated into NISA as complementary sections.

The Guidelines for National Systems for the Estimation of Anthropogenic Greenhouse Gas Emissions by Sources and Removals by Sinks under Article 5.1 of the Kyoto Protocol (Decision 19/CMP.1) describe the elements to be included in a national system.

The overall goal of National Systems is to ensure the quality of the inventory through planning, preparation and management of inventory activities. National Systems should enable Parties to estimate emissions in accordance with the relevant inventory guidelines to comply with the requirements of the Kyoto Protocol.

The general principles for National Inventories are transparency, consistency, comparability, completeness and accuracy of inventories and the quality of inventory activities (e.g. collecting activity data, selecting methods and emission factors).

The general functions are

- to establish and maintain the institutional, legal, and procedural arrangements defined in the guidelines for national systems between the government agencies and other entities,
- to ensure sufficient capacity for timely performance,
- to designate a single national entity with overall responsibility for the national inventory,
- to prepare national annual inventories and supplementary information in a timely manner and
- to provide information necessary to meet the reporting requirements.

Specific functions stipulated in these guidelines are inventory planning, preparation and management.

Austria has taken significant steps to establish a high-quality emission inventory in which uncertainties are reduced as far as feasible and in which data are developed in a transparent, consistent, complete, comparable and accurate manner.

The following steps have been taken to prepare NISA to meet the requirements of the Kyoto Protocol:

- The Umweltbundesamt has been designated as the single national entity with the overall responsibility for the national inventory by law: the Environmental Control Act ("Umweltkontrollgesetz"; Federal Law Gazette I No. 152/1998) regulates responsibilities of environmental control in Austria and lists the tasks of the Umweltbundesamt. One task is the preparation of technical expertise and basic data for the fulfilment of the obligations under the UNFCCC and the UNECE LRTAP Convention. For further institutional arrangements, please refer to sub-chapter 1.2.4)
- The responsibilities for inventory planning, preparation and management are specified and allocated within the Umweltbundesamt. Following internal Umweltbundesamt quality management regulation, a yearly plan is implemented to ensure capacity for timely performance of the functions defined in the guidelines for national systems. The technical competence of the staff involved in the inventory preparation process is ensured by arrangements according to the QMS of the IBE as well as the internal Umweltbundesamt training plan.

- The inventory preparation, including identification of key categories, uncertainty estimates and QC procedures, is performed according to the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines
- A Quality Management System (QMS) has been developed and implemented.
- The national greenhouse gas inventory is prepared by the inspection body for GHG inventories within the Umweltbundesamt which is accredited as inspection body according to the International Standard ISO/IEC 17020 General Criteria for the operation of various types of bodies performing inspections. The accreditation audit of the Umweltbundesamt as inspection body took place in September 2005. The accreditation was completed officially in December 2005 and renewed in July 2011, May 2016 and February 2020.
- The QMS also includes the necessary procedures to ensure quality improvement of the emission inventory. They comprise documentation of allocated responsibilities, of any discrepancies and of the findings by UNFCCC review experts in particular.
- The inventory management as part of the QMS includes a control system for data and calculations, for records and their archiving as well as documentation of QA/QC activities. This ensures the necessary documentation and archiving for future reconstruction of the inventory and for the timely response to requests during the review process.
- Part of the legal and institutional arrangements in place to provide a basis for the national system concern data availability for the annual compilation of the GHG inventory. The main data source for the Austrian inventory preparation is the Austrian statistical office (Statistik Austria). The compilation of several statistics is regulated by law; the compilation of the national energy balance is regulated by contracts. Other data sources include reporting obligations under national and European regulations and reports of companies and associations.
- A process for official consideration and approval of the inventory prior to its submission is established. The inventory information is provided by the Umweltbundesamt to the Austrian Federal Ministry of 'Climate Action, Environment, Energy, Mobility, Innovation and Technology' (BMK), where the National Focal Point for the UNFCCC is established. The inventory is then submitted by the Ministry to the UNFCCC secretariat.

The Austrian national system was reviewed during the in-country review of the initial report of Austria (February 2007). Paragraph 10 of the review report (FCCC/IRR/2007/AUT) states that the national system has been developed in line with the relevant guidelines and can fulfil the requirements of the Kyoto Protocol as well as other obligations regarding its air emissions inventory that Austria has to comply with.

Annex 5.2 – QMS and Inspection Body for Emission Inventories (IBE)

History of the Austrian QMS

A quality management system (QMS) has been designed to achieve the objectives of *good practice guidance*, namely to improve transparency, consistency, comparability, completeness and confidence in national inventories of emissions estimates. After having been effectively implemented during the development of the UNFCCC submission 2004, the accreditation audit of the Umweltbundesamt (Environment Agency Austria) as *Inspection Body for Emission inventories (IBE)*

took place in autumn 2005. Accreditation was awarded in December 2005 and renewed in January 2011, 2016 and 2020.

Table A 108 presents the timetable for the implementation of the quality management system.

Table A 108: Timetable for the implementation of the Austrian QMS.

	Date
Development of a quality management system including Quality Manual	1999–2002
Development of the quality management system	2003–2005
Implementation of the quality management system	
Accreditation Audit	September 2005
Accreditation as Inspection Body for Greenhouse Gas Inventories	December 2005
1 st Re-Accreditation Audit	January 2011
Re-Accreditation as Inspection Body for Greenhouse Gas Inventories	July 2011
2 nd Re-Accreditation Audit	December 2015
Re-Accreditation as Inspection Body for Greenhouse Gas Inventories	May 2016
3 rd Re-Accreditation Audit	February 2020
Re-Accreditation as Inspection Body for Greenhouse Gas Inventories	July 2020

With the start of the EU Emissions Trading system on January 1st 2005 and the entry into force of the Kyoto Protocol on February 16th 2005, greenhouse gas emissions now equal money. Pressure upon national GHG emission inventories is expected to increase, therefore a QMS is considered crucial in order to ensure the quality of emission estimates established according to the requirements of the IPCC 2006 GL as a basis for any kind of international emission trading.

The International Standard EN ISO/IEC 17020

The QMS was drawn up to meet the requirements of the International Standard EN ISO/IEC 17020³. It covers the functions of bodies whose work includes assessments of conformity, and the subsequent reporting of results of conformity assessment to clients and, when required, to supervisory authorities. Inspection parameters may include, among others, matters of quantity and/or quality.

The general criteria, with which these bodies are required to comply in order that their services be accepted by clients and by supervisory authorities, are harmonized in the International Standard EN ISO/IEC 17020:2012 *Requirements for the operation of various types of bodies performing inspections*. This standard has been drawn up with the objective of promoting confidence in those bodies performing inspections which conform to it.

The EN ISO/IEC 17020 also takes into account requirements and recommendations of European and international documents such as the EN ISO 9000 series of standards, and goes beyond: additionally to the requirements of the EN ISO 9000 series, the EN ISO/IEC 17020 also provides a clear statement of requirements regarding competence, independence, impartiality and integrity, as well as confidentiality.

³ The International Standard ISO/IEC 17020 superseded the European Standard EN 45004.

Accreditation Act

According to the EN ISO 17000 series, *accreditation* is the procedure by which an authorized body (accreditation body) formally recognizes that an organisation has the competence to perform a stipulated conformity assessment activity.

The Austrian Accreditation Act 2012 (“Akkreditierungsgesetz 2012”, Federal Law Gazette I No 28/2012, last amended by Federal Law Gazette I No 40/2014)) regulates the accreditation of testing, inspection and certification bodies. It designates the Federal Ministry for ‘Labour and Economy’ (BMAW) as accreditation body and defines the conditions for granting, maintaining and extending accreditation and the conditions under which accreditation may be suspended or withdrawn.

Accreditation is granted after a successful accreditation audit, where an expert nominated by the accreditation body assesses the conformity of the organization of the inspection body and its QMS with the standard, and additionally a technical expert assesses the competence of the inspection body and the conformity of the methodologies applied with specific requirements. This audit takes three days of in-house inspection.

The accreditation requires re-assessment in defined intervals (in the case of an inspection body a one day audit takes place every twenty months on average).

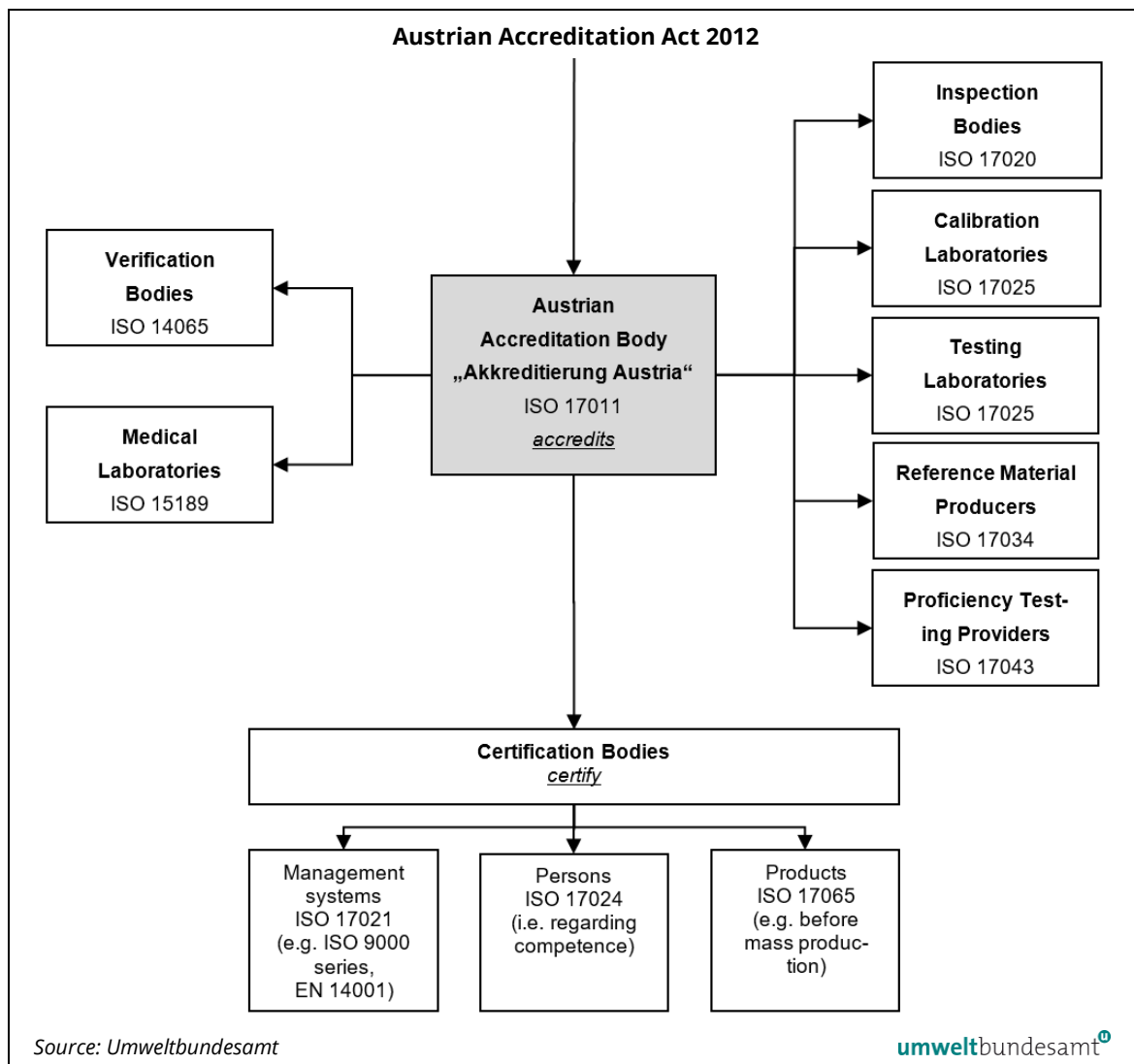
Accreditation and Certification

A certification is the procedure by which an official – or officially recognised – body (certification body) gives written assurance that a product, process or service conforms to specified requirements. Thus, in contrast to an accreditation, the certification gives warrantee for conformity, whereas the accreditation is a warrantee for competence, as well as independence, impartiality and integrity (additionally, both require a QMS that guarantees transparency).

One example for certification is the certification of a QMS according to the EN ISO 9000 series. The certification is issued by a certification body. The certification body on the other side needs an accreditation, which is the warrantee that the certification body is competent to carry out EN ISO 9000 certifications in specific business sectors.

Figure 3 gives an overview of accreditation of conformity assessment bodies by “Akkreditierung Austria” and certification by certification bodies in Austria (based on the Austrian Accreditation Act 2012).

Figure 3: Overview of accreditation of conformity assessment bodies by 'Akkreditierung Austria' and certification by certification bodies in Austria



Reports issued by an accredited body may carry the federal emblem in addition to the accreditation logo. These reports are official documents.

Independence

The impartiality and independence of the Environment Agency Austria can be deduced from the principles laid down in the UKG (especially sections 5, 6 and 11):

- The Environment Agency Austria GmbH is an independent company which has been assigned public governance functions and specific tasks of public administration.
- In addition to these, the Environment Agency Austria performs only tasks which are in the public interest of protecting the environment.
- Basic annual funds are provided to the Environment Agency Austria as stipulated in the UKG. The responsibility for managing these funds lies with the managing directors of the Environment Agency Austria.

Impartiality and Integrity

The personnel of the inspection body shall be free from any commercial, financial and other pressures which might affect their judgement. It has to be ensured that persons or organisations external to the inspection body cannot influence the results of inspections carried out.

We feel that such a regulation is fundamental in order to guarantee that the emission data reflect real emissions as truly as possible.

Inspection body in the context of the National Greenhouse Gas Inventory

In the case of greenhouse gas emissions inventories, inspection covers (i) data collection (emission data and/or of data which are used to estimate emissions e.g. activity data, emission factors, conversion factors), (ii) the application of appropriate methodologies (IPCC, CORINAIR and country specific methodologies) to estimate emissions, (iii) the compilation of the emissions inventory and (iv) the assessment of conformity with national emission reduction targets. The QMS ensures that all requirements of a Type A inspection body as stipulated in EN ISO/IEC 17020 are met, including independence, impartiality and integrity.

When compiling emission inventories according to the standard, the methodologies applied have to be officially approved by the accreditation body.

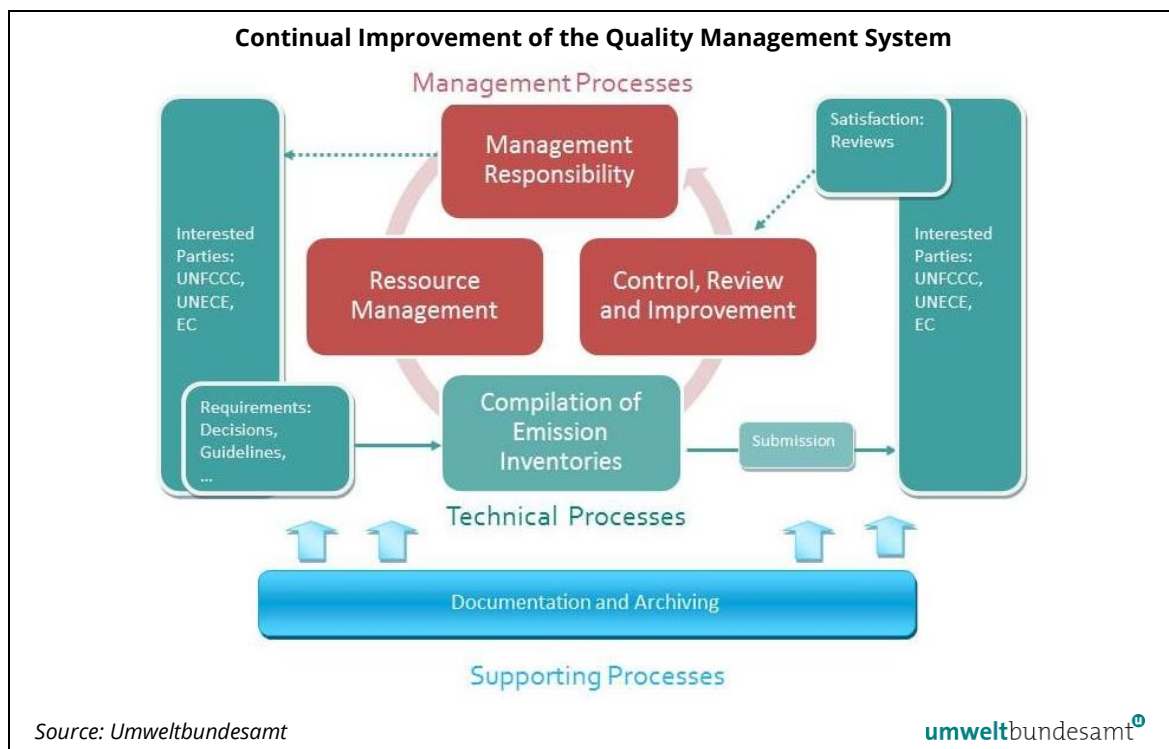
The Austrian Quality Management System (QMS) and requirements of IPCC GL

The implementation of QA/QC procedures as required by the IPCC GL support the development of national greenhouse gas 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 IPCC 2006 GL Volume 1 Chapter 6 'Quality Assurance, Quality Control and Verification', 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).

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*, as illustrated in Figure 4.

Figure 4: Process-based QMS of the IBE



1) Realisation process

The realisation process is the *Inspection Body's for Emission Inventories* (IBE) core competence as they concern the compilation of emission inventories. The inspection process consists of two steps, (i) data collection and (ii) the application of methods to estimate emissions. The Umweltbundesamt uses IPCC methods, CORINAIR methods and country specific methods. Country-specific methods are thoroughly documented and validated. Emission estimates are subject to quality control checks before being published in an inspection report.

The inspection body performs the majority of inspection processes itself. Any subcontractor performing part of the inspection is required to work in compliance with EN ISO/IEC 17020.

2) Management processes

Management Processes comprise all activities necessary for management and control of an organisation: resources and responsibilities, quality system, internal audits, management review, corrective actions and prevention, external communication.

The most important aspect with respect to organisation and management is that it has to be ensured that the personnel is free from any commercial, financial or other pressure which might affect their judgement. Such regulations are considered fundamental in order to guarantee that emission data reflect actual emissions as truly as possible.

The personnel responsible for inspection shall have appropriate qualifications, training, experience and a satisfactory knowledge of the requirements of the inspections to be carried out. They have the ability to make professional judgements as to conformity with general requirements using examination results and to report there-on.

Computers are used for the compilation of emission inventories. Procedures for protecting the integrity of data and for maintenance of data security have been established and implemented. Access authorisation is strictly limited for protecting the integrity of data and to ensure data confidentiality where necessary.

A management review is held every year; the report is presented to the managing directors who are responsible for resources. The management review report includes an evaluation of the QMS based on information obtained mainly from internal audits, as well as results from the UNFCCC review process, the inventory improvement plan (evaluation of fulfilment of previous plan and decision on new plan) and a plan for the QMS (evaluation of fulfilment of previous plan and decision on new plan).

3) Supporting processes

Supporting processes support both the management and the realisation processes. They include a control system for all documents and data as well as for records and their archiving.

ANNEX 6: INFORMATION ON ACCOUNTING OF KYOTO PROTOCOL UNITS

This chapter refers to 'Chapter 12' as annually submitted in the NIR under the Kyoto Protocol as supplementary information required under Article 7, paragraph 1. Information on accounting of Kyoto Protocol Units is continued to be reported, but under this Annex 6.

Background information

Annex I Parties are required to report their national registries' holdings and transactions of Kyoto units and inform about related issues as specified in Decision 15/CMP.1 Section E. The following chapters serve this purpose.

Summary of information reported in the SEF tables

Information from the national registry on acquisition, holding, transfer, cancellation, retirement and carry-over of AAUs, RMUs, ERUs, CERs, tCERs and ICERs for CP2 units in 2023 is included in the 'SEF_AT_CP2_2023_20240109', available in xls and xml format.

The SEF for CP2 2023 was generated on 9 January 2024 with data from the Union Registry from 9 January 2024 and the SEF report tool version 3.8.3, provided by the secretariat on 26 January 2018 and adapted manually with data from the Union Registry with status of the 9 January 2024.

Even though there is no obligation to submit a SEF after the end of the true-up-period of CP1, the SEF was generated by using the SEF report tool, version 3.8.3 provided by the secretariat at 26 January 2018 and adapted manually to the current requirements with data from the Union Registry with status of the 9 January 2024. The 'SEF_AT_CP1_2023_20240109' is available in xls and xml format.

Further details can be found in the electronic SEF files as mentioned above.

Discrepancies and notifications

No discrepancies occurred in 2023. Therefore, no report R-2 is submitted.

No CDM notifications occurred in 2023. Therefore, no report R-3 is submitted.

No non-replacements occurred in 2023. Therefore, no report R-4 is submitted.

No invalid units exist at the 31 December 2023. Therefore, no report R-5 is submitted.

There were no actions necessary to correct any problem causing a discrepancy because there were no discrepancies in 2023.

Publicly accessible information

Section E of the annex to Decision 15/CMP.1 outlines provisions for making available non-confidential information to the public via a user interface. Austria makes available some of the publicly accessible information on the website of the Austrian emissions trading registry <https://www.emissionshandelsregister.at/en/publicreports/unfcccreports>.

Additionally Austria uses the possibility to provide this information in the public section “Kyoto Protocol Public Reports” of the Austrian part of the Union Registry which is maintained by the European Commission (<https://unionregistry.ec.europa.eu/euregistry/AT/public/reports/publicReports.xhtml>) to enable additional access for the public.

Although efforts are taken to keep the information consistent, it might be, that – on this additional place for public information – the information provided there is not exactly the same as on the National Website exceptionally at certain times, as it is not maintained by Austria.

Additional up-to date public information concerning the Consolidated System of EU Registries (CSEUR) is now available at the European Union Transaction Log website <http://ec.europa.eu/environment/ets/>.

Calculation of the commitment period reserve (CPR)

Parties are required by decision 11/CMP.1 under the Kyoto Protocol and paragraph 18 of Decision 1/CMP.8 to establish and maintain a commitment period reserve as part of their responsibility to manage and account for their assigned amount. The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8.

Calculated as 90 per cent of the assigned amount the commitment period reserve is **365 141 085** tonnes carbon dioxide equivalent.

(The calculation based on the most recently reviewed inventory would result in a higher value.)

PPSR-Accounts in the National Registry

Since 16 November 2016 the Union Registry provides the technical possibility to open a PPSR (previous period surplus reserve) account. However, prior to opening it, the PPSR account type had to be first introduced into the EU legislative framework. This was done by the Annex of Commission Delegated Regulation 2015/1844. This provision became applicable, according to Delegated Regulation 2015/1844, with the entry into force of the Doha Amendment to the Kyoto Protocol. As the Communication of the Commission announced the entry into force of the Doha Amendment to the Kyoto Protocol for the 31 December 2020, the PPSR account in our National Registry was opened on the 11 February 2021. Austria has announced in the “Report upon expiration of the additional period for fulfilling commitments by Austria” submitted in December 2015, its plan to carry over 4 945 AAUs, valid for the first commitment period (CP1), into the second commitment period (CP2), and 4 935 of these were carried over to the previous period surplus account on the 24 September 2021. The other 10 AAUs were subject to voluntary cancellation on 11 February 2021.

ANNEX 7: CHANGES IN THE NATIONAL REGISTRY

This chapter refers to 'Chapter 14' as annually submitted in the NIR under the Kyoto Protocol as supplementary information required under Article 7, paragraph 1. Information on changes in the National Registry is continued to be reported, but under this Annex 7.

Information on changes according to Decision 15/CMP.1

The following changes to the national registry of Austria have occurred in 2023.

Table A 109: Changes to the national registry of Austria 2023.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	The name and contact of the registry administrator as an institution has not changed.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	There have been five new EUCR releases in production (versions 13.10, 13.10.2, 13.10.3, 13.10.4 and 13.11.2) after version 13.8.2 (the production version at the time of the last 'Chapter 14' submission). No changes were applied to the database. No change was required to the application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	The changes that have been introduced with versions 13.10, 13.10.2, 13.10.3, 13.10.4 and 13.11.2 compared with version 13.8.2 of the national registry are presented in Annex B. It is to be noted that each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and are carried out prior to the relevant major release of the version to Production. No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No changes regarding security occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change to the registry internet address occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	No change during the reported period.

Previous Annual Review recommendations

The latest available report FCCC/ARR/2021/AUT did not include any recommendations related to the registry.

There is no SIAR report for 2023 due to the simplified process during the CP2 true-up period. This process foresees a comparison of the submitted SEF files with data of the International Transaction Log. No recommendations have been made in this context.

ANNEX 8: RECALCULATIONS

The following Table A 110 shows the recalculations of Austria's GHG emissions solely due to methodological improvements.

Table A 110: Recalculations in kt CO₂e

IPCC Category Code	IPCC Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	Total (without LULUCF)	35.44	32.50	21.05	16.49	99.88	100.96	100.68	81.38	58.64	50.19	41.97	62.86	49.07	64.11	119.21	-172.59
1	Total Energy	0.90	-0.53	-1.29	-0.15	-2.42	-0.57	-0.81	-1.09	-1.51	-1.83	-3.46	-2.41	-2.45	-2.38	63.60	-225.48
1 A	Fuel Combustion Activities (Sectoral Approach)	0.90	-0.53	-1.29	-0.15	-2.42	-0.57	-0.81	-1.09	-1.51	-1.83	-3.46	-2.41	-2.45	-2.38	63.60	-225.48
1 A 1	Energy Industries	0.00	0.00	-0.20	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	53.87
1 A 1 a	Public Electricity and Heat Production	0.00	0.00	-0.20	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.64
1 A 1 b	Petroleum Refining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 1 c	Manufacture of Solid Fuels and Other Energy Industries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.23
1 A 2	Manufacturing Industries and Construction	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-0.21	66.91	-30.86
1 A 2 a	Iron and Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.22
1 A 2 b	Non-Ferrous Metals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
1 A 2 c	Chemicals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68.11	-52.30
1 A 2 d	Pulp, Paper and Print	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.10	8.32
1 A 2 e	Food Processing, Beverages and Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.37
1 A 2 f	Non-Metallic Minerals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2 g	Other (please specify)	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-0.21	-1.09	-2.09
1 A 3	Transport	-2.50	-1.74	-0.80	0.05	0.09	0.24	0.26	0.27	0.25	0.34	-1.05	0.43	0.32	0.39	0.49	-10.15
1 A 3 a	Domestic Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 3 b	Road Transportation	-2.55	-1.79	-0.85	0.02	0.06	0.22	0.24	0.24	0.23	0.32	24.02	0.41	0.31	0.58	-0.47	-10.16
1 A 3 c	Railways	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-25.09	0.00	-0.01	-0.20	0.96	0.00
1 A 3 d	Domestic Navigation	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
1 A 3 e	Other Transportation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4	Other Sectors	0.79	-0.59	-1.12	-0.20	-1.69	0.57	0.72	0.85	0.82	0.87	0.94	1.01	1.33	1.97	1.12	-236.21

IPCC Category		1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Code	IPCC Category																
1 A 4 a	Commercial/ Institutional	0.00	0.01	-0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	-31.06
1 A 4 b	Residential	0.51	-0.84	-1.30	-0.42	-1.82	0.44	0.62	0.75	0.74	0.79	0.87	0.93	1.25	1.68	1.05	-209.07
1 A 4 c	Agriculture/ Forestry/Fishing	0.28	0.24	0.21	0.22	0.13	0.13	0.11	0.10	0.09	0.08	0.08	0.08	0.08	0.08	0.07	3.92
1 A 5	Other	2.60	1.79	0.82	-0.02	-0.82	-1.39	-1.80	-2.21	-2.59	-3.05	-3.36	-3.85	-4.10	-4.54	-4.93	-2.14
1 B	Fugitive Emissions from Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 B 1	Solid Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 B 2	Oil and Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Total Industrial Processes	17.96	18.49	8.90	1.77	3.73	4.19	2.48	-17.01	-40.67	-50.36	-60.16	-39.61	-60.70	-50.38	-62.42	-66.96
2 A	Mineral Industry	16.86	16.86	5.74	-5.38	-6.11	-6.49	-6.86	-7.24	-7.64	-8.01	-8.36	-8.35	-8.45	-8.06	-8.20	-9.41
2 A 1	Cement Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 A 2	Lime Production	16.86	16.86	5.74	-5.38	-6.11	-6.49	-6.86	-7.24	-7.64	-8.01	-8.36	-8.35	-8.45	-8.06	-8.20	-9.41
2 A 3	Glass Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 A 4	Other Process Uses of Carbonates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B	Chemical Industry	1.10	1.53	1.52	1.73	1.77	1.76	1.79	1.48	1.88	1.87	1.89	1.75	1.20	1.84	-0.09	-0.02
2 B 1	Ammonia Production	-0.12	-0.17	-0.17	-0.19	-0.19	-0.20	-0.20	-0.16	-0.20	-0.20	-0.21	-0.21	-0.16	-0.25	-0.09	-0.02
2 B 2	Nitric Acid Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 3	Adipic Acid Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 4	Caprolactam, Glyoxal and Glyoxylic Acid Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 5	Carbide Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 6	Titanium Dioxide Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 7	Soda Ash Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 8	Petrochemical and Carbon Black Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B 9	Fluorochemical Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B-10	Other (please specify)	1.22	1.70	1.68	1.91	1.97	1.96	1.99	1.64	2.08	2.07	2.10	1.95	1.36	2.09	0.00	0.00
2 C	Metal Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.11
2 C 1	Iron and Steel Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.11
2 C 2	Ferroalloys Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 3	Aluminium Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

IPCC Category Code	IPCC Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2 C 4	Magnesia Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 5	Lead Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 6	Zinc Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 C 7	Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 D	Non-Energy Products from Fuels and Solvent Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	2.64	2.36	1.74	2.16	2.30	0.44	-2.93
2 D 1	Lubricant Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 D 2	Paraffin Wax Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 D 3	Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	2.64	2.36	1.74	2.16	2.30	0.44	-2.93
2 E	Electronics Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 E 1	Integrated Circuit or Semiconductor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 E 2	TFT Flat Panel Display	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 E 3	Photovoltaics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 E 4	Heat Transfer Fluid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 E 5	Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 F	Product Uses as Substitutes for ODS	NO	0.10	1.64	5.41	8.08	8.91	7.54	-11.28	-34.92	-46.89	-56.10	-34.83	-55.66	-46.55	-54.69	-54.62
2 F 1	Refrigeration and Air Conditioning	0.00	0.10	1.64	5.41	8.08	8.91	7.54	-11.28	-34.92	-46.89	-56.10	-34.83	-55.66	-45.27	-52.24	-52.18
2 F 2	Foam Blowing Agents	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1.28	-2.45	-3.47
2 F 3	Fire Protection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
2 F 4	Aerosols	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 F 5	Solvents	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 F 6	Other applications	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 G	Other Product Manufacture and Use	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.03	0.05	0.08	0.05	0.09	0.12	0.14
2 G 1	Electrical Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 G 2	SF ₆ and PFCs from Other Product Use	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.03	0.05	0.08	0.05	0.09	0.12	0.14
2 G 3	N ₂ O from Product Uses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 G 4	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

IPCC Category Code	IPCC Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2 H	Other (please specify)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Total Agriculture	16.58	14.54	13.45	15.03	98.89	97.68	99.36	99.82	101.16	102.72	105.93	105.22	104.42	103.02	99.23	100.52
3 A	Enteric Fermentation	0.00	0.00	0.00	3.07	71.46	69.56	70.69	71.40	71.93	72.51	74.64	74.44	74.53	74.49	75.55	79.21
3 B	Manure Management	0.00	0.00	0.00	0.37	11.74	11.70	12.11	12.33	12.67	13.08	13.74	13.93	13.86	13.74	10.25	8.24
3 C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 D	Agricultural Soils	16.58	14.54	13.45	11.59	15.69	16.43	16.56	16.09	16.55	17.13	17.55	16.85	16.03	14.79	13.43	13.07
3 E	Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 F	Field Burning of Agricultural Residues	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 G	Liming	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 H	Urea application	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 I	Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Land Use, Land Use Change and Forestry	525.63	436.96	326.35	319.76	319.79	324.89	324.23	331.24	326.62	328.98	325.27	319.53	300.77	304.41	-621.25	-674.26
4 A	Forest Land	1.52	1.52	1.19	2.49	2.34	1.75	1.15	0.56	-0.03	-0.60	-1.17	-1.74	-2.31	-2.88	-621.25	-1 031.06
4 B	Cropland	13.77	13.77	14.09	14.41	19.18	19.56	20.08	20.18	19.75	20.23	22.97	24.40	23.68	22.85	22.07	21.12
4 C	Grassland	12.20	11.94	11.72	11.51	12.15	12.10	12.23	12.17	12.17	12.20	12.63	12.59	12.06	11.73	11.37	10.94
4 D	Wetlands	0.10	0.10	0.15	0.15	0.18	0.24	0.22	0.53	0.21	0.10	0.27	-10.39	-9.53	-3.04	-2.52	-5.94
4 E	Settlements	495.0	407.3	297.7	289.8	284.5	289.8	289.1	296.3	293.0	295.6	289.1	293.2	275.4	274.3	287.0	329.1
4 F	Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 G	Harvested Wood Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 H	Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5	Total Waste	0.00	0.00	0.00	-0.15	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	7.79	13.85	18.80	19.33
5 A	Solid Waste Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.13	14.20	19.15	20.07
5 B	Biological Treatment of Solid Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5 C	Incineration and Open Burning of Waste	0.00	0.00	0.00	-0.15	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34
5 D	Waste Water Treatment and Discharge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.39
6	Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

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The National Inventory Report 2024 (NIR 2024) gives a detailed and comprehensive description of the trend and the methodologies applied in the Austrian air emissions inventory for the greenhouse gases carbon dioxide, methane, nitrous oxide, HFC, PFC, SF₆ and NF₃.

With this report, Austria complies with its reporting obligations under the EU Governance Regulation No 2018/1999 by providing transparent and verifiable documentation. It contains emission data by sector for the years 1990–2022 as well as information on emission factors, activity data and other basic data for emission calculations.

Moreover, the report provides documentation of the national inventory system and quality control and assurance activities as performed by the accredited Inspection Body for Emission Inventories (ISO/IEC 17020).